AFRICA'S ANIMAL AGRICULTURE: MACRO-TRENDS AND FUTURE OPPORTUNITIES

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Africa map used in preconferenc e proceeding

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Preface

The idea of a regional conference on animal agriculture, initially focusing on Eastern and Central Africa, was conceived by a small group of members of the Animal Production Society of Kenya (APSK) in 1988. This culminated into an Eastern and Central African regional conference on animal agriculture which was held in 1989 in Nairobi and was the precursor of the first All Africa Conference on Animal Agriculture, also held in Nairobi in 1992. It was at that first conference that a decision was made to have such a meeting of livestock sector scientists, other practitioners and stakeholders every 4 years – and this was also the birth of the All Africa Society for Animal Production (AASAP); the second conference was held in Pretoria, South Africa in 1996. It was at that conference that the AASAP became recognized as the African chapter of the World Association of Animal Production. The third one was held in Alexandria, Egypt in 2000, the fourth in Arusha, Tanzania in 2005, and the fifth in Addis Ababa, Ethiopia in 2010. This sixth conference, held in Nairobi and hosted (for the second time) by APSK, marked a return to the 4-year interval established at the birth of the AACAA.

The AACAA is the main mechanism through which the AASAP objectives are met – i.e. providing a forum for stakeholders – professionals and practitioners - to get together to share views on issues germane to animal agriculture. Thus, every one of these conferences focuses on a major contemporary issue or sets of issues which, in the views of the AASAP working with host country organizers, require attention. These may be new technologies or approaches, emerging challenges which require attention, controversial issues with implications for animal agriculture that require rational conversation, or regional or global trends which may have consequences for animal agriculture. The sixth conference focused on examining macro trends that underpin animal agriculture, with a special focus on implications for Africa.

By 2025, Africa is projected to have 350 million middle-class consumers, and the second highest number of city dwellers of any global region. This urbanization will offer opportunities to business throughout the continent and will require the development of innovative products to meet the specific needs of the urban poor and wants of an emerging consumer class. At the same time, it is clear that rural incomes will not be substantially increased by exclusive emphasis on subsistence food crop production; rather, more market-oriented production systems will be needed. Well-functioning agricultural markets are essential for rural growth – yet unfavourable terms prohibit or discourage rural households to fully participate in markets. Increasing (world and regional) markets give rise to opportunities for improved market governance. Reducing risk and transaction costs along value chains is crucial for profitable market participation by smallholder farmers. Such improvements are crucial for agricultural intensification, capturing market opportunities, and securing land tenure. Another important trend is that traditional distinctions between social and economic programs and sectors are disappearing. This opens opportunities for new partnerships and accountabilities, including new ways of working between governments, private, sector, civil society and rural people's organizations – with the international development community playing a supporting or facilitating role.

Mobility out of poverty is associated with personal initiative and enterprise. Improving people's capabilities must be tackled together with investment in rural development. Strengthening community-level organizations and their capacity to develop and execute programs must go hand in hand with expanding the range of financial services to poor rural people.

The 6th AACAA provided opportunity for Africa and the international community working on African livestock sector to discuss these trends and to seek ways of addressing the associated challenges while harnessing the opportunities these trends present. Under the overarching theme "Africa's Animal Agriculture: Macro-trends and future opportunities", specific attention was given to: Youth and future of animal agriculture; the future of smallholder animal agriculture; options for pastoral systems; market access; and strategies for leveraging the available human capacity through innovative capacity strengthening initiatives.

The conference was organized by the AASAP in association with the APSK. We would like to express our gratitude to the sponsors of the conference. Special thanks are due to the government of the Republic of Kenya which was a major sponsor and also host of the conference, presenters and authors of papers and posters, our colleagues on the organizing committee, institutions, groups and individuals who assisted in one way or the other, and the esteemed conference participants.

The venue, the setting and the overall conference atmosphere provided opportunity for networking by participants from across the continent and with colleagues from other corners of the globe. Many new friendships were made, old ones strengthened/renewed, and collaborations born. We have made no attempt to summarize the outcomes of the wide array of discussions on the many papers presented in the six sessions of the conference. After the conference, presenters were asked to submit or revise their papers, taking into account the issues raised during the conference discussions. The papers were then subjected to light technical reviews and language editing, thus ensuring that intellectual content remains that of the authors.

It is our hope that these proceedings will provide useful reference material for those interested in understanding the major trends and associated issues covered during this conference.

Ed Rege
President, All Africa Society for Animal Production (AASAP)

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Keynote

Africa's animal agriculture: New opportunities as a great livestock transition gets under way

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Summary

In coming decades, global demand for animal-source foods is predicted to rise a great deal faster than that for crops, driven by and in developing countries. Africa is outstanding in this regard, with recent estimates predicting milk demand to triple and consumption of pork, chicken and eggs to increase by up to six-fold by 2050. All the themes of this year's All Africa Conference on Animal Agriculture bear upon the continent's ability to grasp these growth opportunities while mitigating harm such growth could cause. For example, countries that meet the growing demand through imports are likely to face significant foreign exchange shortages. On the other hand, proliferation of large-scale industrial livestock production systems within Africa could pollute environments, and/or put public health at risk and/or widen already large socioeconomic gaps. What we can do now is to use this window of opportunity to help millions of Africans employ livestock as powerful instruments for transforming their livelihoods and the continent's food systems both. We are entering a great livestock transition period: in coming years, one-third of today's livestock keepers are expected to move from subsistence to market enterprises, another third to leave the sector, with the final third going either way. To help shape this transition for broad-based, safe and sustainable growth, we need, more than ever, livestock research conducted both *in* and *for* development.

Keynote

Maximising animal welfare and human wellbeing in food production: A global perspective in an African context

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'Animals raised on-farm in Africa are often handled well, considered symbols of wealth, and may even be treated as part of the family' (Menczer, 2008).

Macro trends – what is happening now in the world?

For a current view of what the macro-trends of global agriculture are, perhaps the best and most concise place to start are the five strategic objectives of the Food and Agricultural Organization of the United Nations (FAO, 2014).

- Help eliminate hunger, food insecurity and malnutrition
- Make agriculture, forestry and fisheries more productive and sustainable
- Reduce rural poverty
- Enable inclusive and efficient agricultural and food systems
- Increase the resilience of livelihoods to disasters

Similarly, another globally significant trend are the discussions around the UN's sustainable development goals (SDGs). The SDGs came about because the UN Rio+20 outcome document, *The future we want*, set out a mandate to establish an Open Working Group (OWG) to develop a set of SDGs for consideration and action by the UN General Assembly at its 68th session. The Rio outcome gave the mandate that the SDGs should be integrated into the UN development agenda beyond 2015.

The five strategic objectives of the FAO are echoed in the targets identified by the Open Working Group (OWG) on SDGs under the heading of Goal 2: *End hunger, achieve food security and improved nutrition, and promote sustainable agriculture* - OWG, 2014.

The difference between the FAO objectives and OWG targets is that whereas the FAO objectives place a greater priority on increasing production and productivity, the OWG process increasingly places the emphasis on increasing productivity and production in a **sustainable** manner. What is interesting to note here is that the African states in the OWG were very vocal on the need for a specific reference to **sustainable agriculture** in the title of this particular goal. This emphasis on sustainable agriculture is also shared by the Convention on Biodiversity's Aichi Target 7 as a critical goal for avoiding the erosion of biodiversity. The Common African Position on the post-2015 development agenda has re-affirmed Africa's commitment towards sustainable agriculture, food self-sufficiency and nutrition as an important element towards the realisation of structural economic transformation and inclusive growth in Africa by 2030, and importantly contributes towards the realisation of Africa's Agenda 2063.

If we consider this in terms of routes to change, we can identify a number of main trends taking shape. The **first** relates to a shift away from a singular focus on more efficient production of food towards more efficient use of the food we are already producing. This is to ensure we are not wasting the resources used to produce the food in a context of increasing resource scarcity. As a result we see a greater emphasis on reducing food loss and waste, with global efforts to reduce speculation with food commodities.

The **second** trend relates to an increasing focus on producing food where it is needed. As a result we see a strengthened focus on small-holder producers as these produce the vast majority of food consumed by those that are food insecure.

A **third** trend concerns the increasing acknowledgement that the food that we consume and the manner of food production has a significant impact on human health. The growing relevance of the One Health concept to the work of the key global agencies is an indication of how important this is. The FAO, OIE and WHO are committed to working more closely together to align activities related to the animal-human ecosystems interfaces. The emergence

of new or the re-emergence of existing animal diseases, including zoonoses, the growing threat of trans-boundary animal diseases, the impact of environmental changes and globalisation, concerns about genes from genetically-modified crops and animals escaping into natural ecosystems and reducing the resilience of agricultural landscapes, as well as new societal demands related to food security, food safety, public health and animal welfare, emphasise the critical need for collaboration between the three organisations (WHO, 2010).

Although the scale of the challenge can seem overwhelming, there are a number of opportunities to explore which demonstrates how good animal welfare can lead to improved outcomes. The SDGs will set the global agenda for the next 15 years. The Open Working Group on the SDGs outcome document will be a main input into the final negotiations on the SDGs and offer a number of opportunities for introducing good animal welfare as part of the solution:

- **Target 2.3** provides that increased productivity and production is sought through small holders and pastoralists. World Animal Protection's argument that better animal welfare increases productivity and longevity offer a route in this regard.
- **Target 2.4** seeks to make agriculture more resilient to climate change and disasters. World Animal Protection's disaster management related work, both in terms of protecting livestock and working animals during disasters, and working with governments to mainstream animals in disaster risk reduction and disaster preparedness offer routes to change for better animal welfare.
- **Target 12.2** seeks to significantly reduce losses throughout the food production cycle. World Animal Protection's work on transport and slaughter can be used to present good animal welfare as a route to reduce losses.

Separately, the Committee of World Food Security principles for responsible agricultural investments (RAI) – adopted in October 2014– confirm the existence of a direct link between animal welfare and human health. This is an enormous milestone, as it is the first time that a UN-agreed text makes explicit reference to the concept of animal welfare. The text states that responsible investments support '*animal health and welfare, and plant health, to sustainably increase productivity, product quality, and safety*.' This is exciting as it is implicit acknowledgement that increasing productivity without supporting animal welfare is not sustainable. Focusing our efforts on proving that better animal welfare leads to greater food safety and food quality can and should influence new investments to consider animal welfare.

When we consider the issue of ending hunger, sometimes what seems to be the 'obvious' solution is anything but. Some would argue that increasing food production is the only, or main, solution to ending hunger. However, in a report submitted in December 2010 by the then UN Special Rapporteur on the right to food, Olivier De Schutter, he stressed that increasing food production will not of itself be sufficient to combat hunger (De Schutter, 2010). It must be combined with improved livelihoods for the poorest, particularly small-scale farmers in the developing world. Smallholder livestock farmers must be helped to increase their productivity in ways which are appropriate for their circumstances. This should not entail the introduction of industrial livestock systems as these exclude participation of the poorest farmers. They are out-competed by industrial production which provides little employment. And the indigenous breeds of animals that are most productive and resilient to droughts and changes in local climate are generally not used in industrial livestock systems – CBD Aichi Target 13 encourages agricultural systems that do not erode genetic diversity.

Increased production may be needed in certain regions or specific cases but, in light of the various forms of loss and waste referred to below, the claim that a 60% increase in global food production is needed by 2050 (FAO, 2012) seems to substantially overestimate the quantity of extra production needed. This (arguably erroneous) 60% figure leads policy makers to place undue emphasis on further intensification while giving insufficient weight to the need to farm in ways that do not undermine the natural resources on which our continuing ability to produce food depends.

A constructive approach would be to help small-scale farmers provide improved healthcare and nutrition for their animals by better disease management, the expansion of veterinary services and the cultivation of fodder crops such as legumes. For example, in East Africa fodder shrubs have been identified that provide cheaper and easily available protein feeds for improving milk production in smallholder farms. Around 200,000 smallholder dairy farmers (40–50% being women) have planted such fodder shrubs which contribute about US$3.8 million annually to farmers' incomes across the region (Pretty 2011).

The same issues apply when we consider food security. Achieving food security is often presented as a primarily quantitative challenge. However, more than enough food is already produced to feed the anticipated world population in 2050 of 9.6 billion. **The real challenge lies not so much in producing more but in wasting less, and**

ensuring a more equitable distribution of food and agricultural resources. Sufficient caloric availability at the national or global level, while a critical component of food security, neither ensures equitable distribution of those calories, nor does it ensure that those calories are nutritionally appropriate (Pinstrup-Andersen 2009). Further, over 50% of global crop calories are lost or wasted or otherwise used in ways that do not contribute to the human food supply:

Combatting food loss and waste is absolutely central to achieving food security. A 2014 report by the High Level Panel of Experts on Food Security and Nutrition states that worldwide 25% of food calories are lost or wasted post-harvest or at the distribution, retail and consumer levels (High Level Panel of Experts, 2014).

We do not need to produce large amounts of extra food; we just need to use the food we produce more sensibly. Waste of food from animals represents a waste of animals' lives. Looking after livestock better while they are alive, and using their products better after slaughter will improve both animal welfare and food availability.

What does looking after livestock better while they are alive mean in practice? For one, it means excessive use of cereals in animal feed should be avoided and instead more emphasis should be given to different approaches. The welfare of animals in alternative systems (such as the examples suggested below) is generally better than in intensive farming, so again, a focus on animal welfare can help to achieve benefits for efficiency and sustainability.

- *Raising animals on pastures or other grasslands*: The benefit of extensively reared ruminants is that they convert grass and other inedible vegetation into food that we can eat and are able to use land that is generally not suitable for other forms of food production. Also, semi-natural grasslands support biodiversity and store carbon. However, care must be taken to avoid overgrazing which in marginal lands can lead to desertification. Nor should new pastures be created by deforestation.
- *Integrated crop/livestock production*: The World Bank is extremely positive about the benefits of such rotational mixed farming as crop residues can be used to feed animals (World Bank, 2009). Moreover, their manure, rather than being a pollutant, fertilises the land and improves soil quality.

The One Health concept has animal welfare as a key part of its approach. To that end, a viable primary health care system is an important and underpinning part of improving animal welfare in Africa. Disease is a major constraint to increased animal production and a significant source of suffering in animals in Africa. World Animal Protection works with the veterinary profession worldwide to increase awareness and support the advocacy role of veterinarians in animal welfare, while acknowledging that global needs may not always reflect those of the African continent.

It is precisely in this region where we can focus veterinary efforts at improving the welfare of animals used in agriculture, by addressing specific issues such as the way these animals are raised and housed. In countries where there is inadequate health care, this must come first as this is where most gains can be made for animals and people dependant on them for their livelihoods. As such, we believe that by creating synergies with human health care delivery, both can be better served by the 'One Health' approach.

Can we achieve enhanced animal production and productivity without compromising animal welfare? Setting the context.

Turning from global macro-trends to the African context, we know that approximately 70% of dairy production in Kenya is from smallholders. Production in such systems is negatively impacted by factors such as poor nutrition, substandard husbandry and management practices and diseases; consequently, low incomes are realised. All of these factors impact the welfare of dairy cattle (Aleri *et al*., 2012).

Intensification of smallholder dairy production in response to these issues and to maximise profits has led to deteriorating husbandry standards resulting in stressful conditions which reduce dairy cow welfare. Poor welfare conditions have direct negative effects on physiology, behaviour, disease susceptibility and productivity (Aleri *et al*., 2012).

Before continuing, it may be useful to define exactly what is meant by animal welfare. In the Terrestrial Animal Health Code, the OIE define animal welfare as: 'How an animal is coping with the conditions in which it lives. An animal is in a good state of welfare if (as indicated by scientific evidence) it is healthy, comfortable, well nourished, safe, able to express innate behaviour, and if it is not suffering from unpleasant states such as pain, fear, and distress. Good animal welfare requires disease prevention and veterinary treatment, appropriate shelter, management, nutrition, humane handling and humane slaughter/killing. Animal welfare refers to the state of the animal; the

treatment that an animal receives is covered by other terms such as animal care, animal husbandry, and humane treatment' (OIE, 2010).

Moderate Intensification, Productivity and Welfare.

Theoretically, a more moderate intensification of livestock production is associated with improvement in animal welfare, as livestock producers have economic incentives to invest in upgrading the quality of their animals by improving the quality of their feeding, health care, and general management (Devereux, 2013). McInerney (2004) proposes a general relationship between the productivity of livestock and their welfare, summarised in Fig. 1.

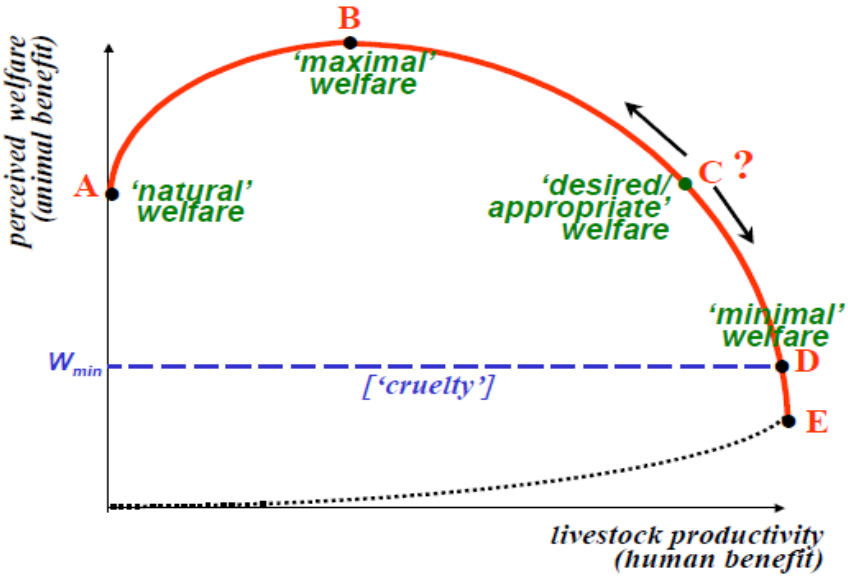

Figure 1. Synergies and conflicts between animal welfare and livestock productivity (McInerney, 2004)

Point A in Fig. 1 represents the welfare of animals living in their 'natural' state, or being reared under free range conditions. The trajectory between A and B represents 'win-win' gains: "As husbandry inputs are employed to feed and house the animals, protect them from predators, control disease and so forth, it is generally believed their welfare increases as well as their economic productivity" (McInerney, 2004).

As intensification of production rises and husbandry techniques seek to further exploit the biological potential of the animal, increases in productivity are made at the expense of animal welfare, so human wellbeing outcomes and animal welfare outcomes change from a state of mutual benefit to conflict.

Clearly, aiming for 'win-win' development strategies are the most sustainable way forward in terms of both animal welfare and human wellbeing. Devereux (2013) proposes a decision-tree model for analysis of animal welfare decisions (Fig. 2).

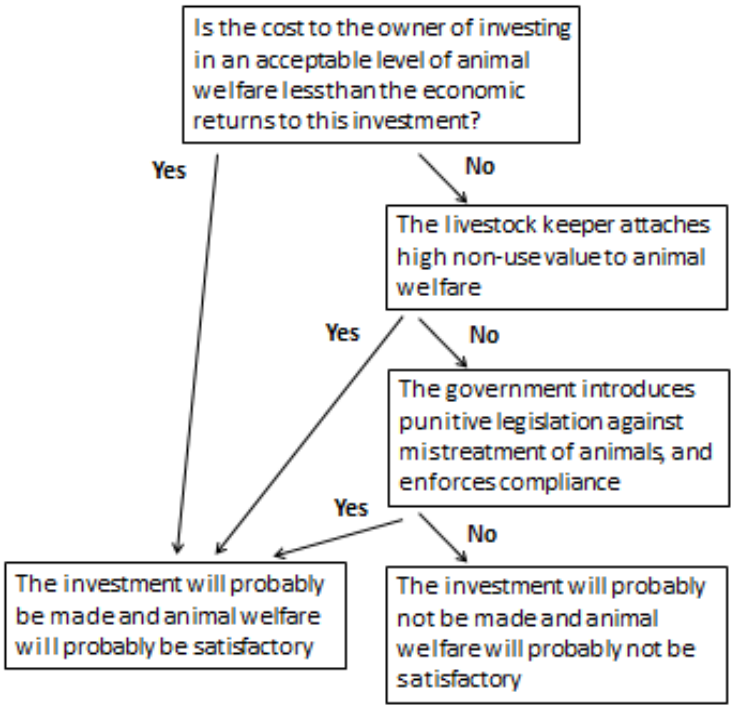

Figure 2. Animal welfare: a decision-tree analysis (Devereux, 2013)

The topmost box (Fig. 2) models the sustainable 'win-win' situation, where the economic value of the animal increases by more than the cost of investment in the animal's welfare. Of course, animal welfare considerations are influenced by and interact with other factors, some of which are outlined above. As stated at the opening of this paper, animals may be considered symbols of wealth and may be treated as part of the family, hence they have a non-use (or non-economic) value. If this is of great enough importance to the livestock keeper, investments may be made in animal welfare irrespective of any economic advantage (and even economic cost). Furthermore, as a result of cultural and social attitudes and pressures, governments may introduce and enforce legislation or regulation to safeguard animal welfare and, depending on the costs of non-compliance, this may result in investments being made in animal welfare.

Working towards sustainable 'win-win' solutions – some examples

An example of how economic benefit can be an incentive to the promotion of animal welfare is provided by the beef industry in Namibia. Dominated by small-scale commercial producers, 80% of Namibia's beef production is exported, mostly to the European Union. The EU offered a quota to Namibia on condition that specified meat quality and animal welfare standards were adhered to. The Farm Assured Namibian Meat Scheme (FANMEAT) was the government response to this opportunity. This set standards for livestock production systems, veterinary care, animal handling, transport and housing conditions, as per the table below.

Table 1. Animal welfare standards in the Farm Assured Namibian Meat Scheme. Source: Bowles et al. (2005).

Issue	***Standard and animal welfare applicability***
Production systems and general animal welfare	Hormone free; livestock owners are responsible for the welfare of their animals and must ensure that they are aware of all welfare requirements.
Veterinary issues	Records are kept and annual veterinary inspections carried out.
Animal handling	All animal handling facilities must be designed to ease handling of the animals and prevent injuries.
Transportation	The animals must be handled carefully to prevent stress and injuries. The use of electric goads is prohibited. The vehicle must comply with the conditions of the Code of

	Practice for the Transport and Handling of Animals. There must be adequate handling facilities at the point of loading and off-loading.
Housing and environment	There should be no features of the environment that could cause recurring injuries to animals.

Turning to another example, dairy production is Kenya's leading agricultural sector (Muriuki *et al*., 2003) with almost two million small-scale farmers (Smallholder Dairy Project, 2005) depending on it for their livelihoods and food security. Small-scale farmers are the backbone of the dairy sector, delivering 80% of all milk in the country (Wambugu *et al*., 2011). Domestic production meets current demand, despite milk consumption in Kenya being among the highest in the developing world. At an estimated 145 litres per person per year, Kenya's milk consumption is more than five times that of other East African countries (Smallholder Dairy Project, 2005).

LELBREN was founded in 2004 to provide support to the production and marketing of milk from small-scale farmers. What started as a community-based organisation of 29 farmers is now a limited company with a board of directors elected by the current membership, which in 2012 stood at almost 4,000 small-scale dairy farmers. It aims to improve the livelihoods of the community through advising on improved farm management, increasing milk distribution levels and facilitating access to markets, knowledge and inputs by dairy farmers. Co-operatives and farmers' organisations like LELBREN play a fundamental role in supporting the production, processing and marketing of milk from small-scale pasture-based systems, as well as increasing productivity, incomes, and supporting livelihoods and food security.

The model of farming supported by LELBREN has made a positive impact on public health: a fleet of trucks link producers to two collection centres, ensuring that milk does not spend long periods in hot conditions. A new cooling plant has opened to serve farmers in more remote areas. The co-operative also provides veterinary support to farmers, meaning animals are in good health and diseases that might compromise milk quality are not left untreated. From an animal welfare perspective, well managed pasture-based dairy systems provide excellent health and welfare for dairy cattle. LELBREN cattle experience good health with a low incidence of mastitis and lameness. In case of illness or disease, veterinary care is available via the co-operative. During the dry season, pasture is supplemented with hay or silage. Economically, LELBREN farmers receive a premium price for every litre of milk, substantially more than they would receive if they sold their milk to the open market. Farmers recognise the financial benefit of being part of LELBREN, which is evident from the rapid growth in membership. The economic benefit of LELBREN goes beyond direct financial incentive for farmers. The growth of the co-operative has attracted business opportunities and service providers such as banks, IT companies, dairy equipment, veterinary and artificial insemination services, which has led to setting up service points and establishing business relationships. In an area where the poverty index was estimated at 47.4% in 2005–2006, LELBREN is proving to have a positive impact on the economic development of the area (Kenya Open Data, 2012).

Examples of non-African 'win-win' scenarios nonetheless provide lessons applicable to the African context

Appleby and Huertas (2011) discuss a two year training course in Uruguay sponsored by the Ministry of Livestock, the Uruguayan meat board, the producers' association and academia. The training course focussed on animal handling techniques, and as well as bringing animal welfare benefit, resulted in reduction of carcass bruising by over 50%, significantly reducing meat loss during dressing.

McLeod and Sutherland (2012) discuss how making transporters financially accountable for bruises, poor meat quality and loss of animals has improved handling during transport in the USA and Brazil. In one Brazilian example, bruising in cattle was reduced from 20% to 1% through this measure. Paying a bonus to animal handlers for low levels of bruises, injuries and pre-slaughter deaths, and limiting the speed at which people work in slaughterhouses as well as the length of their shifts has also proved effective, and is repaid by the additional value of the carcases due to reduction in damage.

Translating global issues to the African context – youth, governments and policy drivers

Translating global issues to the African context is vital. Sub-Saharan Africa is the youngest region in the world, with about 65% of the total population of Africa being below the age of 35 years, and over 35% are between the ages of 15 and 35 years - making Africa the most youthful continent in the world. By 2020, it is projected that out of four

people, three will be on average 20 years old. This has real implications for food production (Agriculture for Impact, 2014).

The youth of Africa have an important role to play in advocating for animal welfare and in this regard, the importance of animal welfare education for this young audience, as well as other key stakeholders in the region, needs to be emphasised. Improved awareness and attitude change is critical for mainstreaming animal welfare in socio-economic development; indeed, the youth present the opportunity to discover a new connection (reflecting today's realities) between present generation humans and animals.

Today's African youth ('leaders of tomorrow') represents a major transition – from deeply rooted, locally defined cultural influence of their parents to more open, globally shaped mind sets –shaped by different realities and willing to do things differently. Demographics indicate that investing in youth awareness has high potential payoff – larger numbers in shorter time. This can be achieved through youth awareness projects – linked to selected primary, secondary and tertiary education, developing animal welfare curricula and disseminating them widely with major public awareness campaigns, and using social media to reach large numbers – driven by youth ambassadors or champions (World Animal Protection, 2014).

Recent events in Africa at the government and policy level demonstrate a renewed commitment to accelerate agricultural growth and transform the continent for shared prosperity and improved livelihoods. Some of the key events include the AU Joint Conference of Ministers of Agriculture, Rural Development, Fisheries and Aquaculture that took place at the African Union Conference Centre in Addis Ababa, Ethiopia from 28 April - 2 May 2014. This was one of a series of events commemorating 2014 as the Year of Agriculture and Food Security in Africa, and a critical part of a process that led up to the AU Summit of the Heads of State and Governments Twenty Third Ordinary Session of the AU Assembly in Malabo, Equatorial Guinea, held from 26-27 June 2014.

This Summit, entitled 'Transforming Africa's Agriculture for Shared Prosperity and Improved Livelihoods through Harnessing Opportunities for Inclusive Growth and Sustainable Development', also marked the tenth anniversary of the adoption of the Comprehensive Africa Agriculture Development Programme (CAADP)", and culminated in the Malabo Declaration. This demonstrable recommitment by African governments towards revitalizing its agricultural sector is significant and this paper recognises the opportunity these policy drivers offer for animal welfare to become central to the African agenda.

Animal welfare, human wellbeing and food production – challenges, best practice and key opportunities for Africa

There are a number of challenges to promoting animal welfare in the African context – and globally as well. These need to be clearly recognised so that efforts to address them are more effective.

- **Commercial interests.** Pursuit of commercial interests overshadows animal welfare issues. For instance, wildlife conservation in Africa is primarily focused on their 'tourism attraction' benefits and associated economic value of the wildlife; the value of the animal in its own right and its link to the overall functionality of the ecosystem is given limited attention. In addition, traders and producers are reluctant to adopt internationally recommended designs for animal transport vehicles due to added cost and reduced monetary gains associated with transporting fewer animals in comfortable trucks.

- **Entrenched negative** attitudes towards animals. Fixed mind sets and attitudes exist towards animals. Most people are not aware that animals are sentient creatures and still consider concern for animal welfare as an unnecessary western influence. Animals such as cats are just considered as rat-catchers, while dogs are for hunting or for security/protection of property.

- **Weak animal welfare legislation and enforcement.** There is low level of enforcement of national animal welfare regulations (where they exist) due to inadequate resources for this purpose. Moreover, the general 'policing' approach is ineffective while at the same time given the current low-level of awareness, changing the situation and achieving attitude change is a slow and resource-intensive process.

- **Inadequate political participation in protecting animals**. In most African countries, political debates are centred on resource allocation for human development and politicians are generally reluctant to focus on animal welfare issues that are not seen as offering direct returns – in a development sense.

- **Lack of disposable income for animal needs.** Most African households are struggling to feed their families and have no income to spend on animal welfare, which is still considered a luxury and preoccupation of the wealthy.

- **Low media interest and coverage of animal welfare.** Unlike other continents (especially North America and Europe) where increased media focus on animal welfare led to enhanced awareness and improved animal welfare, the media in Africa seldom highlights animal welfare issues. This is a clear indication of the pervasive low awareness in society and system as a whole.

- **Inadequate animal welfare education.** There is limited understanding of animal welfare issues by the average person. This is worsened by the fact that there is hardly any training on animal welfare in existing formal education systems.

Despite these challenges, there are clear examples of where best practice in animal welfare has resulted in significant gains. One example is World Animal Protection's disaster management operational work in the Mwingi district in Kenya. Losing livestock in a disaster has an enormous impact on communities and households, as well as real economic consequences. This is because livestock often play a critical role in economic productivity for these communities. World Animal Protection's goal in Mwingi was to provide veterinary care and feed as an early intervention in the drought that was occurring across the country at the time. This was done utilising the University of Nairobi veterinary emergency response team that we have funded, equipped and trained.

Following external analysis, the results of World Animal Protection's Mwingi intervention over a one-year time period were truly startling. Over a one-year time period, this intervention generated US$2.74 of benefits in the form of avoided losses for every US$1 spent. If the time period is extended to three years, the benefit-cost ratio increases to US$6.69 in benefits for every US$1 spent.

Opportunities for animal welfare in Africa

The greatest opportunity for significantly changing the status of animal welfare in Africa lies in finding a win-win between animal welfare and highest priority challenges for Africa and its development partners – improving human livelihoods through poverty and hunger eradication programs.

For example, how can animal welfare be made to offer *business opportunities*? What changes could be made in the way wildlife and farm animals are managed that will generate positive animal welfare benefits while also providing direct human livelihood benefits? Some leading supermarkets such as Pick n' Pay and Woolworths in South Africa sell free range eggs to loyal customers and get more returns than is possible with conventionally produced eggs from commercial – usually intensive - layer chicken systems. How can these models be scaled up and out throughout Africa?

A major opportunity area is awareness and training. There are collaborative opportunities for improving animal welfare through capacity building funded by support from the FAO, OIE, governments and multilateral organizations that work to promote animal welfare in Africa (FAO, 2008).

There is also opportunity to engage African countries through the CAADP process and latterly the Malabo Declaration. By February 2014 a total of 40 countries had developed their CAADP compacts (agreements of consensually identified national priorities and a roadmap to implement the country's strategy for agricultural development) and 28 have developed National Agricultural Investment Plans (NAIPs), a clear indication of their commitments to applying the CAADP framework in prioritising and leveraging investments in agriculture. It is through policy imperatives such as these that areas relevant to animal welfare issues in Africa – both in terms of livestock development and wildlife – can be identified.

Animal welfare is not incompatible with food production or human wellbeing in the African or global context. On the contrary, these concepts can co-exist and even enhance each other and embody African's respect for life. Africa has a unique opportunity to demonstrate this, with the active participation of all key stakeholders and World Animal Protection looks forward to working with them to make it happen.

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WHICH WAY FOR SMALLHOLDER PRODUCTION SYSTEMS?

Contextualizing smallholder systems in Africa's livestock production systems.

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Summary

African agriculture is predominantly smallholder with over 80% of Sub-Saharan population deriving their livelihoods from that system. In the last half century of self-governing Africa there have been massive investments in smallholder production systems in the name of poverty eradication. Yet whether smallholder farming will eradicate poverty in developing countries remains an unanswered question. Some schools of thought contend that smallholder farming is an obstacle to development in developing countries. While farm sizes have been used to define small holdings, this is tricky in livestock production systems, where land factor is complicated by tenure system and agro-pastoral and pastoral households are marginalised in the crop biased agricultural development framework in most developing countries. This paper present a review of development trends in African post-independence livestock production system in the wake of fast changing social and economic global development trends. We look at the future of smallholder livestock production systems with major shift from public to private led agrarian economy. What is the role of state and non-state institutions, the AU led African countries agricultural development policy and the effects of increasing, large foreign and domestic investments on land and large-scale farming? Will smallholder livestock producers benefit from the undoubted opportunities of science and technology advancement as well as increasing livestock products demand, or are they going to miss out?

Implementation of genomic selection: Steps and experience in dairy cattle and goats populations: Implications for intensification of dairy production in Africa

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Summary

Genomic prediction and selection of animals on the basis of single nucleotide polymorphisms (SNP) from dense marker maps in practical animal breeding has not only grown in popularity in recent years but is becoming the method of choice. This has been fuelled by the reduction in genotyping or sequencing costs over time. In this talk, steps involved in the implementation of genetic selection on basis of genomic breeding values in the dairy cattle and goat populations in the UK are briefly outlined. With large number of genotyped bulls available for the Holstein breed in the UK, a SNPBLUP model has fitted, with the subsequent incorporation of parental contributions from conventional genetic evaluations; the so called two-step approach. The gain in reliability for genomic breeding values of young bulls was about 0.33 for production traits but varied from 0.20 to 15 for fitness traits of lower heritabilities such as somatic cell counts and lifespan. The comparison of initial genomic breeding values for a group of bulls with no daughter information to evaluations that later included daughters' records demonstrated good predictive of the SNP BLUP model. However, when number of genotyped animals is limited as in the dairy goat population in the UK, results indicated that the single step approach was optimal. The implications of both approaches are assessed in terms of the application of genomics for small holder farmers in Africa.

Options and future of smallholder production system in Africa

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Abstract

A review was conducted to examine the status of smallholder production system, major constraints and opportunities that exist for improvement. It is acknowledged that Smallholder livestock keepers representing 20% of the world population play a critical role in providing the ever increasing demand for livestock and livestock products. Smallholders in the tropics are the steward of agricultural land and the environment. They provide subsistence economies, but in some market oriented smallholder systems, they provide sufficient incomes for non-subsistence needs. However, the main challenge confronting smallholder farmers is how to increase the production to meet the ever increasing demand for food with a core problem of climate change and variability, and increased population growth. Experience from Eastern Africa and elsewhere in the developing world indicate that one major opportunity lies in increasing overall productivity through an integrated approach combining climate smart and sustainable agriculture practices such as crop-livestock-fish systems. These practices act as means for smallholder farmers to diversify production, thereby providing nutritious foods for both subsistence and surpluses for sale, which help reduce vulnerability to external drivers such as fluctuating markets and climate change. This paper suggests that smallholder farmers need to participate in developmental agenda and decision making processes to foster collaboration and information sharing among public and private sector stakeholders where integrated crop-livestock-fish systems are not only technically feasible but environmentally and economically viable.

Keywords: Smallholders, Crop-livestock-fish, Climate smart agriculture technologies

Introduction

There is ample evidence for increased global demand for livestock and livestock products (Herrero *et al*., 2008). The demand is projected to more than double by 2050 (Conforti, 2011) due to increasing human population, urbanization, rising incomes and dietary changes towards higher meat and milk consumption. Livestock sector plays a critical role in the economies of most countries in the World. It is also evident that most of the households and families particularly in developing world rely on livestock and that livestock keeping supports communities' livelihoods (Staatz and Dembele, 2007). More than 80% of African farmers are rural based smallholders and produce more than 90% of the food (Wiggins, 2009). In Africa, livestock, especially smallholder mixed crop/livestock production systems are important to both household and national economies.

Increase in productivity of crops, livestock and fisheries have been recognized by the Comprehensive Africa Agriculture Development Programme (CAADP) of the African Union/New Partnership for Africa's Development (NEPAD) as a key means to accelerating growth in agricultural sector. Experience and lessons leant from various developmental work in Eastern Africa and elsewhere in the developing world indicate that integration and intensification of crop, livestock and fish (CLF) in smallholder production systems is a major opportunity to increase the overall farming systems' productivity (Kabirizi *et al.,* 2013; Musiba *et al.,* 2013; Owori *e al.,* 2013). Smallholder farmers are however faced with challenges that limit their ability to undertake integrated production systems ranging from global climatic changes, economies, resource availability and technology requirements. This paper highlights the challenges and discusses the opportunities for integrated smallholder production systems as a way forward for increased production and sustainability of African agricultural systems.

Major challenges in smallholder production systems

Human population growth, climate change and variability, poverty, poor soils, low and unreliable rainfall, pests and diseases, unfavourable policies, increased population pressure, lack of market, inadequate quantity and quality feeds, high labour costs, gender inequality, and inequitable markets are some of the major causes of vulnerability of livelihoods in smallholder production systems in many of the developing countries. Below follows analyses for some of the above challenges.

(a) Increase in human population and allocation of resources among smallholder

It has been estimated that each day more than two hundred thousand people are added to the world food demand. According to United Nation Population Division (2007) the world's human population has increased nearly fourfold in the past 100 years. The rate of population growth, however, is still relatively high in Central America, and highest in Central and part of Western Africa. In relative numbers, Africa will experience the most rapid growth, over 70% faster than in Asia (annual growth of 2.4% versus 1.4% in Asia, compared to the global average of 1.3% and only 0.3% in many industrialized countries) (UN Population Division, 2007). In sub-Saharan Africa, the population is projected to increase from about 770 million to nearly 1.7 billion by 2050. As population grows, subdivision is reducing individual land holdings and farmers are struggling with declining levels of soil fertility and crop-livestock yields with few opportunities to diversify. Land and livestock are the major assets available to smallholder crop and livestock farmers. Farmers allocate fertile land to food and cash crops and marginal lands are allocated to forage crops leading to low forage yields, low milk yield and long calving intervals (Kabirizi *et. al.* 2010). Traditional farming systems are breaking down under human and livestock population pressure. As these conversions take place, livestock increasingly depend on the use of crop residues for animal feed. This traditional crop–livestock integration is largely supported by formal and informal relationships between crop farmers and transhumant livestock producers. The latter derive access to seasonal feed resources, while the former benefit from the manure deposited. An important challenge to wealthy investigation is to develop technological options that promote the benefits of crop–livestock interactions in a manner which facilitates the expansion of food production while sustaining or even increasing land and labour productivity under conditions where there is severe competition for resources. On the other hand, increasing demand for food by a rising population, observed dietary shifts also have implications for world food production. It has been reported that as people get richer they consume more animal products (Steinfed *et al*., 2006).

(b) Effects of climate change

The productivity and sustainability of smallholder crop-livestock-fish systems is greatly threatened owing to climate change and climate variability. The increasing intensity and frequency of climate change disasters has escalated farmers' risks and losses, and is now a major reason for the disparity between the crop and livestock productivity and sub-sector growth. The seasonal gain and loss in weight of animals results in poor growth pattern accompanied by low reproductive performance. Milk yields of dairy cattle on low quality diets alone rarely exceed 10 litres per cow per day leading to a reduction in household income (Kabirizi *et al.*, 2010). The integration of the crop livestock enterprises provides an important interlinked system which enables farmers attain enhanced incomes from livestock and crop production and increased household nutrition, thus improving livelihoods of small scale farmers.

(c) Poor infrastructure as influenced by policies

Poor infrastructure plays a key role especially in the informal market that dominates the dairy and vegetable sectors. This is a major constraint on production, significantly reducing farm-gate prices and raising the cost of inputs and services. Policies that target improvement of road infrastructure and monitoring of feed quality are likely to have a positive and significant effect on livestock production.

(d) Inadequate policy and regulation enforcement on livestock feeds

Earlier work has reported that livestock feeds contribute over 70% of the total cost in smallholder dairy enterprise (Kabirizi, 2006). However, concerns over high feed prices and poor quality have continually been raised after liberalization of the feeds market and decontrol of feed prices. Some of the necessary ingredients, especially those not locally available, are in low supply and often adulterated. Inadequate enforcement on policy guidelines and regulations has resulted to supply of feeds with poor quality standards which would improve the competitiveness of smallholder farmers and increase production.

(e) Limited labour in integrated production systems.

Rural women play an import role in African agricultural production as more than 80% of agricultural labour is supplied by women and the elderly (Manju, 1995; Rietveld *et al.*, 2012) Limited labour is available for integrated production systems. Integration means more labour is needed, yet African agriculture is already constrained by labour. Therefore, if there were to be integration, we need labour saving technologies. Increasing labour productivity is another important challenge and it may be partially addressed by crop–livestock integration. However, over time, the average age of rural farmers is expected to increase, given historic evidence that younger people, mostly males, tend to migrate to urban centres. Technologies that can increase the labour productivity of rural women and the ageing are likely to become prerequisites for ensuring agricultural output.

(f) Nutrient deficiencies

An important link in mixed farming systems is the cycling of natural vegetation and crop residue biomass between livestock and soil via faeces and urine. Also the link between Irrigation water/pond silt as fertilizer in crops/vegetable fields and in return the vegetable and crops that feed the pond. In similar manner the water wastes

from the pond to livestock where manure also can fertilize the pond. Nutrient deficiencies common in many developing countries can contribute to imbalances by excessive removal of vegetation while grazing and in harvested feeds and by not recycling nutrients or depositing them unevenly on the land. In a typical dairy farm in the developed countries nitrogen fertilizers are the major source of nitrogen while in developing countries manure are the only significant nitrogen input.

Opportunities for improvement of smallholder production practices/systems

Integration of Crop-livestock-fish (CLF)

The main challenge confronting smallholder farmers in Africa is how to increase the production from smallholder farming systems to meet the increasing demand for food from the ever increasing human population. Given the declining land holdings, integration of several agricultural enterprises in way that outputs from one enterprise are used as inputs in another enterprise holds the future for smallholder farmers. The integration of CLF production, do complement each other through use of by-products from one system as inputs into another system. Crop residues can be used to feed livestock and fish, livestock manure can be used to fertilize crop fields and fish ponds, and waste water from fish production can be used in irrigation of crops. Such an integrated system therefore not only results in increased production and productivity but also reduction in the costs of production, increased overall system productivity and enhanced sustainability. The success of such integration could be limited by lack of specific standards and environmental criteria for production of safe fish and fish products as argued by Charo-Karisa *et al.* (2008). A simple conceptual framework in smallholder dairy-vegetable-fish/aquaculture and climate change is presented in Figure 1.

Labour saving technologies:

Labours saving technologies developed and validated by various developmental partners if adopted could significantly contribute to smallholder production (Kabirizi *et al.*, 2013). Women youth and children play a central role in poverty reduction and food security because they are responsible for both production and reproduction. Labour saving technologies and innovation such as manual fixed forage choppers and wooden hay bailers are meant to reduce workload on chopping fodder for feeding dairy cattle. Also wooden bailers are meant to facilitate conserving fodder to ensure year around supply. Water harvesting enables farmers to collect additional water for both home consumption and livestock.

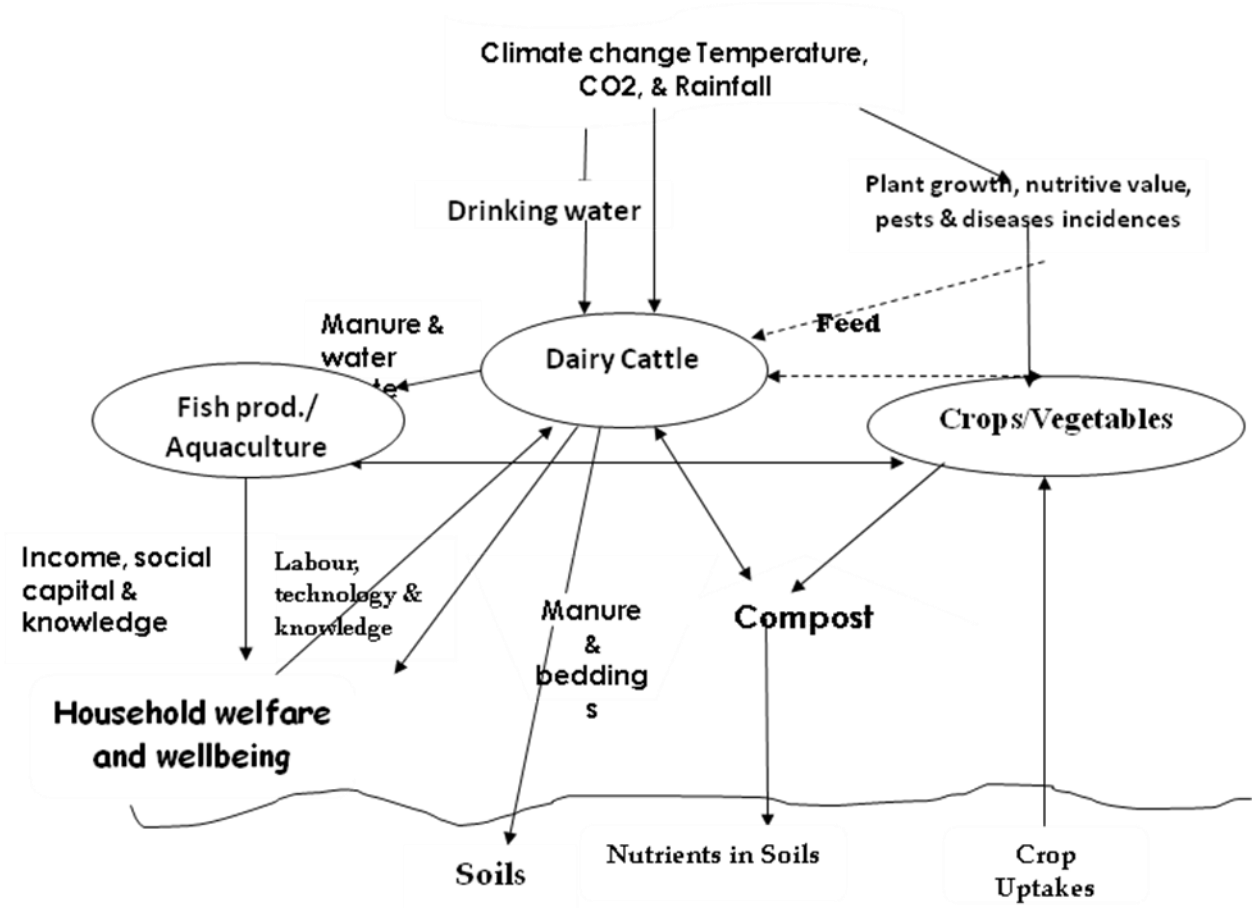

Figure 1. Conceptual framework for small holder integration production system of CLF

Experiences from Eastern and Central Africa have shown that up to 35,000 litres of water can be harvested per season which is sufficient to meet family needs of four people, 0.1 ha of vegetable irrigated plot and drinking water for two lactating cows and can take four to six weeks. With this provision a family can save about USD 30 per month (Kabirizi, *et al.* 2013). The significance of this is the labour saving from searching for water. Small scale vegetable production with manure from the zero grazing cattle and irrigation using gender sensitive treadle pumps reduces workload to draw water from water tanks and shallow wells. These enable women to actively participate and engage in more than one enterprise and also attract youth to farming.

Drought tolerant and high yielding forages

Some forage technologies involving mixtures of grass species (*Brachiaria cv* Mulato; Napier or Giant *Panicum*) with forage legumes (*Desmodium intortum*, *Clitoria ternatea* or *Centrosema pubescence*) have been recommended (Kabirizi *et al*., 2013). Pasture species capable of growing out of season can be planted to prolong the period of good-quality forage. Recommended drought-tolerant legumes can be particularly useful in grass-legume mixtures for various agro-ecological zones. Some success has been recorded with forage species such as Buffel grass, Rhodes; Napier; Guetamala, Panicum, Lablab, Blue pea, Glycine, Desmodium and stylo (Mtengeti *et al*., 2001; Mwilawa *et al.*, 2005; Njarui *et al.*, 2011; Kabirizi *et al.*, 2013) and the need to explore more of them with climate change is highly emphasized.

On farm studies have revealed that incorporation of drought tolerant forage legumes such as *Clitoria ternatea* in Napier grass fields increased fodder availability by 42% (Table 1). The increment in fodder yield can sustain a crossbred (Friesian x indigenous) lactating cow (470+21.0 kg liveweight) for an additional 119 feeding days when compared to sole Napier fields. An additional 14,119 kg DM/ha/yr of fodder was obtained by establishing an additional forage bank of 0.5ha of B. mulato/*Clitoria ternatea* mixture on the same farms containing Napier grass fields. This implies that increased forage yield was able to sustain adequate availability of fodder to a lactating cow throughout the year and alleviate farmers labour to look for forages on roadsides.

Table 1. Forage yield and feeding period of different established forage banks (Source: Kabirizi *et al.*, 2013)

Fodder bank	Mean (±SEM) yield (kg DM/ha/yr)	Mean (±SEM) feeding period (days) from 0.5 ha for one lactating cow
Napier grass monocrop	10,354±393	165.4±16.3
Napier grass/*C. ternatea* mixture	17,790 ±331	284.2.±26.9
Brachiaria hybrid cv. Mulato/*C. ternatea* mixture	14,119±196	193.6±19.4
Maize monocrop (stover yield)	3,732±145	88.1±10.1
Maize/*L. purpureus* intercrop (stover yield)	4,998±155	161.0±21.4
Maize monocrop (grain yield)	1,747±.289	-
Maize/*L. purpureus* intercrop (grain yield)	2,912±110.7	-

SEM – Standard error of mean

Forage conservation technologies

(i) Hay making

The production of hay from natural pastures as well as improved pastures appears to be an easy and cheap method of conserving forage. The technology has been well documented and demonstrated by many workers (Mwilawa *et al.*, 2013). Baling hay saves storage space and avoids waste during feeding. The bales or bundles are stored under a roof and stacked on raised wooden structures. The good quality legume hay (leaf meals including tree leaf meals – e.g. use of leucaena leaf meal by Tanga dairy farmers) may replace certain amount of concentrate in the ration, thus reducing the cost of production. The fodders can be harvested at the stage when there is maximum accumulation of nutrient in the plant. The disturbances of weather during hay making have rather been worked with and fence hay drying technology during the rainy season have been demonstrated and successfully adopted among smallholder dairy farmers in Njombe district (Sundustøl *et al,*. 2008). The major intervention here could be sensitization and knowledge dissemination to farmers on owning pasture fields that could be used for hay conservation.

(ii) Silage making

Mwilawa *et al.* (2013) demonstrated silage making in farmers farmlands in the Lake zone of Tanzania and farmers have adopted the practice although at limited scale. Small quantities of Napier/guetamala silage and occasionally maize silage are produced on some dairy farms around the country. Both bana grass and Napier grass have been shown locally to have higher yields (Mtengeti *et al.*, 2001) and can be conserved as silage (Mtengeti *et al.*, 2014). If cut and chopped at the recommended maturity stage, the giant fodder grasses are no more difficult to ensile than maize, although they do have a higher protein content necessitating the addition of a carbohydrate supplement such as molasses or locally available additives such as chewing sugarcane crush or maize bran (Mtengeti *et al.*, 2013).

Potential proven technologies for adoption by smallholders

There has been a number of technologies developed among developing countries that has been tested and validated and could be used in integration systems. The developed climate smart agricultural (CSA) technologies and productivity enhancing technologies along the CLF value chains included: improved food crops and drought tolerant forage varieties (Kabirizi *et. al.*, 2013; Njarui *et. al.*, 2013), simple rain water harvesting and conservation methods (roof catchment and surface run-off) (Itabari *et. al.* 2012; Habai *et al.*, 2013; Wanyama *et. al,*. 2013), feed formulation, forage conservation and utilization for dairy production (Mugerwa *et al.* 2012; Mwilawa *et al.*, 2013; Ngendello *et al.*, 2013; Kabirizi *et al.*, 2014); soil fertility management for forages and vegetable production (Mugerwa *et. al.* 2012; Minani *et. al.* 2013); labour saving technologies such as the use of fixed knife forage chopper and the treadle pump (Lubwama., 2013), feed, breeding and animal health management (Kanuya *et al.*, 2006), postharvest handling and value addition on vegetables, fruits, milk and milk products (Nattabirwa *et al.*, 2012); and fish production, fish feed rations; breed improvement and fish seed production and distribution (Owori *et al.*, 2013) and market access technologies and innovations (Birungi *et al*., 2013). Development of the CLF value chains to enhance their efficiency along the value chain is a key strategy to transform smallholder farmers from subsistence production to market oriented profitable enterprises that are well positioned to face the challenges of feeding the populating world in the 21st Century. Access to markets and competitiveness of the strategic value chains will be facilitated by the existence of an enabling policy environment that regulates the inputs and outputs markets. Access to market information and better linkages to other actors in the value chains will improve market opportunities for smallholder farmers.

Conclusion

This paper concludes that integrated approach using climate smart agricultural technologies will allow smallholder farmers to diversify production, thereby meeting both subsistence and surpluses for sale, which help reduce vulnerability to external drivers such as fluctuating markets and climate change. Ensuring the participation of all stakeholders is key for sustainably managing natural resources and increasing the scale of climate smart agricultural innovations and technologies. Small holders need to participate in developmental agenda and decision-making processes to foster collaboration and information sharing among public and private sector stakeholders. It is more critical that appropriate climate smart agriculture technologies need to be available among smallholder farmers where integrated cop-livestock-fish systems are not only technically feasible but environmental and economically viable.

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Homecoming of Brachiaria: Improved hybrids prove useful for African animal agriculture

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Abstract

Species of the genus *Brachiaria* originate primarily from Africa, where they are constituents of natural grasslands. Due to their adaptation to acidic, low-fertility soils, millions of hectares of *Brachiaria* species have been sown as improved pastures in South and Central America, especially *B. brizantha* cv. Marandu and *B. decumbens* cv. Basilisk. Due to *B. decumbens*' susceptibility to spittlebug insect pests in the Americas, CIAT in Colombia and EMBRAPA in Brazil initiated breeding programs in the 1980s. First cultivars released from CIAT's breeding program, cvs. Mulato and Mulato-II, have also been investigated in African countries. They have been examined for integration in conservation agriculture systems (Madagascar), for drought and acidic soil tolerance (Rwanda) and for intercropping forages in dairy systems (Uganda, Madagascar), among others. Seed sales to African countries suggest that an area of at least 1,000 ha has been sown so far. Largest adoption of cv. Mulato-II is currently happening in eastern Africa, where it is used by over 20,000 farmers as trap plant in the push-pull system for control of maize stem borers and parasitic Striga weed. Cv. Mulato-II's particular advantage is relatively high crude protein content due to greater leafiness and thinner stems than those of traditional Napier grass, resulting in higher nutritive quality. Yet, new pest challenges have emerged requiring further research attention. Though, diverse hybrids are in the pipeline for release, among them such suitable for cut-and-carry systems prevalent in eastern Africa. This paper reviews research, development and incipient adoption of new *Brachiaria* hybrids in African countries.

Keywords: Conservation agriculture, cv. Mulato-II, East Africa, Forage adoption, Push-pull system

Background

Species of the genus *Brachiaria* originate primarily from eastern, central and southern Africa, where they are natural constituents of grasslands (Boonman, 1993). The largest impact of *Brachiaria* in agriculture, though, is in the Americas, especially in Brazil. Due to their adaptation to acidic, low-fertility soils, an estimated 99 million hectares of *Brachiaria* species have been sown as improved pastures in Brazil alone (Jank *et al.*, 2014). This refers especially to *B. brizantha* cv. Marandu and *B. decumbens* cv. Basilisk. Despite Africa being their center of origin and diversity, *Brachiaria* species had not been selected for pasture improvement in eastern Africa, when grassland research was most active in the 1960s and 1970s (Boonman, 1993). The then available commercial cultivars of *B. brizantha*, *B. decumbens*, *B. ruziziensis* and *B. humidicola* were evaluated in small-plot agronomic trials in western and central Africa in the 1990s (Ndikumana and de Leeuw, 1996). However, none of them appears to have found its way into commercial agriculture at a significant scale in any African country (Boonman, 1993). Only Congo Signal grass (*B. ruziziensis*, K5832[1]) has been used as a cultivated grass in some areas of Congo (DRC, formerly also Zaïre), Uganda and Kenya according to Boonman (1993) review. This nutritious and persistent grass has been in commercial seed multiplication since 1960.

Brachiaria improvement in the Americas

Due to the susceptibility to spittlebug insect pests of *B. decumbens* in the Americas, CIAT in Colombia and EMBRAPA in Brazil initiated breeding programs in the late 1980s (Miles *et al.*,. 2004). Accessing useful resistance genes for cross-breeding was a particular challenge due to the apomictic nature of the grass (i.e., reproducing

asexually by seed). This was only made possible by applying modern biotechnological tools then available (Miles *et al.*, 2004). The first inter-specific hybrids from CIAT's *Brachiaria* breeding program (cvs. Mulato and Mulato-II) were released in the Americas in early and mid-2000s by Grupo Papalotla (Table 1). Since 2012, cv. Cayman – as a plant with higher water-logging tolerance – has been made commercially available by Grupo Papalotla (Pizarro, 2013), and the new, relatively taller cv. Cobra that is more suitable for cut-and-carry system will be soon available on the market.

Table 1. Commercially available hybrid *Brachiaria* cultivars

Cultivar	CIAT ID	Special characteristics	Country, year of variety protection (first release)	Reference
cv. Mulato	CIAT 36061	Spittlebug-resistant, high forage yield and nutritive quality, poor seed fill	Mexico, 2004 (2001)	Argel *et al*., 2007; Miles *et al.*, 2004
cv. Mulato-II	CIAT 36087	Spittlebug-resistant, high forage yield and nutritive quality, good seed yield	Mexico, 2007 (2005)	Argel *et al.*, 2007
cv. Cayman	BR02/1752	Higher tolerance to water logging than other hybrids	Mexico, 2013 (2012)	Pizarro, 2013
(cv. Cobra)	BR02/1794	Relatively taller than other hybrids, suitable for cut-and-carry	Mexico, 2013	Pers. comms. E. Stern, M. Peters – cv. name not yet official

These interspecific hybrids originate from crosses between three *Brachiaria* species (*B. ruziziensis* x *B. decumbens* x *B. brizantha*) and subsequent screening conducted by CIAT's Tropical Forages Program in Colombia (Argel *et al.*, 2007). Being apomictic hybrids, these cultivars are true-breeding and will not segregate from one generation to the next.

Commercialization of hybrid Brachiaria

In 2000, the Mexican seed company Grupo Papalotla/Tropical Seeds entered into agreement with CIAT for 10 years, for obtaining rights to commercialize CIAT hybrid *Brachiaria* cultivars by receiving first-generation hybrids bred during that period for further evaluation and determination of their commercial potential. Papalotla is paying royalties for protected and commercialized cultivars during protection period (E. Stern pers. comm.). After expiry of protection 15 years from the first sale, according to the International Union for the Protection of New Varieties of Plants (UPOV), cultivars will pass into the public domain and no other right may prevent free use. Global variety protection for the released cultivars has been obtained in Mexico (Table 1). While Grupo Papalotla/Tropical Seeds has been marketing the seeds directly in the Americas, so far the Australian company Heritage Seeds has been responsible for countries in Oceania, Asia, and Africa. Commercial seed production of the hybrids at low latitude in the tropics has been a major challenge. Therefore, Papalotla transferred seed production of cv. Mulato-II to sites of higher latitude (≥15 °N) in Mexico and Thailand, from where most exports have been realized (Hare *et al*., 2013). This paper reviews research, development and incipient uptake of new hybrid *Brachiaria* cultivars in Africa to document the existing knowledge on their current uses.

Hybrid Brachiaria in Africa

The first cultivars released from CIAT's breeding program, cv. Mulato and cv. Mulato-II, have likewise been researched and distributed in Africa. Seed sales (2001-2013) by Grupo Papalotla/Tropical Seeds to African countries (M. Peters pers. comm.) suggest that an area of at least 1,000 ha has been sown to hybrid *Brachiaria* hitherto. The new hybrid *Brachiaria* cultivars have been distributed since 2001 to Eritrea, Ethiopia, Nigeria, DR Congo, Uganda, Rwanda, Burundi, Kenya, Tanzania, Malawi, South Africa and Madagascar according to combined information from seed sales and published research. While the largest share of known commercial seed sales of hybrid *Brachiaria* cultivars went to Kenya, this only reflects the fact that a big project is being conducted from Kenya (ADOPT[2] – see details below), from where the seed is further distributed to participants in Ethiopia and Tanzania. Key findings from both on-station and on-farm research and development, emphasizing agro-ecological adaptation of the plants and their acceptability for farmers, are described below.

Small-scale agronomic and participatory evaluation

Rwanda. During participatory research with farmers on sites with low rainfall and acidic soils in 2007, among various *Brachiaria* commercial cultivars, released hybrids and advanced lines, cv. Mulato-II was preferred because of producing green forage year round without any fertilizer input, high above-ground biomass production, palatability, drought tolerance, quick regrowth, persistence, being a perennial and easy for cut-and-carry (Mutimura

and Everson, 2012). Therefore, cv. Mulato-II is considered an excellent alternative to traditional Napier grass (*Pennisetum purpureum*) predominantly used in zero-grazed dairy systems of the region. Napier grass, though, has been widely suffering from Napier stunt disease (caused by *Phytoplasma*) and smut that both decrease severely herbage production and, thus, put dairy-dependent livelihoods at risk (Khan *et al.*, 2014a). More than 150 individual farmers and over four farmer cooperatives are now using cv. Mulato-II as erosion control on contour bunds, livestock forage and hay-making for income generation. Currently, >50 ha are planted with cvs. Mulato-II, Marandu and Basilisk to multiply planting material to satisfy the high demand in the country (Pizarro *et al.*, 2013).

Kenya. While the Kenya Agricultural Research Institute (KARI) set up small-plot agronomic experiments in several KARI research stations across the country in 2011 to compare the performance of cv. Mulato-II with that of available local grasses and to assess its agro-ecological adaptation (D. Njarui pers. comm.), currently various *Brachiaria* cultivars are tested, including hybrids, within the new project 'Climate-smart *Brachiaria* grasses for improved livestock production in East Africa' (see below). At KARI-Kiboko Research Station, cv. Mulato-II was found superior to native range grasses such as buffel (*Cenchrus ciliaris*) and horsetail grass (*Chloris roxburghiana*) in both primary dry matter production and subsequent regrowth (Machogu, 2013). It also had higher nutritive quality, especially in terms of high DM digestibility (65%) assessed in 12-week-old plants, whereas crude protein content (13.3%) was similar to that of the other grasses. While this trial was conducted with irrigation until 16 weeks after sowing, cv. Mulato-II in another rain-fed trial at Kiboko was heavily infested by red spider mite and both biomass production and plant survival were affected by drought.
Eritrea. Wolfe *et al.* (2008) evaluated cv. Mulato at two agricultural research stations in Eritrea, Halhale in the Central Highlands and Shambuko in the Western Lowlands, from 2006 to 2007 and found it was among the most promising grasses in Halhale.

Eastern Democratic Republic of the Congo (DRC). Both cv. Mulato and Mulato-II were introduced for assessing agro-ecological adaptation in Sud-Kivu province. Small plots for agronomic evaluation were established at the INERA (Institut National pour l'Etude et la Recherche Agronomiques) Research Station in Mulungu and on farmers' fields in Kabare and Walungu 'groupements'. Cv. Mulato was also evaluated when planted on contour bunds for erosion control within CIALCA (Consortium for Improving Agriculture-based Livelihoods in Central Africa) (B.L. Maass unpubl.). Unfortunately, the plants became so severely diseased that evaluation was disrupted and plots abandoned. Not only symptoms of fungal diseases (e.g., rust – probably caused by *Uromyces setariae-italicae* Yosh – and anthracnose) were found, but also of mites (H. Maraite pers. comm.). J. Linné (pers. comm.) explained this undue susceptibility of hybrid *Brachiaria* as a re-encounter phenomenon induced by returning plants (hosts) selected under completely distinct biotic challenges back to the species' centers of origin and, consequently, center of diversity also of its diseases and pests.
Madagascar. The Centre for Rural Development and Applied Research (FIFAMANOR) and the French Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) conducted medium-sized plot agronomic experiments to compare the performance of cv. Mulato as compared to other *Brachiaria* species (*B. brizantha*, *B. decumbens* cv. Basilisk, *B. humidicola* and *B. ruzizensis*) (P. Salgado unpubl.). Herbage production of cv. Mulato, local B. *brizantha* and cv. Basilisk was around 20 t DM/ha/year and significantly higher than that of the other species, while nutritive value (net energy for lactation) was similar. Rahetlah *et al.* (2012) demonstrated its superior herbage production and nutritive value than grass alone when combined with forage groundnut (*Arachis pintoi*).

Systems integration
Dairy production systems in Uganda. Cv. Mulato was introduced as an alternative to Napier grass, the predominant forage for dairy cattle in zero-grazing systems (Kabirizi *et al.*, 2013). After initial on-station and further participatory on-farm evaluation in Masaka district, incipient uptake of cv. Mulato took place (Mugerwa *et al.*, 2012). Demand for cv. Mulato has been increasing since (Kabirizi *et al.*, 2013). Mainly in smallholder dairy systems, cv. Mulato is being used for cut-and-carry together with legumes like *Clitoria ternatea* or *Centrosema molle* (Kabirizi *et al.*, 2013). Cv. Mulato along with other grasses like *B. brizantha* cv. Toledo is now being promoted by NGOs such as 'Send a Cow' (Kato, 2011). It is recommended to feed drought-tolerant cv. Mulato with a forage legume during the dry season, when Napier grass mono-crops are disadvantaged due to drought, Napier stunt disease and/or poor agronomic practices (Kabirizi *et al.*, 2013). As no seed is available commercially, farmers, even with only small plots, sell vegetative planting material (splits) (B.L. Maass unpubl.). This, hence, creates small-scale agro-business opportunities, especially for women. In the more sub-humid area around Jinja, cv. Mulato also appears to be an ideal solution for grazing of calves due to its relatively high nutritive quality (R. Jones pers. comm.).

The push-pull-system in Kenya, Tanzania and Ethiopia

The largest uptake of hybrid Brachiaria cv. Mulato-II is currently taking place in eastern Africa, where the grass is used as a trap plant in the push-pull system that helps control maize stem borers and the parasitic weed, Striga hermonthica (Khan *et al.*, 2014b). The push-pull-system has been developed and promoted by the International Centre of Insect Physiology and Ecology (icipe) (Khan *et al*,. 2014b). This smart technology successfully harnesses agro-biodiversity for improving productivity of cereal crops while providing fodder for livestock. Initially, its components included Napier grass and Silverleaf desmodium (*Desmodium uncinatum*). Yet, on the systems' limit to semi-arid lands (500-700 mm rainfall p.a.), cv. Mulato-II has been identified as a new trap crop together with Greenleaf desmodium (*D. intortum*) as the intercrop; both are currently being disseminated. These two components are more drought-tolerant than the traditional ones. In addition, cv. Mulato-II seems to be resistant to Napier stunt disease (Z.R. Khan unpubl.) that devastates Napier grass in the region. Over 20,000 smallholder farmers benefiting from the ADOPT project in Kenya, Uganda, Tanzania, Nigeria and Ethiopia have already planted cv. Mulato-II (C. Midega unpubl.). Farmers in Kenya indicated that their dairy goat milk production has doubled due to the availability of the improved grass and Greenleaf desmodium (B.L. Maass unpubl.). They prefer cv. Mulato-II over Napier grass for several reasons: it is drought-tolerant, highly palatable and nutritious for livestock, easier to handle as cut-and-carry and for making hay to be used during the dry season. As the push-pull-system has been developed to control maize stem borer, thus far little attention has been paid to the possible importance of livestock production improvements for the uptake and further spread of the technology.

Conservation agriculture and dairy systems in Madagascar: In Madagascar, cv. Mulato has been tested since 2008 for soil structure improvement, high biomass production and carbon accumulation in the soil by its root system as a first step for direct seeding on compacted soils. However, the conservation agriculture system did not spread as initially expected as it requires herbicides for grass control, which are not easily accessible in Madagascar (O. Husson pers. comm.). On the other hand, in dairy production systems in the highlands, specifically in the Vakinankaratra region, almost 20 ha were planted with cv. Mulato in 2011 (V.B. Rahetlah unpubl.). Owing to its better palatability and higher biomass yield as compared to other Brachiaria spp., cv. Mulato has been rapidly adopted by small-scale dairy farmers. It is mainly grown for green forage production under cut-and-carry systems during the warm and rainy season extending from November to April.

Research and development of new hybrid Brachiaria for Africa: Despite all the enthusiasm and demand in the region, cv. Mulato-II seed is not yet available on the African market, except for experimental purposes. Therefore, Grupo Papalotla/ Tropical Seeds has requested varietal release from Kenyan authorities, possibly being granted later in 2014. A new research project led by the Biosciences eastern and central Africa (BecA)-ILRI Hub that, among other outputs, focuses on integrating improved *Brachiaria* grasses into smallholder mixed crop-livestock systems, while considering climate-relevant effects on the environment (Djikeng *et al*., 2014), will most likely push further the adoption of hybrid *Brachiaria* in the region.

Outlook

Apparently, hybrid *Brachiaria* has a role to play in improving African agriculture. Yet, new pest and disease challenges have emerged that require further research attention. On the other hand, an array of diverse hybrids is still in the pipeline for release (Pizarro *et al.*, 2013; E. Stern pers. comm.); some of these new materials may better address the specific biotic and abiotic challenges identified as well as the requirements for particular production systems in African locations. In order to maximize benefits for smallholder farmers and deploy the new hybrid *Brachiaria* cultivars effectively, the following research needs and opportunities have been identified:

Researchable knowledge gaps (e.g., effects on livestock production in mixed crop-livestock systems; agronomy of system-integration; assessing the socio-ecological niche – considering gender and economics, and adoptability by smallholder farmers);

Upcoming research needs (e.g., dealing with biotic challenges like red spider mite, sorghum shoot fly, fungal diseases; seed production on the continent); and

Research and development opportunities (e.g., testing advanced hybrids under biotic and abiotic stress as well as in representative African production systems; fitting the right cultivars into different production systems and further develop their agronomy).

Brachiaria, so far neglected grasses in their continent of origin, have not only returned home in the form of improved hybrids, but they have been very welcome by African farmers.

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Comparison of production performance and tolerance to helminthosis of Toggenburg and Norwegian crossbred goats under smallholder production system in Tanzania

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Abstract

This study was carried out to compare the growth rate, lactation performance and tolerance to gastrointestinal nematode infection of Toggernburg and Nowergian breeds in Kongwa district, Tanzania, with a semi-arid environment and Mvomero district with a sub- humid environment. Milk production of does, nematode eggs per gram of faeces (EPG) and packed cell volume (PCV) were recorded for one year in 57 Toggenburg crosses and 72 Norwegian crosses raised by 107 small-scale farmers in the two districts. Kid body weights and mortality were recorded in 65 kids who were born. Kid birth weight of Norwegian crosses (3.07 ± 0.13 kg) and Toggenburg crosses (2.91 ± 0.14) were not significantly different ($P > 0.05$). The growth rate of Norwegian crossbred kids from birth to one year (54.26 ± 4.33 g/day) was lower than that of Toggenburg crossbreds (61.50 ± 4.38 g/day). Toggenburg crossbred does produced slightly higher average daily milk yield (0.81 ± 0.08 l/day) compared to Norwegian crossbred does (0.64 ± 0.09 l/day). Norwegian crosses had higher mean EPG (211.78 ± 0.02) and lower PCV (23.93 ± 0.96%) than the Toggenburg crosses (129.51 ± 0.02 EPG and 26.71 ± 0.99% PCV). It is concluded that the Toggenburg crosses are relatively better suited to the smallholder production environments in rural areas compared to the Norwegian crosses.

Keywords: Dairy goats, Growth rate, Milk production, Nematode infection

Introduction

Dairy goat production has been adopted as an intervention strategy for poverty reduction and improving the livelihoods of rural poor households in developing countries (Devendra, 2013). In recognition of the importance of dairy goats to poor farming households, the government of Tanzania introduced dairy goat breeds, namely, Saanen, Alpine, Anglo-Nubian and Toggenburg in the country in the early 1960s (Das and Sendalo, 1991). These breeds of dairy goats were imported mainly from Europe and kept in research stations and missionary centres. Smallholder dairy goat production in rural areas started to be promoted in 1980s as one way of mitigating the problem of malnutrition and improving the living conditions of poor families. It was envisaged that helping the rural poor people, especially women, to successfully raise dairy goats can have a very significant impact on their income, social status and even on the local environment (De Varies, 2008). However, the distribution of these breeds has been carried haphazardly without taking into consideration the environmental conditions in rural areas. No efforts have been done to match the genotype with the right environment. This study was carried out to assess the growth performance, lactation performance and tolerance to gastrointestinal nematode infection of Toggernburg and Nowergian breeds in Kongwa district with a semi-arid environment and Mvomero district with a sub- humid environment.

Materials and Methods

Location of the study

The study was conducted in Masinyeti and Ihanda villages of Kongwa district, Dodoma region and Kunke and Wami-Luhindo villages of Mvomero district, Morogoro region. Kongwa district is located between latitude 5°30' and 6°0' south and longitude 36° 15' and 36° east. The district is found in semi-arid areas and has annual rainfall ranging from 400 to 800 mm and temperatures that vary from 18 to 34°C. Mvomero district is located in sub-humid zone and lies between latitudes 8° and 10° south and longitudes 28° and 37° east. The district receives an annual rainfall of 600 - 2000 mm and has temperatures that range from 18 to 30°C.

Experimental procedure

A total of 29, 28, 21 and 29 small-scale farmers from Kunke, Wami-Luhindo, Ihanda and Masinyeti villages (107 in total) were trained on improved goat husbandry practices, including feeding system, housing, feeds and feed compounding, breeding, health management and record keeping. After the training, each farmer constructed a raised slated goat house using locally available materials. A total of 72 Norwegian crosses (65 females, 7 males) and 57 Toggenburg crosses (52 females, 5 males) were distributed to the 107 farmers between March and April 2012. In each village, half of the farmers received Norwegian crosses and the other half received Toggenburg crosses. The crossbred goats were crosses of Toggenburg with the Small East African (SEA) goats (75% Toggenburg blood and 25% SEA blood) and Norwegian goats with the SEA goats (75% Norwegian blood and 25% SEA blood). For each breed, one buck was shared by about 10 farmers, each one keeping one female goat. Before distribution to the project farmers, all animals were ear-tagged for identification and screened to know their health status with regard to gastrointestinal nematode infection. Before the beginning of data collection, all goats were treated with an anthelmintic drug (Ivomec®) to control endoparasites and sprayed with acaricides to control ectoparasites. All goats were kept indoors under zero grazing and managed according to individual farmer's conditions. Each farmer observed heat signs for the female goat, if the animal was found to be in heat it was taken to the buck of the respective breed for mating.

Data collection on kidding, milk production and kid growth

A weighing scale for measuring live body weight, a calibrated cup for measuring milk production and a record card for data recording were distributed to each farmer. Upon kidding, the birth weight of the kid(s) was measured using the weighing scale and daily milk production for each doe was measured and recorded after each milking by the farmer. Data on kidding, kid weights at births, monthly weights, kid deaths and daily milk production were routinely collected by each farmer. The research team made monthly visits to the research sites to collect data recorded by farmers on goat kidding, body weight measurement and milk production. Body weights of the offspring were measured at birth and then every month up to 12 months. Growth rate and yearly body weight were determined and used for evaluation of growth performance.

Collection of data on gastrointestinal nematode infection

Gastrointestinal nematode infection was monitored in all animals from June 2012 to April 2013. During this period field visits were made by the research team every month and faecal samples were collected from the rectum of each animal. Each faecal sample was placed in a separate polythene bag, labelled and then all samples were packed and stored in a cool box and transported within 24 hours to the laboratory at Sokoine University of Agriculture (SUA) where they were stored at 4°C until analysis. The presence of gastrointestinal nematode eggs in faeces was determined using the McMaster counting technique (Hansen and Perry, 1994). The number of eggs counted in the McMaster slide was multiplied by 100 and expressed as nematode eggs per gram of faeces (EPG). Animals with medium (500 - 1,000 EPG) to high rate (> 1,000 EPG) of infection were treated. In addition to faecal sampling, blood sample from each animal was collected from jugular vein using 10 ml vacutainer tubes containing EDTA. Packed cell volume (PCV) and haemoglobin concentration (HB) were determined as complementary tests for nematode infection.

Results and Discussion

Results for milk production and lactation period are shown in Table 1. Average daily milk yield, total milk production and lactation period did not differ ($P > 0.05$) between the breeds, but differed among the villages. On average the Toggenburg crosses produced 22.26 litre more than the Norwegian crossbred goats, indicating that the Toggenburg goats are superior to Norwegian goats in terms of milk production. The average daily milk yield observed in the project villages for Toggenburg does is lower than the mean milk yield of 1.7 and 2.2 litre/day reported for Toggenburg goats in Babati, Tanzania (Jackson *et al*., 2014) and Meru, Kenya (Ahuya *et al*., 2003), respectively. Similarly, the average daily milk yield of Norwegian does is lower than the mean yield of 1.0 and 0.9 litre/day reported for pure and 75% Norwegian goats, respectively, in Mgeta, Tanzania (Safari *et al*., 2008). The difference between the current study and previous studies could be due to differences in the age of the animals, management and environmental conditions. Normally milk production is lower during the first lactation and it increases gradually from the first to the fourth lactations. The goats in the research villages were either in the first or second lactation. It is anticipated that in subsequent lactations, milk production will increase to the levels comparable to those observed elsewhere. Moreover, Meru, Babati and Mgeta are highland areas with cool temperature and adequate rainfall; hence, their climatic conditions could be more favourable for raising dairy goats compared to the semi-arid condition in the research villages. Lactation length was not significantly ($P > 0.05$) different between Toggenburg and Norwegian crosses. The mean lactation length of 3.5 months observed in the present study is lower than the lactation length of 7.5 months reported by Ahuya *et al*. (2003) in Toggernburg breed

and 10 and 8 months observed by Safari *et al*. (2008), respectively, in Norwegian goats. The difference in lactation length might be due to differences in management, nutrition, dairy breed blood level and environmental conditions.

Table 1. Effects of breed and location on milk production of dairy goats

Factor	Lactation period (days)	Mean daily milk yield (litre/day)	Milk production per lactation period (litre)
Breed			
Norwegian (n = 21)	103.87 ± 11.45[a]	0.64 ± 0.09[a]	82.32 ± 11.78[a]
Toggenburg (n = 25)	104.12 ± 9.55[a]	0.81± 0.08[a]	104.58 ± 9.83[a]
P > F	0.9865	0.1504	0.1565
Village			
Ihanda (n = 12)	73.08±10.76[b]	0.50±0.09[b]	36.1 ±11.1[b]
Masinyeti (n =23)	93.23±6.40[b]	0.66±0.05[b]	62.9±6.59[b]
Kunke (n =7)	63.17±16.44[b]	0.47±0.13[b]	35.0±16.9[b]
Wami-Luhindo (n =4)	186.50±21.52[a]	1.29±0.16[a]	239.8±22.1[a]
P > F	0.0003	0.0014	0.0001

[a,b] The means with different letters in the same column within the same factor differ significantly (P ≤ 0.05).

Table 2 shows the growth performance of Toggenburg and Norwegian crossbred kids in the research villages. The results show that among the kids born, 74.7% were born as single and 25.3% were twins. The mean birth weight of single kids was not significantly different (P > 0.05) from that of twins. Similarly, the overall growth rate of singles was not significantly (P > 0.05) higher than that of twins. The mean birth weight of Norwegian kids was slightly higher compared to that of Toggernburg, but not significantly different (P > 0.05). However, the growth rate of Norwegian kids from birth to one year of age was significantly lower (P ≤ 0.05) than that of Toggenburg kids. The average birth weight of male and female kids did not differ significantly (P > 0.05), but in terms of growth performance for the first 90 days, male kids had higher (P ≤ 0.01) growth rate than female kids. The average birth weight and growth rate of Toggenburg kids are lower compared to the birth weight of 3.2 – 3.6 kg and growth rate of 104 – 127 g/day reported in Meru, Kenya (Ahuya *et al*., 2003). For the Norwegian goats, the mean birth weight observed in the present study is slightly higher that that reported in Mgeta (2.5 – 2.8 kg) (Safari *et al*., 2008), but the kid growth rate is lower than the growth rate of 65 – 118 g/day which has been reported for Norwegian goats in Mgeta. The differences could be attributed to the differences in climatic conditions and age of the dam.

Table 2. Effects of breed, location, sex and type of birth on growth performance of dairy goats

Factor	Birth weight (kg)	Growth rate to 90 days (g/d)	Growth rate to 180 days (g/d)	Overall growth rate (g/d)
Breed				
Norwegian(n = 33)	3.07 ± 0.13	114.40[a]±6.81	24.22[b]±11.55	54.26±4.33
Toggenburg(n = 32)	2.91 ± 0.14	89.88[b]±7.02	71.97[a]±11.71	61.50±4.38
P > F	*0.3753*	*0.0087*	*0.0025*	*0.3088*
Village				
Ihanda (n = 18)	3.00 ± 0.13	97.56±6.94	42.15±12.61	59.04[a]±4.16
Kunke (n = 10)	3.22 ± 0.20	113.70±10.18	7.11±17.94	43.85[b]±7.24
Masinyeti (n = 31)	2.90 ± 0.10	104.38±5.44	74.89±9.58	70.76[a]±4.63
Wami (n = 6)	2.84 ± 0.26	92.94±13.60	68.24±26.44	-
P > F	*0.4777*	*0.4885*	*0.0122*	*0.0426*
Sex				
Female (n = 25)	2.95 ± 0.14	91.16[b]±7.39	48.03±12.08	56.05±12.39
Male (n = 40)	3.03 ± 0.11	113.13[a]±5.89	48.16±10.39	55.01±10.58
P > F	*0.6107*	*0.0103*	*0.9923*	*0.6610*
Birth type				
Single (n = 46)	3.04 ± 0.10	109.97±5.15	58.79±9.34	60.84±3.15
Twins (n = 19)	2.93 ± 0.15	94.32±8.02	37.41±13.15	54.92±4.34
P > F	*0.5002*	*0.0699*	*0.1349*	*0.2851*

[a,b] The means with different letters in the same column within the same factor differ significantly (P ≤ 0.05).

The effect of breed and location on gastrointestinal nematode infection is shown in Table 3. Breed had no significant effects (P > 0.05) on EPG and HB, but significantly influenced (P ≤ 0.05) PCV. The Norwegian crosses had slightly higher values for EPG (211.78 ± 0.02) than the Toggenburg crosses (129.51 ± 0.02) while the Toggenburg crosses had higher HB (7.09 ± 0.35 g/dl) and PCV (26.71 ± 0.99%) values than the Norwegian crosses. The higher EPG

values observed in the Norwegian crossbred goats compared to Toggenburg crosses may suggest that the Norwegian goats are more susceptible to gastrointestinal nematodes than the Toggenburg goats. Breed differences with respect to nematode infection in dairy goats have been reported by other studies (Costa *et al*., 2000). The Toggenburg goats have been in the country for longer time (since early 1960s) compared to the Norwegian goats, which were introduced in the late 1980s. Hence, the Toggenburg goats may have adapted better to the local conditions and developed traits for tolerance to endemic diseases compared to the Norwegian goats.

Kid mortality rate is shown in Table 3. The results show that kid mortalities of Toggenburg and Norwegian goats were not significantly different (P > 0.05). However, the average kid mortality rate in Toggenburg kids was higher by 2.9% compared to that observed in Norwegian kids. Kid mortality rate observed in this study is higher than the recommended kid mortality of 10%. However, the kid mortality rates observed in the research villages are lower than the mortality rate of 17 – 33% reported for Norwegian goats at Sokoine University of Agriculture farm (Mruttu, 2001).

Table 3. Effects of location and breed on EPG, HB, PCV and kid mortality of dairy goats

Factor Factor	Parameter			
	EPG	HB (g/dl)	PCV (%)	Kid mortality (%)
Village				
Ihanda	184.14 ± 0.03	7.27 ± 0.38	25.52 ± 1.06	22.2
Kunke	96.55 ± 0.02	6.59 ± 0.36	24.39 ± 1.01	22.9
Masinyeti	155.43 ± 0.03	7.12 ± 0.41	24.79 ± 1.16	13.8
Wami-Luhindo	246.46 ± 0.06	7.02 ± 0.62	26.58 ± 1.75	18.18
P > F	*0.6776*	*0.3630*	*0.5706*	*0.2931*
Breed				
Norwegian	211.78 ± 0.02	6.91 ± 0.34	23.93^{b} ± 0.96	16.5
Toggenburg	129.51 ± 0.02	7.09 ± 0.35	26.71^{a} ± 0.99	19.4
P > F	*0.2638*	*0.5856*	*0.0023*	*0.3326*

Conclusions

The study has revealed that the Toggenburg goats produce slightly higher amount of milk and are relatively tolerant to nematode infection than the Norwegian goats. In addition, the study has found that milk production and growth performance of Norwegian and Toggenburg goats in research villages areas are relatively low. Therefore, there is a need to improve management practices in order to improve productivity of the dairy goats in the research villages.

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Nutritional attributes and gas production of silages from two forages inoculated with locally-derived substrates for smallholder setting

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Abstract

Smallholder dairy farmers are challenged with feeding their cows. Silage is a world-wide recognized method of preserving fodder. Also feed additives may be necessary to attain good quality silage. Conventional additives such as molasses may be out of reach of smallholder dairy farmers. This calls for investigating locally available substrates with a potential to act as feed additives, for example, whether other crops common in smallholder setting such as millet and sorghum can be used. This paper investigated the nutritional attributes and quality of maize (Ma) and millet (Mi) silages treated with 5% molasses (Mo), chibuku (Chi), and sun dried melon (Mel) (*citrullus vulgaris)* or no additive (control; Co) resulting in the following treatments; MaMol, MaChi, MaMel, MaCo, MiMol, MiChi, MiMel and MiCo. Silages were tested for dry matter (DM), ash, crude protein (CP), fibre components (NDF and ADF), dry matter digestibility (DMD), gas production (after 48hrs) and pH. There was treatment, forage and feed additive effect (ranging from $P<0.05$ to $P<0.001$) on DM, CP, and pH whereby silage from millet had high DM (383.1 vs 233.2 g/kg), silages from maize had high CP (108 vs 89.5 g/kg) and addition of chibuku resulted high levels of CP (113.7 vs 95.7 vs 94.3 vs 91.2 for chibuku, molasses, control and melon respectively). Maize resulted in the lowest pH than millet (4.0 vs 4.4) while addition of chibuku and melon lowered pH to 4.1 and 4.0 respectively while lack of additive and addition of molasses resulted in pH of 4.3 and 4.5 respectively. However, only treatment ($P<0.001$) and feed additive influenced ash ($P<0.05$) and DMD ($P=0.067$), whereby MaMol had the higher levels of ash (133 g/kg) while MiCo had the least ash content (11 g/kg) and molasses resulted in the highest ash (88.2 g/kg) and the least was in silages without inoculum (19.5 g/kg). Dry matter of MaMol was highly digestible (835 g/kg) and that of millet without feed additive was the least digestible (751 g/kg) but the addition of chibuku tended to improve DMD (814 g/kg) than silages without feed additives (777 g/kg). Addition of feed additives (NDF and ADF) and forage type (ADF) did not have an effect ($P>0.05$) while treatment (NDF and ADF; $P<0.01$) and forage (NDF; $P<0.05$) had an effect. It was observed that levels of NDF in millet was higher than that of maize forage silages (289 vs 255 g/kg) while MiCo (305 g/kg) and MiMol (298.5 g/kg) had the highest NDF levels and MaMol (226.5 g/kg) and MiMel (241.6 g/kg) had the least NDF levels. The highest and least levels of ADF were observed in MiMol (205 g/kg) and MiMel (131.5 g/kg) respectively. Gas production after 48 hrs was similar between treatments, between forage type but tended ($P = 0.056$) to vary with addition of feed additives, even though MiChi (22.5 ml/200mg) and MiCo (25.0 ml/200mg) produced less gas than MaMel and MiMel (42.5 ml/200mg). Addition of melon elicited more gas than molasses (42.5 vs 25.8 ml/200mg). Addition of additives or forage did not influence ME ($P>0.05$) but treatment ($P<0.001$) did, whereby MiMol had more ME than MiCo (13.1 vs 11.8 MJ /kg respectively). The current results indicate that millet can also be used to produce high quality silage while the addition of either melon or chibuku improves nutritive value of silage and increases gas production. This is a significant production advantage because millet, melon and chibuku can be easily accessible under smallholder setting.

Keywords: Crude protein, Digestibility, Gas production, Maize, Millet, Silage

Introduction

Small scale dairy production is constrained by lack of high quality feeds, resulting from lack of water for irrigation or low and erratic rainfall. Silage is normally used to preserve forage crops for dairy cattle and as a source of energy. However, crops such as maize which is traditionally used for making silage in temperate climate may not be ideal in arid conditions. The question is whether other crops common in small holder setting can be used for silage making. Sorghum is more tolerant to drought compared to maize (Ambula *et al.,* 2001). The high physiological adaptation of sorghum to acquire and retain moisture has made it more genetically suited to arid conditions (FAO and ICRISAT 1996). Pearl millet silage produced equal amount of milk with higher milk fat levels than corn silage in a dairy feeding trial at McGill University in Quebec (Levital *et al.,* 2009). Therefore crops adapted to arid environments such as sorghum and millet should be considered for silage making by smallholder farmers. However, crops that are rich in soluble carbohydrates and cultivated grasses are the most suitable for ensiling (Iranha, 2011). During the process of adapting to hot areas, sorghums and millets develop high fibre levels and this reduces highly fermentable carbohydrates. Under such conditions of low soluble carbohydrates, such feed additives as molasses are normally used. However, in countries where sugar is not farmed and molasses is not available, it will be out of reach of smallholder farmers. This necessitates investigation on locally available substrates with a potential to act as feed additives. Small amount of grains can be used in the form of malts or brewers spent grains which are available during traditional beer making. Another common crop that is not effectively used at farm level is melon. In Botswana the edible melon type is processed into small strips and sun-dried to increase shelf life. This product is hypothesized by the present authors to have high fermentable sugars and will be suitable as a feed additive in silage making. The objectives of the present study was to investigate the nutritive attributes and gas production of silage made from sorghum and millet and treated with chibuku and melon as compared to maize as forage and molasses as an additive.

Materials and methods

The study was conducted at Botswana College of Agriculture (BCA) near Gaborone Botswana. BCA is located in Sebele Content farm. The experiment crops were grown in the field under rain fed conditions. Two types of crops (maize and millet) were collected from different fields Notwane and Modipane farms. For silage three additives were used; molasses, sundried melon, chibuku all in powder form and a control (without additive) for each crop, and two replicate for each crop. Both maize and millet samples were obtained at milking stages, hand harvested and passed through a commercial silage chopper at Notwane farm. The bulky chopped material was taken and placed and compacted into one litre plastic bags. Sun-cured melon was dried in an oven and ground. The ground melon, chibuku and molasses were added to the 600g chopped materials at rate of 30g. The silage plastic were closed airtight and placed in the big bag and store in a warm cool environment. The resultant silages were assessed for chemical composition and quality after 21 days.

Chemical composition determination at ensiling

Dry matter and chemical composition determination of samples was done in duplicates. A 100g sample was placed in an oven at 70ºC for 48 hours and thereafter the samples were weighed and grinded. Crude protein (CP) was calculated from the nitrogen content of the samples determined by modified Kjeldahl methods (AOAC, 1996). Acid detergent fiber (ADF) and neutral detergent fibre (NDF) were analysed using ANKOM^{220} fiber analyser (AOAC, 1996) using reagents suggested by van Soest *et al.* (1991). For ash weighed samples were burned in a muffle furnace at 550ºC for four hours. Digestibility was determined by incubating silage samples in 100ml syringes (150ml) according to Menke and Steingass (1988) modified by weighing the samples in a multi-layered polyethylene cloth bags, (F57 filter bags: ANKOM, Technology Crop). The rumen fluid was from steers fed with maize silage. At the end of the incubation (48 hrs), gas produced was recorded and the bags were removed from the syringes, rinsed four times with distilled water, dried, weighed and placed in an ANKOM fiber analyzer and boiled in neutral detergent solution for 60 min. In vitro dry matter digestibility (IVDMD) was calculated as the difference between DM incubated and the residue after NDF analyses. Organic matter digestibility was used for calculating metabolisable energy according to McDonald *et al.* (2011); ME (MJ/kg DM) =DOMD (g/kg DM) × 0.016. pH was assess by putting samples in a blender and reading the pH using a digital pH meter.

Statistical analysis

Data was on chemical composition was analysed using General Linear Model (GLM) procedures of SAS Statistical package (SAS, 2002-2008) as a factorial to test for the effect of treatments (Forage/Additive), effect of forage and

effect of additive. Where there was differences, mean separation was done using Duncan multiple range test. Mean were considered at significant at $p \leq 0.05$ and are reported as least square means ± standard deviation.

Results and discussion

The concentrations of DM, NDF, ADF, CP and Ash were significantly different in maize and millet silage treated with melon, chibuku and molasses (Table 1). Ash from millet without any additive was significantly lower (P<0.05) than all other types of silages. The CP for maize treated with chibuku was higher (P<0.001; 126g/kg) than other silages. MaMel, MiChi, MaCo, and MaMol had similar (P>0.05; 98, 108, 101.5 and 99.5g/kg respectively) CP which was higher (P<0.001) than those of MiMel, MiMol and MiCo (84, 83.4 and 89.2g/kg respectively). Both additive and forage had a highly significant (P<0.001) effect on CP. It would seem that addition of chibuku improved (P<0.001) CP concentrations of silages while maize silages had higher (P<0.001) CP concentration. Chibuku is a malted starter culture of maize/sorghum for traditional beer making and a recent study by Legodimo and Madibela (2013) showed that malting improves crude protein of sorghum grains. Beer making to get Chibuku is a result of alcoholic fermentation by a fermenting yeast *Saccharomyces cerevisiae* (Togo *et al.,* 2002). Yeast (*Saccharomyces cerevisiae*) is widely used in diets for dairy cows (Bruno *et al.,* 2009) to shift ruminal microbial population (Ghasemi *et al.,* 2012) and to promote health (Bruno *et al.,* 2009). Therefore the addition of chibuku, which is local product, into silages may result in these beneficial effects.

The NDF of silage from MiCo had the highest (P<0.01) amount of fiber (305g/kg) which was similar to that of MiChi (298.50g/kg), MiMol (295g/kg) and MiMel (273.5g/kg). On the other hand NDF of silage from MaChi (261g/kg) was not significantly different (P>0.05) from that of MaCo (260g/kg). MaMel had the lowest level of NDF (226.5g/kg). Silage from MiMol had the highest ADF level (205g/kg) while that from MaMel, MiChi and MaMol were similar (P>0.05). Silage from MiMel had the lowest (131.50g/kg) and significantly different (P<0.01) ADF levels than all other silage types. De Boever *et al.* (1996) also found NDF levels (45g/kg) which were higher than those in present study.

For these fiber components (ADF and NDF) additives did not (P>0.05) affect, but forage did (P<0.05) affect NDF but not ADF concentration (P>0.05). The low level NDF of less than 300g/kg accompanied by low dietary DM in diets, as is the case with maize in this study (Table 1) of cows fed maize silage may create problems of rumen and hoof health (Kolver *et al*., 2000 as cited by Kolver *et al.* (2001). Millet silages had the highest (P<0.05) NDF but also low CP as discussed above. This high NDF and low CP may affect digestibility of silages made from millet and eventually lead to low milk solids as suggested by Kolver *et al.* (2001). Forage crops are best preserved within an oxygen-free (anaerobic) environment with a low pH (3.8-4.5). According to McDonald *et al.* (2002) silage with a pH range of 3.8 to 4.2 is considered well preserved, an observation made in the present study. Kolver *et al.* (2001) reviewed literature on the quality of maize silages and identified that pH ranging from 3.8 to 4.5 would contain high concentrations of lactic acid. In the present study MiMol and MiChi silages had the highest (P<0.001) pH values (4.8 and 4.5 respectively) while the least pH values was recorded from MaMol and MaChi (3.9 and 3.7 respectively). A highly significant effect was due to forage (P<0.001) than additive (P<0.05) with maize silages having lower pH and addition of chibuku or melon resulting in lower pH values. This indicate that local additives such chibuku or melon could be a potential additives in silage making. Togo *et al.* (2002) noted that there is spontaneous lactic acid fermentation during traditional beer making using chibuku due mostly to mesophilic lactic acid bacteria (LAB) inherent in the malt and the authors identified Lactobacillus lactococcus leuconostoc bacteria in chibuku beer. Normally, in silage making, to ensure that there is enough LAB for the efficient fermentation of forages during ensiling, bacterial inoculants comprising mainly LAB are used (Nkosi *et al.,* 2011). Therefore, further investigation on the potential use of chibuku as silage additive is worth undertaking.

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Table 2. Least square means ±standard deviation of chemical composition, in vitro dry matter digestibility (g/kg DM), 48hrs gas production (ml/200mg), ME (MJ/kg DM) and pH of maize and millet silage treated with sun dried melon, chibuku and molasses after 21 days.

Treatments	DM	ASH	CP	NDF	ADF	pH	Gas	DMD	ME
Maize/melon	236^{cb}	29^{c}	98^{b}	273.5^{ab}	182.5^{abc}	4.2^{c}	42.5^{a}	81.6^{bc}	12.7^{bcd}
Millet/melon	453.5^{a}	38^{cb}	84^{c}	241.5^{cd}	131.5^{d}	4.1^{c}	42.5^{a}	80.4^{cd}	12.7^{bc}
Maize/molasses	261^{b}	133^{a}	108^{b}	226.5^{d}	161.5^{bc}	3.9^{bc}	35^{c}	83.5^{a}	12.4^{ab}
Millet/ molasses	427^{a}	43.5^{b}	83.5^{c}	295^{a}	205^{a}	4.8^{a}	40^{abc}	78.9^{d}	13.1^{cde}
Millet/chibuku	439^{a}	36.5^{cb}	101.5^{b}	298.5^{a}	171^{bc}	4.5^{a}	22.5^{ab}	82.6^{ab}	12.9^{a}
Maize/chibuku	235.5^{cb}	25.5^{c}	126^{a}	261^{bc}	160^{c}	3.7^{b}	32.5^{abc}	80.2^{cd}	12.6^{e}
Millet/control	213^{c}	11^{d}	89.2^{c}	305^{bc}	185^{ab}	4.4^{b}	25^{bc}	75.1^{e}	11.8^{f}
Maize/control	200.5^{c}	28^{c}	99.5^{b}	260^{a}	162^{bc}	4.2^{bc}	37.5^{abc}	80.4^{cd}	12.5^{de}
Std Dev	107.54	36.58	13.85	28.79	22.21	0.33	8.84	2.56	0.37
Additive effect	**	*	***	NS	NS	*	NS	*	NS
Forage effect	***	NS	***	*	NS	***	NS	NS	NS
Treatment effect	***	***	***	**	**	***	NS	***	***

Means with the same letter along the same column are not significantly different.
DM = dry matter; CP = crude protein; NDF= neutral detergent fiber; ADF = acid detergent fiber; DMD = dry matter digestibility; ME = metabolizable energy; NS=P>0.05; * = *=P<0.05; ** = P<0.01; ***=P<0.001

The present results show no effects of treatment, none of forage or additive in gas production by silages. However, MiChi and MiCo produced the least gas (22.5 and 25 ml respectively). Melon produces more and molasses produce less gas even though the model shows that there was no significant effect. Gas production methods have been used to determine the rate and extent of dry matter degradation (Karabulut *et al.*, 2007). The more fermentable carbohydrate available for the micro-organisms the more gas production occurs. Therefore the low gas production of millet silages may be indicating low rate and extent of digestion in the rumen, probably because of high NDF observed in the present study. Dry matter digestibility was highly different between silages ($P<0.001$) but forage had no effect ($P>0.05$) while an additive effect was observed ($P<0.05$). MiMol and MiChi had the highest DMD (82.6 and 83.5% respectively). It would appear that additives are actually improving dry matter digestibility. Metabolisable energy was found to be high for silage from MiMol but low from MiCo reflecting trends in OMD. Metabolisable energy in this study are typical ME for silages according to McDonald *et al.* (2002).

Conclusion

We conclude that sun dried melon and chibuku powder improved the fermentation characteristics of maize and millet silages. The results of this study suggests that sun dried melon and chibuku can be used as alternative silage additives as they gave results in line to those obtained with molasses as an additive to maize and millet silage.

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Trends and risks associated with erosion of Sahiwal cattle genetic resources

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Abstract
With continuous crossbreeding and selection, the Kenya Sahiwal cattle face the risk of losing their genetic diversity and purity. The objective of this study was to quantify the level of genetic diversity within the breed by evaluating and monitoring the trends of pedigree depth, amount of inbreeding, effective population size, and the additive genetic relationships through pedigree analysis. Pedigree data from National Sahiwal Stud and Kenya Stud Book were combined and analyzed using POPREP software package. The maximum number of discrete generation equivalents traced was 6.41 while the average was 2.46. The average annual level of inbreeding was 0.66% for all animals and 5.24% for inbred animals. Average annual inbreeding level for the entire breed increased at 0.025% per annum. The effective population size of the breed was lower than that proposed to avoid extinction in long term and showed a gradual decline over time. The average AGR in the whole population was 0.0087. The breed was found to be losing genetic diversity over time, showing that the Sahiwal genetic resources may be lost over a short evolutionary timescale.

Keywords: Conservation, Genetic diversity, Pedigree analysis

Introduction

Animal genetic resources (AnGR) contribute to the livelihoods of over a billion people and thus form an essential component for world food security (Anderson, 2003). They provide meat, milk, eggs, draft power, manure and other resources for economic development (FAO, 2011). Over the past years, available AnGR have declined considerably due to changes in production systems, loss of rangeland grazing resources, natural calamities, disease outbreaks, inappropriate breeding policies and practices, and the failure to assess the sustainability of farming practices (FAO, 2007).

Considering their importance, the continuing loss of AnGR would compromise efforts to achieve food security and rural development. An important aspect of AnGR is their genetic diversity (within-breed and between-breed). It has made it possible for humans to survive in a wide range of environments, from the hot and humid tropics to arid deserts and extremely cold mountainous regions (FAO, 1999). Maintaining the diversity of AnGR is therefore essential to enable farmers, pastoralists and animal breeders meet current and future production challenges resulting from changes in the environment (FAO, 2007).

The status of genetic diversity within a given population needs to be assessed because its understanding ensures sustainable use and development of AnGR (Barker, 2001; Fernandez *et al*., 2001). The current study aimed to assess the status and monitor trend of genetic diversity within the Sahiwal breed by quantifying the depth of known pedigree, amount of inbreeding, effective population size (*Ne*), and average relatedness (AR) based on pedigree data so as to provide baseline information to advance conservation strategies for the breed.

Materials and Methods

Data source

Pedigree data collected from the NSS were complemented by additional records from the Kenya Stud Book (KSB). The pedigree files consisted of unique identification of each animal, indicating the sire, dam, birth date and sex. Pedigree file was converted from Microsoft Office Excel to American Standard Code for Information Interchange and then uploaded to http://popreport.tzv.fal.de web portal.

Data analysis

After computations of genetic diversity parameters, a typeset report was generated containing definition, computation and meaning of the parameters (Groeneveld, *et al*., 2009). To assess the quality of the pedigree data used to estimate inbreeding and relatedness, a measure of pedigree completeness was calculated on a per year basis, as described by MacCluer *et al*. (1983). Inbreeding coefficients (*F*) for each animal in the pedigree were computed using the algorithm of Meuwissen and Luo (1992) in the POPREP software package. Average annual *F* was computed from 1960 to 2008 while the rate of inbreeding was estimated by the method described by Falconer and Mackay (1996). The number of inbred animals was quantified and expressed as percentage according to their level of inbreeding. The annual rate of inbreeding was then estimated by fitting a linear regression of annual average inbreeding level on years through the time period from 1960 to 2008. The effective population size (*Ne*) was calculated using two methods: (1) *Ne* based on the rate of inbreeding, (2) *Ne* based on the number of parents (Falconer and Mackay, 1996). Average relatedness (AR) within and between groups was computed using CFC computer program following the efficient indirect method of Colleau (2002). Average additive genetic relationship (AGR) was computed using the PEDIG Fortran Package (Boichard, 2002).

Results and discussion

Pedigree Completeness decreased with generations

Pedigree completeness is the extent to which an individual's ancestry is known to some defined generation in the past. It was computed to assess the quality of the pedigree data in estimating inbreeding level of the breed. The more complete the knowledge of an individual's ancestry, the higher the pedigree completeness and the more reliable is its estimate of inbreeding level (MacCluer *et al*., 1983). Pedigree completeness for animals born in the last ten years decreased with increase in generation depth from 1st to 6th generation, implying that animals in older generations were founders with no sire and dam records (Sargolzaei and Iwaisaki, 2004). The results are summarized in Table 1.

Table 1. Pedigree completeness index, maximum and average number of generation equivalents for the Kenya Sahiwal breed

Parameter	Value
Average pedigree completeness index (%) for:	
1st generation	75.7
2nd generation	73.8
3rd generation	69.9
4th generation	64.7
5th generation	58.3
6th generation	51.4
Longest ancestral path traced	16
Maximum generation equivalents	6.41
Average generation equivalents	2.46

Pedigree completeness of the Kenya Sahiwal was comparable to that reported for the Spanish beef cattle breeds which ranged between 0.81 and 2.97 generation equivalents (Gutiérrez *et al*., 2003). Therefore, the breed has a reasonable pedigree depth and completeness level for assessment of inbreeding and average relatedness.

High level of inbreeding within Sahiwal populations

The total number of inbred animals recorded annually increased over time from one animal in 1960 to 221 animals in 1984 and then changed erratically until 2008. The proportion of inbred animals increased with about 73.12% of calves born in 2008 inbred. A total of 4,656 (23.76%) animals in the entire population were inbred,

with the number of inbred animals increasing at a rate of 17.2% per annum. There was a steady decrease in the average *F* of inbred animals but the average *F* of the entire breed population showed a gradual increase over time. The average annual level of inbreeding was 0.66% for all animals and 5.24% for inbred animals. Large variation between inbreeding level of all animals and inbred animals suggest presence of highly inbred animals within the breed. On average, sires had a higher inbreeding level than dams i.e. 0.80% vs 0.69%. Inbreeding level of the dams showed a gradual increase with time at a rate of 1.90% per annum. The average inbreeding of sires increased at a rate of 2.90%. A wide range of inbreeding level was reported in the breed with about 87.24% of the inbred animals having 0 %<F≤5% while 0.26% had 25%<F ≤30%. Regression of the rate of inbreeding on year of birth of animals born between 1960 and 2008 resulted in an estimated rate of inbreeding of 0.025% per year which represents rate of inbreeding of 0.185% per generation for the breed ($P<0.05$). Rate of inbreeding for inbred animals decreased at -0.0012% per year ($P<0.05$). The shrinking breed population and increase in the number of inbred animals may result most of the animals in the breed population being closely related thus limiting mate choice. Inbreeding level will also accumulate over time leading to intensively inbred animals and consequently economic losses due to inbreeding depression (Weigel and Lin, 2002), unless counteractive measures are introduced and implemented on time.

Effective population size

The *Ne* estimates based on ΔF ranged between 0 and 1,000 with a mean of 247 animals while *Ne* based on the number of parents ranged between 31 and 184 with a mean of 32 animals. Regression of *Ne* on year of birth of the registered animals showed a decline in *Ne* when both methods were considered. The rate of decline was faster when *Ne* was estimated using the number of parents. This was mainly because of slow replacement rate of breeding animals and failure to recruit more individuals particularly males into the breeding herd. The reduction of *Ne* in 2008 is largely attributed to intensive use of only a few prominent sires (8 sires) for breeding since the number of sires used for breeding is expected to have more effect on *Ne* than the dams (Moriya *et al*., 1997). The Sahiwal cattle breeding program in Kenya is characterized by small nucleus herds where a few bulls are used for mating. Outstanding bulls have numerous female descendants that eventually enter the breeding scheme, therefore limiting breeding opportunities because available bulls are closely related to a large proportion of the females. Under such circumstances, it is increasingly challenging to maintain given levels of effective population size (Falconer and Mackay, 1996). The *Ne* of the Kenya Sahiwal can be expanded by increasing the number of breeding bulls to control loss of genetic diversity and as well ensure genetic progress within the breed.

Average Relatedness and additive genetic relationships

The AR among individuals in different groups of registered animals ranged between 0.07% and 1.41%. The highest AR was recorded among males while the lowest AR was recorded among the founders. The higher AR of males suggested that some males were overused and indicated that inbreeding may increase unless the breeding program is changed. Founders of this breed are under-represented (Goyache *et al*., 2003; Gutierrez *et al*., 2003). The average additive genetic relationships (AGR) of the whole population was about 0.87%. The rate of change of the AGR (Δf) between 1963 and 2008 for the Kenya Sahiwal breed was 0.04% per year resulting in a Δf per generation of 0.3%. The AGR of the breed remained lower than the inbreeding level before 1988 indicating wider use of within herd mating. After 1988, AGR increased and remained higher than inbreeding level until the year 2000 owing to reports of declining performance due to inbreeding in 1978 that led to minimal use of related individuals within the breed (Boichard, 2002; Mpofu and Rege, 2002).

Conclusion

Although mean inbreeding is still low and its rate has not yet reached the critical level, existence of highly inbred individuals within the breed population necessitates introduction of breeding strategies to prevent losses due to inbreeding depression. For long-term maintenance of genetic diversity and dynamics of the breed, there is need for minimization of the increasing genetic relationships between individuals. Conservation of the Sahiwal genetic diversity requires re-optimization, as with the utility of its enormous potential.

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Production Systems, diversity and richness of cavy culture in Cameroon

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Abstract

In order to assess existing cavy production systems of Cameroon western highlands and rain forest agro-ecological zones, a household baseline survey was carried out in a total of 500 households randomly chosen. It appears that cavy culture is a women (> 60%) and youth (>12%) driven livestock production system for both regions. The main motives are consumption (62%), income generation (32%) and manure (18%). The majority of actors are smallholders, more or less organized, with flock size varying from 3 to >500, with a mean of 16 per

farmer. Average adult cavy live weight was 620g (±35). The most common production technique was 'kitchen free roaming', with only few caging. A total of 475 cavy biodata samples were collected to estimate the genetic variability using 13 microsatellites markers. Inbreeding was a real challenge in all study sites (Fis = 0.32852). Cameroon's cavy populations demonstrated four putative subpopulations with a wide range of variation, and very distant to 2 other country types. Genetic potential and breeding-related constraints were identified in all the zones. Traits of importance from farmers' views were growth, adaptability and fecundity. There is need for a well designed and comprehensive national breeding program for cavies, and increased capacity building of farmers to address mortality rates and health issues. Rapid improvements in production could be easily achieved with huge potential impacts through improved feeding and reproduction management.

Keywords. Cameroon, Domestic cavy, Genetic diversity, Husbandry, Smallholders.

Introduction

Cavyculture offers an alternative for food and income generation for many rural and peri urban households in sub Sahara Africa (Dikko *et al*., 2009; Lammers *et al*., 2009). The potential has not yet been thoroughly exploited for Cameroon context where accessibility to animal protein is becoming a real challenge (Ngoupayou *et al*., 1995). Beside the production systems per se, genetic material introduced in various stages from South America has received little or no attention. Recent molecular techniques opened wide the opportunity to populations characterization (Sportono *et al*., 2004). The aim of our study was respectively to assess the cavy production systems and cavy populations' genetic variability in Cameroon.

Material and methods

A baseline survey was undertaken on a total 500 households randomly chosen using snow ball approach in western highlands and rainfall agroecological zones of Cameroon. Data were analyzed under SPSS 18.0. Genomic DNA was extracted from 475 FTA cards collected from non related cavy individuals. Following Sportono *et al*., (2004) procedure genetic variability was evaluated using 13 cavy microsatellites and data processed under GenAlex 6.0. Native populations were genetically compared to some cavies populations from Colombia, Cote d'Ivoire and DRC.

Results

It appears from our findings (not shown) that cavy keeping is a women (> 60%) and youth (>12%) driven livestock production system. As displayed in table 1 here below, the main motives are consumption (62%), income generation (32%) and manure (18%).

Table 1: Cavy keeping motives in Cameroon

Motives for cavy keeping	Main motive	Secondary motive
Sales	33.5%	37.0%
House consumption	27.5%	35.0%
Manure	18.5%	17.8%
Secondary self employment	16.0%	6.0%
Pet	4.5%	4.2%
Total	100.0%	100.0%

Majority of actors are smallholders, more or less organized, with flock size varying from 3 to >500, average adult cavy live weight being 620g (±35), with a mean of 16 per farmer (data not shown). Health and feeding were the highest constraints faced by cavy keepers. As shown in table 2, only 4% of cavy keepers were able to feed their flock with both grass and legume forages.

Table 2: Cavy feeding systems

Feeding systems	Frequency	Percentage
Kitchen free roaming and cavies fed with fresh harvested forage	7	1.9
Kitchen free roaming and cavies fed with fresh harvested forage and kitchen wastes	340	91.4

Kitchen free roaming and cavies fed with fresh legumes and forage	4	1.1
Total kitchen free roaming	21	5.6
Total	372	100

The most common production technique was 'kitchen free roaming', with only few caging. Total penning was very scarce in general. High mortalities were noted in all households, particularly for kids before weaning stages. Sudden mortalities were also common (data not shown) depriving the overall growth of cavy populations.

From molecular analysis, it appears that inbreeding was a real challenge in all study sites with inbreeding index (Fis) = 0.32852 (data not shown). All the 13 loci were polymorphic and structured the samples cavies in their respective origin groups in general (Figure 1). Cameroon cavy population is very distinct with a clearly 02 genetic types (data not shown).

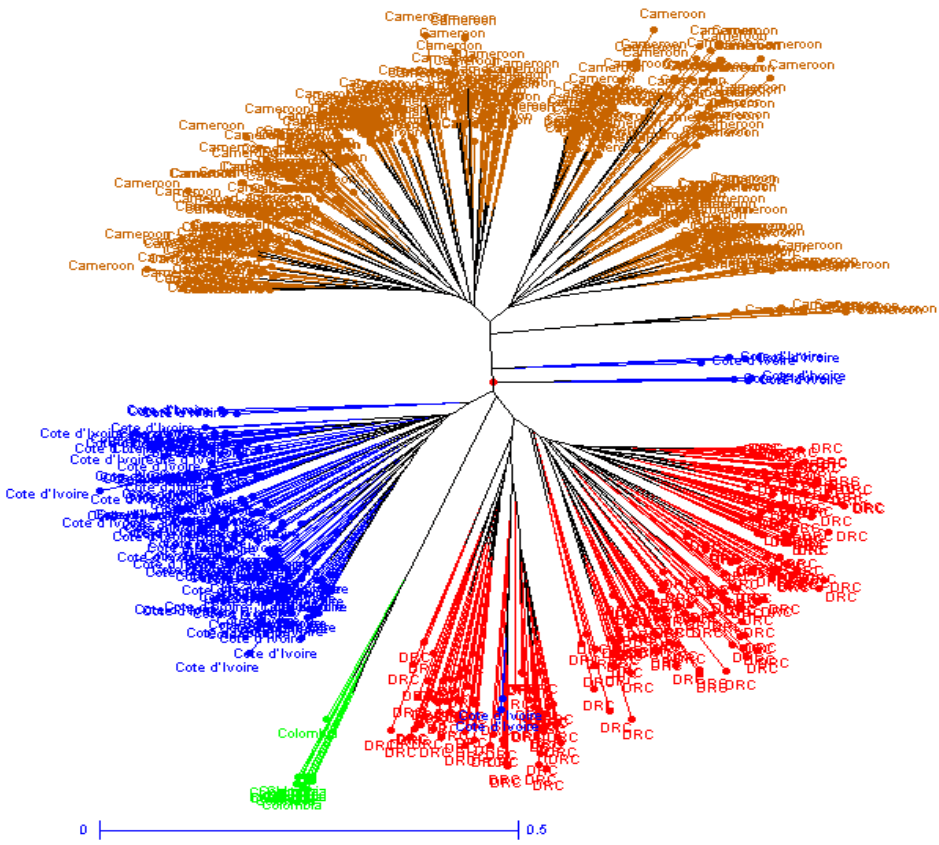

Figure 1. Four countries Cavy populations' phylogenetic relationships

Discussion, conclusion and implications

Production systems we described in our findings were identified earlier (Manjeli *et al*., 1998) as traditional guinea pig management system. Most of challenges were also those found by Dikko *et al*. (2009) in Nigeria. The opportunities for better cavy keeping development were discussed by Niba et al. (2012) and are being unraveled by our study. Genetic variability and population segregation could have been caused by isolation or introduction of foreign "blood" into local genepool (Niba *et al*., 2012). There have been some private initiatives to distribute heavy Central America breeds in order to improve the live body weight of native genetic types.

Cavyculture in Cameroon is dominated by smallholder systems, with variegated cavy populations. Developing opportunities are enormous, while considering better feeding practices and health management, as well as reproduction to address inbreeding issues. Solutions could be tapped locally from available resources, within the country or in connection with other African countries.

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Small is beautiful: Women and youth rear cavies to improve livelihoods in DR Congo South Kivu Province

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Abstract

Domestic cavy (*Cavia porcellus*) has high potential as alternative and rapid access to food and income in Cameroon and the eastern Democratic Republic of Congo (DRC). Cavies are small and kept mostly by women and youth. Cavies are one of the farm animals controlled by women for food and incomes. Poor access to regular, reliable and profitable markets by small-scale farmers is one of the causes for low technology adoption and lack of interest in improved production. The project under report established cavy farmers groups with activities implemented under Innovation platform (IP) approach where women inevitably became the majority. This gave them a voice and space for leadership. Women constitute 73.4% of those who had planted forages for cavies by March 2014. Cavies have ready market within production neighborhoods and have short value chains. This makes it easier for women not only to participate but to take the lead in cavy trade. Given the local prices and the reliable ready markets, it can be deduced that if a family of 5.6 members had only cavies as the sole source of livelihood (which is unlikely), under the current low-input husbandry, they would need to have over 230 cavies at any one single time within an year. This would enable them meet their protein requirement and generate enough income of at least 1.25 Dollars a day. With reliable feeding and feeds, right housing and

improved husbandry, the same family would need only 130 cavies to achieve the same. Cavy husbandry in addition provides easy to use high quality manure among others.

Introduction

The current debate on African agriculture has given substantial attention to African Women within small-scale farming households, where they provide the bulk of the labour required both for cash and food crops. They are also in charge of household welfare, health, and food and nutrition security. They meet these obligations with limited access to and control of production assets, services and information. Hence, the sub-Saharan agricultural sector is underperforming because women do not have equal access to resources and opportunities that they need to be more productive. As a result, many African countries have been unable to meet their Millennium Development Goals on gender equality (MDG 3), poverty and food security (MDG 1) which are mutually reinforcing.

In order to address the gender differences, use of small livestock is imperative. Thornton *et al*. (2003) estimated that 600 million small livestock keepers are women from developing countries. According to Kristjanson *et al*. (2010), it is easier for many women in developing economies "…to acquire livestock assets, whether through inheritance, markets or collective action processes, than it is for them to purchase land or other physical assets or to control other financial assets". This means that, women's ownership of small livestock may be a faster route to their access and control of resources and assets that can propel them to empowerment,

Methodology and Site Selection

After the commissioning of Sud-Kivu Provincial Cavy Innovation Platform, a baseline survey was conducted with a sample of 250 households. Snowball sampling method was used to target only those households with cavies. Based on information gathered during the baseline study, four sites have been selected for establishing Cavy sub-Innovation Platforms (sub-IPs) in three territories (in brackets), Muhongoza (Kalehe), Nyacibimba (Kabare), Kamanyola and Tubimbi (both Walungu).

Impact Pathway and Data Correction
The pathway to impact is constructed through innovation platforms (IPs) (Figure 1). An IP is defined as 'a space for learning and change composed of a group of individuals (who often represent organizations) with different backgrounds and interests: farmers, traders, food processors, researchers, government officials among others. They come together to diagnose problems, identify opportunities and find ways to achieve goals (Homann-Kee Tui *et al*., 2013).

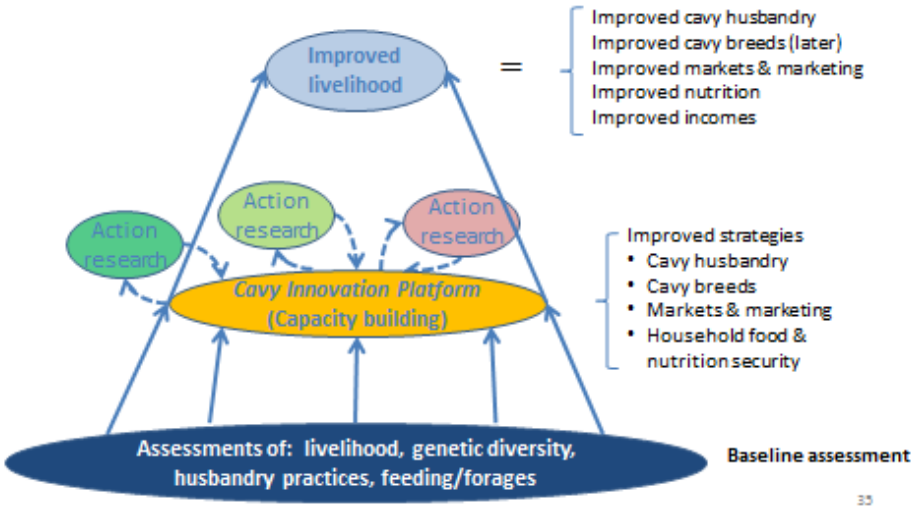


Figure 1. Pathway to impact by making use of Innovation Platforms.

In South Kivu Province, we have two layers of innovation platforms; the provincial platform, which is the official platform with a wide variety of stakeholders, and village-level sub-platforms, which are composed of farmers' and traders' associations. These sub-IPs are in four sites selected after the baseline study and they are the forums which propose the agenda for the required research activities and other interventions depending on

the farmers/traders/consumers' felt needs, problems and opportunities. Members participate in information gathering that is then shared with the rest of the group and with the provincial IP if necessary.

Results and discussions

Innovation Platform

The cavy project was designed to use the IAR4D approach. Therefore, at the onset of the project, a Sud-Kivu Cavy Provincial Innovation Platform (IP) was established and commissioned on 2nd-5th May, 2012 in Bukavu. The project team established cavy farmers groups in each research site which are key pillars for the provincial IP. Membership was based on cavy ownership. Four sub-IPs exist in Kalehe, Kabare, Kamanyola and Tubimbi. Each sub-IP has a management committee assisted by sub-committees (commissions) to handle, (i) Market; (ii) Monitoring & Evaluation; (iii) Technical; and (iv) Credit (Table 1). Women are inevitably the majority and they are very active. This gives them a voice and space for leadership.

Table 1: Women/men in leadership

S-IP Committee			S-IP Commissions			
Men	Women	Total		Men	Women	Total
Kalehe						
4	6	10	Market	1	3	4
			M&E	2	2	4
			Credit	2	1	3
			Technical	3	2	5
Kabare						
3	8	11	Market	1	2	3
			M&E	2	3	5
			Credit	2	2	4
			Technical	2	4	6
Tubimbi						
3	6	9	Market	1	3	4
			M&E	2	2	4
			Credit	1	2	3
			Technical	1	2	3
Kamanyola						
5	6	11	Market	3	3	6
			M&E	2	1	3
			Credit	2	2	4
			Technical	1	2	3
15	26	41		28	36	64

As Table 1 above shows, women were keen to take leadership in cavy associations. The office bearers in each of these positions are democratically elected through secret ballot. Women are maintaining leadership as exemplified in recent elections in two of the study sites; Kamanyola and Tubimbi which were conducted in June 2014 where they took most positions. Sud-Kivu provincial Cavy IP meets thrice annually while the sub-IPs meet every month. Women participate a lot more than men in the meetings (Table 2).

Table 2: Attendance list July 2013 - June 2014

Gender	2013						2014					
	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Women	119	129	188	109	127	146	70	101	76	71	91	70
Men	78	78	93	91	85	91	55	34	37	41	37	37

Each of these sub-IPs are registered with the provincial government.

Savings and Credit

After the sub-IPs were registered, it was imperative to introduce savings and credit to the members. This meant that they needed to have group bank accounts and also agree to start group savings. Members were encouraged to open up bank accounts with savings from membership contribution and from cavy sales. The banking activity

is a learning experience on how to save and borrow from formal financial institutions and thus demystifying micro finance. Members in each sub-IP decided their monthly contributions which range from half a dollar to a dollar. Tubimbi sub-IP is the exception; the members have yet to decide how much each will contribute to common savings.

Women's livestock

Women and children own, control eat and sell cavies. Main reason for keeping cavies is consumption, followed by incomes generation and manure production is the third. Cavies in DR Congo provide women with a livestock asset they are in total control of in terms of incomes, production, manure, purchase, sales and consumption. Cavy culture is common across the humid tropics belt of sub-Saharan Africa with high potential as a start up kit out of poverty for the most poor rural and peri-urban households.

Cavy husbandry provides a primary source of asset accumulation that can enable women and their families start climbing the livestock ladder to improved incomes, food and nutrition security, source of manure, and ultimately improved livelihoods. If larger livestock are acquired, they often become the property of adult males in the households as culture dictates. However, women may still retain the cavies or 'step out' of the livestock ladder and engage in other livelihood options. However, in the study site, insecurity is still a major hindrance to larger livestock keeping. Therefore, families have settled for small livestock like cavies for women and chicken for men.

Cavy value chain and markets

Poor access to regular, reliable and profitable markets by small-scale farmers is one of the causes for low technology adoption and lack of interest in improved production. Farmers are shy to invest if the market is unreliable, unprofitable or non-existent (Jack, 2013). In addition, women, face special market access challenges especially if the markets are too far away from the villages or if the market value chains are long and complex (Kristjanson *et al*., 2010). Cavies on the other hand, have a ready market within production neighborhoods and have short value chains making it easier for women not only to participate but to take the lead in cavy trade. Many cavies are traded among neighbors and the nearest markets.

Demand for cavies still far exceeds supply and prices are based on size and the season, ranging from 0.5 USD for small size of less than 500g; USD 0.8$ for medium sized (500-800g), and about 2 dollars for large size of over 800g. In Tanzania, Matthiesen (2011) found the same, that cavies have good local ready market at Tanzanian shillings 1500-3500 (1.0-2.3USD) per animal depending on size and season. Most cavy keepers sell them seasonally to raise money for school fees and school supplies. Prices rise during Easter and Christmas due to high demand which far exceeds the supply (Maass *et al.,* 2014). Prices also escalate when armed forces/soldiers and miners are paid.

Table 3: Total recorded sales and average prices in USD for selected months in 2013 and 2014

	2013				2014		
		April	May	June	Jan	Feb	March
		Total sales (numbers)					
Total sales	No	2453	3982	2984	2790	4644	3956
	Approximate weights range (gm)	Average price (USD)			Average price (USD)		
Small (kids)	300-500	0.55	0.52	0.45	0.6	0.57	0.7
Medium sized	500-800	1.03	1.15	0.93	1.2	1.27	0.98
Large sized	800-1200	1.82	1.87	1.7	1.87	1.97	2.03

Cultivated forages for Cavies

Women constitute 73.4% of those who had planted forages by March 2014. They are taking the lead trying various forage options on their plots. Most of the farmers integrate the grasses with other crops. Many of them plant the grasses on the edge of their plots and some are also used to curb soil erosion

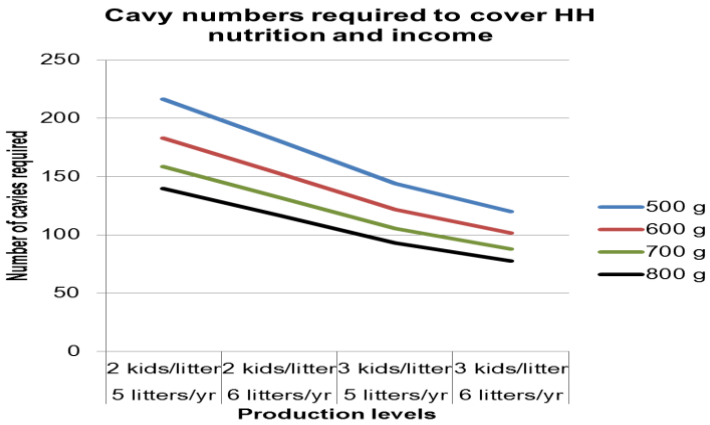
Table 4: Number of men and women cavy farmers with forage production

Site	Men	Women	Total
Kalehe	9	23	32
Kabare	3	17	20
Kamanyola	5	3	8
Tubimbi	4	15	19
Total (No.)	21	58	79
Total (%)	26.6	73.4	100

Figure 2. Grass legume as a soil erosion control crop

Cavies' impact on livelihoods

Small livestock and cavies in particular can improve families' livelihoods by providing cheap reliable source of animal protein, quick cash incomes and manure to improve production of other food crops. Given the local prices and the reliable ready markets we made the assumption that if the family of 5.6 members had only cavies as the sole source of livelihood (which is very unlikely), under the current low-input husbandry, they would need to have over 230 cavies at any one single time within an year. This would help them meet their protein requirement per month and generate enough income of at least 1.25 dollars a day. With reliable feeding and feeds, right housing and improved husbandry the same family would need only 130 cavies in one year for the same (Fig. 2). Thus a cavy keeping family which adopts forage production and improved cavy husbandry can improve its livelihood using cavies as the starter kit.



Conclusions

Small is beautiful and profitable. Cavy husbandry in the humid tropics highlands provide an avenue for easy, cheap and quick alternatives to animal protein source, manure, soil erosion vegetation among others. But the most exciting role that cavies are playing and can play in African agriculture is in empowering women and giving them space and voice to take leadership in local cavy institutions as well as have assets that they are in total control of. For African women to make the changes needed to get the continent self-sufficient in food and

nutrition security, more assets, like the cavies, that can be under total control of women need to be identified and promoted vigorously. Men rarely interfere with cavy production within their households. They are more interested in owning and controlling poultry and eggs and this should be promoted alongside cavies to have gender equity.

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Dairy intensification strategies and dairy contribution to sustainable livelihoods in smallholder systems

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Abstract

This paper discusses the relationship that exists between smallholder dairy development strategies and dairy's contribution to sustainable livelihoods using Malawi as an example. There are four strategies in dairy development namely: genetic improvement, optimising feeding, mitigation of disease and improving general husbandry. Genetic intensification strategies have traditionally included; importation of breeds such as Holstein Friesian (HF) and Jerseys, crossbreeding of the indigenous breeds with HF, and upgrading towards HF. Improvements in dairy cow management have mainly been through stall-feeding or zero-grazing systems unlike the more extensive grazing system. In order to determine the trade-offs among the different parameters, an analysis was conducted on data from three milk-shed areas of Mzuzu, Lilongwe and Blantyre. Milk samples for milk composition comparison were obtained from Lilongwe milk-shed area. In order to estimate the prevalence of brucellosis and tuberculosis in smallholder dairy cattle, a survey was conducted to assess dairy farmers' knowledge and practices that could increase the risk of milk-borne zoonoses. A total of 684 farmers in the

Mzuzu dairy region were interviewed. Supplemental data from a cross-sectional study which was carried out in April 2011 was used to estimate the seroprevalence of *Brucella* spp. The prevalence of tuberculosis was determined using Single Comparative Intradermal Tuberculin (SCIT) test.
The emphasis on increasing productivity has been yielding some results. In the Blantyre milk-shed area alone total milk production has steadily increased from 10,000 litres per day in 1997 to 45,000 litres per day in 2011. However, the continued volume-based milk payment system has promoted the predominant use of Holstein Friesian cattle and hence increased milk yields but not milk constituents high in nutritional content. Thus although the indigenous Malawi Zebu (MZ) produces only 2 to 4 litres of milk per day compared to 10 to 15 litres, MZ milk had butter fat content of 4.6% and protein content of 2.8 %. HF milk had 3.2 % BF and 2.8 % P. On the other hand, stall feeding systems has helped in the control of transmission of tick-borne diseases and has also allowed collection of manure for crop production. Of the tested animals, 7.7% had antibodies against brucella species while 13% reacted positive to Single Comparative Intradermal Tuberculin Test. More than three-quarters of the sampled farmers were aware of zoonotic diseases. However, only a third of the sampled farmers had had at least one medical examination and none of the animals were checked for zoonoses. Inter-linked policies that promote synergies for dairy development strategies, human nutrition and health in smallholder dairy systems should be promoted to achieve the desired goal of dairy systems and sustainable healthy livelihoods.

Key words: Dairy strategies, Human nutrition, Zoonoses

Introduction

In most Sub-Saharan African countries, milk is produced on both small and large-scale dairy farms. Small-scale dairy farms are commonly referred to as smallholder dairy farms. Among others, the major differentiating features of these two dairy sub-sectors are the holding size, the genotype of cattle raised and the level of management (Chagunda, *et al*., 2004). Smallholder dairy production is an important agricultural activity, producing a valuable nutritious food product and providing a regular income and work for poor households. Although smallholder dairy farms on average have anything from one to five milking cows, their contribution to national dairy production is high and this plays an important part in the dairy value chain. For example, in Malawi, smallholder dairying supplies about 60% of the milk that is processed at the formal processing plants every year (Department of Animal Health and Livestock Development (DAHLD), 2008).

During the past two decades, two technological approaches have been used to improve small scale dairy productivity in sub-Saharan Africa. The application of agricultural ecological processes (ecological intensification), and utilising modern livestock breeding (genetic intensification) have both been used (The Montpellier Panel 2013). In terms of ecological intensification, some of the strategies that have been applied are, continuous housing of cows applying a cut-and-carry feeding system, the introduction of purpose-bred forages and pastures, and the introduction of agro-forestry within the dairy systems (The Montpellier Panel 2013). Genetic intensification strategies have included the importation of world-renown dairy breeds such as Holstein Friesian (HF) and Jerseys, crossbreeding of the indigenous breeds with HF with the aim of upgrading towards HF. Training and capacity building activities to create sustainable livelihoods have been initiated to not only impart farming and technological practices of animal husbandry but also to enhance appropriate leadership and corporative-building skills. The objective being that they would create and support an enabling environment for livestock sustainability. One problem that has been identified as arising with intensification is that of unintended consequences of not driving all the facets of development at the same pace.

Strategies for Sustainable Intensification in Malawi
Sustainable intensification, has been defined as strives to utilise the existing resources to produce greater yields, better nutrition and higher net incomes while improving the resources use efficiency and lowering emissions of harmful greenhouse gases (The Montpellier Panel 2013). There are four major strategies in dairy development namely: genetic improvement, optimising feeding, mitigation of disease and improving general husbandry (Payne and Wilson, 1999).

Genetic intensification strategies have traditionally included; importation of breeds such as Holstein Friesian (HF) and Jerseys, crossbreeding of the indigenous breeds with HF, and upgrading towards HF. In dairy production in Sub-Saharan Africa the major genetic driving force that has been employed are genotype migration and crossbreeding (Hodges, 1984). Only in a few cases has selection within local breeds been used (Seo and Mendelsohn, 2008). Migration has been applied through the importation of germplasm and stock from the traditional global dairy regions of Europe, and North America, and to a lesser extent from within Africa for breed substitution and crossbreeding. Most of these initiatives have been carried out by either national

governments or practical entrepreneurs. For example, in 1979 the Malawi Government imported 400 Canadian Holstein Friesian heifers as foundation stock for a dairy improvement programme (Chagunda *et al*., 2004). Crossbreeding has been another genetic improvement strategy that has been employed. Crossbreeding has been aimed at upgrading the indigenous Zebu cattle towards the productivity levels of the traditional dairy breeds such as the Holstein Friesian. The strategy has been used to explore the difference in milk yield and tropical stress adaptability between the *Bos Indicus* and *Bos Taurus* breeds (Cunningham and Syrstad, 1987). Previous studies have shown that heterosis for production traits such as milk yield, butter fat, and milk protein range from 2% to 10% (Cunningham and Syrstad, 1987).

In terms of ecological intensification, several initiatives have been carried out in the livestock sector. These initiatives include the introduction of more intensive cattle management systems than the extensive communal grazing commonly found, integration of crop and tree species, and the introduction of non-conversional livestock feeds. The majority of smallholder farmers have adopted cut-and-carry feeding system. Cut-and-carry feeding system are a form of zero grazing, an approach in which livestock are permanently housed and provided with fodder and water. The benefits of using zero grazing management on dairy farms include increased monitoring of the health of the animals, reduced energy and time costs to livestock, and reduced risk of tick-borne diseases. The other common initiative is that of agroforestry, the integration of crops with trees insert ICRAF

http://www.do.ufgd.edu.br/omardaniel/arquivos/docs/a_matdid/saf/artigos_interessantes/trees_on_the_farm.pdf. Agroforestry provides some very important sustainable advantage for the farmer through nutrient recycling and adding additional value to the system by providing extra forage that would otherwise be underutilised. In addition, livestock also provide an incentive for farmers to plant legumes and other leguminous plants. In addition to fixing nitrogen into the soil and hence serving to improve soil fertility and reduce soil erosion, legumes provide protein to livestock (FAO, 2012).

Socio-economic intensification centres on enabling the environment of the production system efficient, resilient and contributing to the stock of natural environmental capital. Training and capacity building activities to create sustainable livelihoods have been initiated to not only impart farming and technological practices of animal husbandry but also to enhance appropriate leadership and corporative-building skills that would create and support an enabling environment for sustainability. Examples of the result of these initiatives are the emergence of rural artisanal groups such as village farmer technicians, para-veterinary practitioners, lead farmers and farmer extension workers. Improvements and policy shift initiatives in the service delivery have been championed by either the national governments or development partner institutions and non-governmental organisations through different programmes and projects. For example, in Malawi, the government has made smallholder dairying its flagship in the livestock sector (Department of Animal Health and Livestock Development (DAHLD), 2006). Furthermore, the Malawian Government has recently launched the Presidential Initiative on Poverty and Hunger Reduction with the one cow a family programme to promote smallholder dairying to majority rural areas. This initiative also aims to enable women and women headed households to own and participate in dairying and livestock activities. While one cow may not be huge in number, it is a step for diversifying women's livelihood trajectories.

Dairy Productivity and Milk composition

The emphasis on increasing milk productivity has been yielding some results. In the Blantyre milk-shed area alone total milk production has steadily increased from 10,000 litres per day in 1997 to 45,000 litres per day in 2011. Figure 1, shows the steady increase in milk yield over the period between 1997 and 2011.

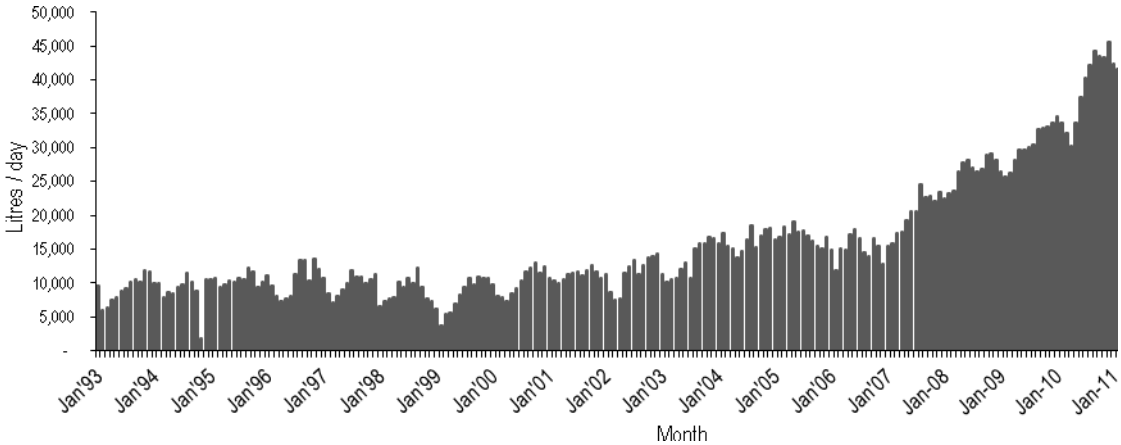

Figure 1. Change in milk collected daily from smallholder farmers in Blantyre Milkshed area from 2003 to 2011 (Source: Brian Lewis, Shire Highlands Milk Producers Association)

This increase in milk yield has positively contributed to the income that smallholder farmers receive from dairy farming. However, the continued volume-based milk payment system has promoted the predominant use of Holstein Friesian cattle and hence increased milk yields but not milk constituents high in nutritional content. Thus although the indigenous Malawi Zebu produces only 2 to 4 litres of milk per day compared to 10 to 15 litres, Malawi Zebu milk had butter fat content of 4.6% and protein content of 2.8 %. Holstein Friesian milk had 3.2 % butter fat and 2.8 % protein.

Zonooses prevalence and awareness

In order to estimate the prevalence of brucellosis and tuberculosis in smallholder dairy cattle, to assess farmers' awareness of zoonotic diseases and to identify behaviours that could favour transmission of milk-born zoonoses to humans, a study was conducted in northern region of Malawi (Tebug *et al*., 2014). In the study, a total of 155 (149 cows and 6 bulls) and 195 (100 using SCITT and 95 using SIT) dairy cattle were tested for brucellosis and tuberculosis respectively. Data to investigate zoonotic disease awareness among farmers, were collected through face-to-face interviews of 140 randomly selected smallholder dairy farmers from February to June 2011. A questionnaire was designed to include information on respondent's awareness about zoonoses, mode of transmission between man and animals, milk consumption habits, herd size, duration in dairy farming, origin of animals, sale of milk and history about zoonoses in their herd and family amongst others.

The results of this study showed that 7.7% (95 % CI, 3.5– 11.9%) and 8.1% (95 % CI, 3.7– 12.5%) of all tested dairy cattle and dairy cows had antibodies against brucella species respectively. No antibody against brucella species was found in serum collected from the 6 bulls. Generally, farmers were aware of tuberculosis (74.3%) while a small proportion knew of brucellosis (2.9%). Other relevant zoonotic diseases cited were rabies and bird flu. Most farmers knew that milk (67.1%) and meat (56.4%) as routes for animal to human transmission of zoonotic diseases. When asked about measures taken to prevent contracting zoonotic diseases, about a quarter of the farmers interviewed had once gone for medical check-up or had their animals checked against one of the zoonotic diseases. All farmers consumed unpasteurised milk produced at home and a majority (54%) sold their milk directly to the general public. Additionally, over 30% of the farmers indicated that they consumed unpasteurised milk either as fresh milk or as cultured "chambiko", with a significantly higher proportion ($P<0.05$) being farmers.

The high awareness about bovine tuberculosis revealed by this study was not reflected by farmer's milk consumption and disease prevention habits. These results do not differ from other public health studies, e.g. sexually transmitted diseases. Knowing about how diseases are transmitted, has little correlation with peoples sexual behaviours About 95% of farmers exhibited one or more risk behaviours such as drinking of fresh or cultured milk or sale of fresh milk to the general public. Furthermore, some farmers indicated that poor market access for milk, irregular collection of milk by processors and late payment of dues leave them with no other option but to produce sour milk, chambiko. Additionally, more than half the number of dairy farmers included in the study sold fresh milk to the general public and a minority had their animals checked at least once for a

zoonotic disease. Raw or unpasteurised milk has been associated with brucellosis and tuberculosis transmission from animals to humans (Al Shaalan *et al*., 2002; Makita *et al*., 2008; Fetene *et al*., 2008) making milk-borne zoonosis a considerable threat on human health in the study area.

The livestock development policy is to increase productivity in dairy cows. This has been translated as increasing milk yield using imported Holstein Friesian cattle. All the processors in Malawi buy milk from farmers based on milk volume and not milk constituents such as buffer fat and protein. This clearly conflicts with the need for agriculture to contribute to combating protein-energy malnutrition especially in children under the age of five years. Further, unlike enzoonotic diseases which receive full attention from a veterinary point of view, zoonotic diseases tend to be 'forgotten' diseases (Marcotty *et al*., 2009).

Conclusion

This review aimed at examining the relationship that exists between smallholder dairy development strategies and dairy's contribution to sustainable livelihoods using Malawi as an example. Using the four strategies in dairy development, genetic improvement, optimising feeding, mitigation of disease and improving general husbandry, the review demonstrated that the inter-linked policies that promote synergies for dairy development strategies, human nutrition and health should be promoted to achieve the desired goal of dairy systems and sustainable healthy livelihoods. Policies intervening in the post-milking phase could significantly reduce zoonosis and contribute towards value addition and production of high value milk products.

Acknowledgements

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Productivity and economic impacts of selected intervention in the rural poultry production system

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Abstract

Changes in the productivity and economic impacts of selected interventions in village poultry production system were evaluated. Interventions and existing values of the rural poultry production system (base situation) were identified using a questionnaire survey conducted into two districts from 240 Household. Data were analyzed using a dynamic simulation program, the VIllage POultry SImulation Model (VIPOSIM). A deterministic sensitivity analyses was used to identify the most important variable that affect the profitability of the rural village poultry production system. Over the simulated periods of three years, supplementation of formulated feed, housing, and application of vaccinations and introduction of an improved indigenous chicken breed resulted in a positive change in flock size, bird offtake, egg production and egg offtake. The use of formulated feed, housing and vaccinations into the system resulted in negative returns. The base situation that represents the existing low input and low-output system showed in a positive net benefit. The use of improved indigenous improved chicken breed resulted in a break-even situation. The sensitivity analysis revealed that the cost of feed as the most important factor to affect the profitability of poultry production in rural areas followed by housing, vaccination and breed.

Keywords: Base situation, Cost-benefit, Simulation,

Introduction

The demand for poultry products has shown a massive increase in developing countries (Sonaiya *et al*., 2004).Rural poultry production is a predominant system and contributes to poverty alleviation and household food security in developing countries (Alders and Pym, 2009). However, traditional poultry producers raise small number of domestic fowl for home consumption with small, mostly seasonal surpluses being sold at villages (Farrelly, 1996). Ondwasy *et al*., 2006, suggested that commercialization of indigenous poultry production is timely to meet the unmet market demands. It was also indicated that investments in small scale poultry farming generate attractive returns and contribute to poverty reduction and increased food security (Mack *et al*., 2005; Pica-Ciamarra and Otte, 2010). Feed cost, market price, stock size, number of birds sold and consumed were found to significantly affect profitability of the system (Siyaya and Masuku, 2013). Suitable breed and proper knowledge of management can results in profitable poultry production (Mahapatra, 1990). However, inadequate nutrition has greater effect on production than the genetic factors (Sazzad *et al*., 1988). This study evaluates the productivity and economic impacts of some interventions in the rural poultry production system. Sensitivity analysis was further conducted to indicate the most important factor that affects the profitability in this system.

Methodology

Primary data were collected from a total of 240 farmers in two districts of Ethiopia (Ada and Horro), where mainly a rural poultry production system is being practiced by farmers. A two stage sampling procedure was followed to select eight villages and thirty sample households from each village in both districts. In the first stage, four rural villages from each district were selected purposively based on their prior experience in chicken

production and proximity to the road. The second stage, individual households (n=240) were selected using a systematic random sampling. Systematic random sampling is often used to select large samples from a long list of households using a sampling interval. A structures survey was conducted to collect the relevant information for modeling of the village poultry production system.

Simulation model, interventions and sensitivity analysis

A dynamic simulation program, the VIllage POultry SImulation Model (VIPOSIM), was employed in the study. VIPOSIM was developed at Wageningen University, the Netherlands, and validated with data from Ethiopia (Asgedom, 2007). VIPOSIM takes into account the complex and dynamic aspects of village poultry production system and gives the flock dynamics and cost-benefit after a simulation period. This model performs calculations in time steps which represent reproduction cycles. Each step has a length of a season of 3 months and the maximum number of steps in the model is 12, which corresponds to a period of three years (Asgedom, 2007). It was programmed in Microsoft Excel® and integrates quantitative relationships of various elements of the system in a series of mathematical equations. (Tomo *et al*., 2012). Four interventions that are believed to affect the performance and economics of rural poultry production were selected. The interventions formulated feed, housing, vaccinations, and improved indigenous poultry breed. A simple deterministic sensitivity analysis approach was used (Marchand *et al*., 2008). It is based on the idea of varying one uncertain parameter value, or set of parameter vales, at a time and evaluating the change in the outcome variable which can be any performance measure or indicator and can easily be shown in a tornado diagram (Eschenbach, 1992). The underlying logic of the one-at-a t-time sensitivity analysis is similar to that of the VIPOSIM program that both evaluates the changes in the outcome variable by changing each variable at time while the rest are kept at their base (default) values collected from the field. The sensitivity analysis however ranks the most influential variables in the order of importance using visual and easy to understand presentations such as a tornado diagram (Eschenbach, 1992). A tornado diagram can include a large number of parameters without becoming over crowded. It shows the lower and upper values of the outcome variable (profit in our case) obtained from the variation of each variables (inputs), with the variable with the widest limits displayed on the top, and the parameter with smallest on the bottom.

Results

The base situation

The survey revealed that farmers keep 15 chicks, 4 pullets, 3 cockerels, 4 hens and 1 cock. Figure 1 shows the dynamics of the number of different class of chickens of the base situation during the simulated period of 12 seasons (3 years). The number of cocks, pullets, cockerels, and the hens did not change too much during the simulated periods of three years. However, chicks show significant variation over the period of simulation as their number can easily change due to mortality (Wilson, 1986). Generally the flock change indicates that the base situation represents a more or less stable flock over the three years of simulated period.

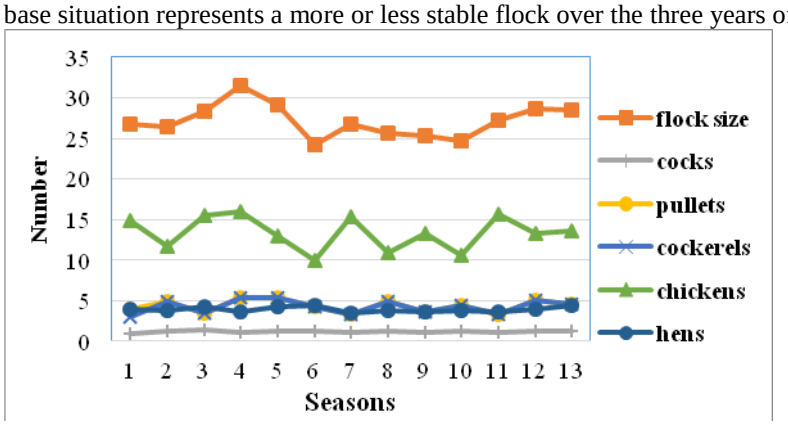

Figure 1. Simulated development of flock size, number cocks, pullets, cockerels, chickens and hens over 12 months (base)

Impacts of interventions

Flock size, bird offtake, egg production and egg offtake changes as a result of four simulated interventions to the base situation at the end of the simulated period of three years is presented in Table 1. Each intervention had positive effect on the variables considered vaccination being the most important. The analysis also showed that the effect of feed was higher than the breed.

Table 1. Percent changes in flock size, bird offtake, egg production & egg offtake as a result of four simulated interventions to the base situation at the end of the simulated period.

	Flock size	bird offtake	egg production
formulated feed	223	268	217
housing	244	292	259
vaccinations	324	333	362
breed	154	165	210

Cost - benefit analysis

Total costs, benefits and net returns for the base situation, formulated feed, housing, vaccination, improved indigenous breed over the simulated period of 12 seasons are shown in Figure 2. The cost benefit analyses of the simulation indicates that all selected interventions applied to the base situation were found to be not-economical except the base situation that resulted in positive net return. A break-even situation was found when an improved indigenous chicken was introduced. Sensitivity analysis was further conducted. The result was presented in tornedo chart. The result of the sensitivity result presented in Figure 3, shows that feed cost was most important parameter that needs attention for the profitability in rural areas followed by housing, vaccination and breed

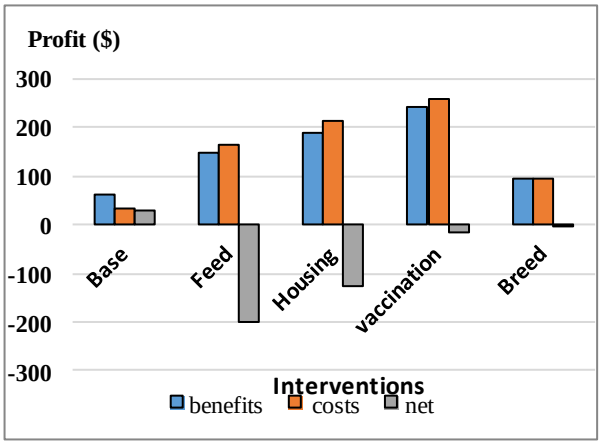

Figure 2. Total costs, benefits and net returns for the base situation, formulated feed, housing, vaccination, improved indigenous breed over the simulated period of 12 seasons

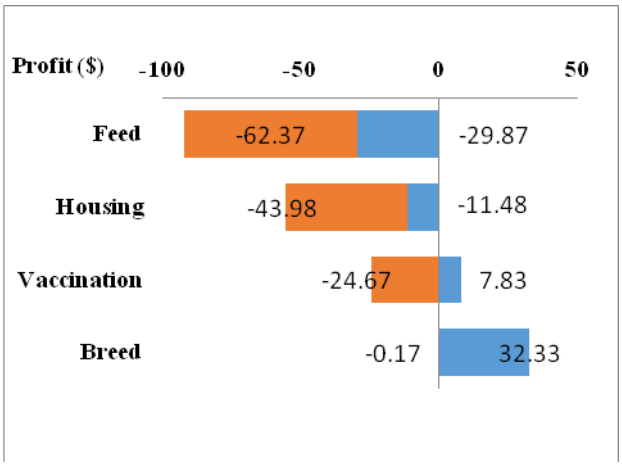

Figure 3. A tornado diagram showing the range of variables representing the profit (in USD) for high and low values of each of the variables

Discussion

The importance of rural poultry production in improving the livelihood and source of food for the ever increasing population has been recognized. The rural poultry production system remains important to the developing countries where the system dominates. The improvement is closely related to the inputs used into the system. Governments need to revisit their interventions into the system. This study has shown issues that need attention. Simulation models can never include all factors that affect a system under study (Udo *et al*., 2006), but are an alternative approach to measure impacts of interventions (Tomo *et al*., 2012). By integrating the different processes and management options involved in the complex and dynamic system, it provides insights on the dynamics of the system (Udo *et al*., 2006; Asgedom, 2007). In the current study, each intervention applied to the base situation resulted in a positive change (productivity). The base situation was reported to have been significantly improved by interventions such as feed (Huque *et al*., 1990). The cost-benefit analysis showed that formulated feed, housing, and vaccination were not economically feasible. The economic results of interventions depend very much on local conditions and all interventions require additional cash inputs (Udo *et al*., 2006). The cost of feed was very high as ingredients are used for human consumption. Keeping chickens in a housing requires provision of feed. The use of vaccination in the absence of any outbreak of diseases, together with the application of effective biosecurity measures, could maximize poultry protection whenever a risk of exposure exists, so an overall cost-benefit analysis should be performed by taking into account the costs of vaccines and all other related activities. (Marangon and Busani, 2006). The introduction of proper vaccination, goes with housing and feeding which inflates the cost of the intervention. The base situation appeared to be economically feasible as farmers invest little: raise their own stock, the birds are left to scavenge and occasionally supplemented, do not provide any type of vitamins or veterinary services, and often with no housing provided. (Farrelly, 1996). The breed that was used in the simulation was the one being improved for more egg and fast growth. Genetic improvement increases productivity and can determine profitability of family flocks (Hossen, 2010). The introduction of this breed resulted in a break even situation. Further, the sensitivity analysis showed that feed cost was the most important factor in the village production system followed by housing, vaccination and breed. Similar result was reported by (Sazzad *et al*., 1988). With the current price of feed, it is not possible to make profit. In line with Masuku, 2013, recommended that farmers should organize themselves to take advantage of discounts when purchasing feed. The use of appropriate breed can result in more profit in the rural poultry production system.

Conclusion and implications

This simulation study showed that interventions can positively affect the variables considered but not economically. The base situation appeared to be economically feasible as it is low input-low output system. Farmers seem to be convinced that investment in the current system is not economically feasible. That could be among the reasons that rural farmers are reluctant to use inputs. Further improvement of the breed used and feed supplementation could help maximize the net profit. Governments and development organizations should revisit appropriate interventions that not only increase productivity but also improve the profitability.

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Implications of smallholder dairy milk handling practices and cow welfare on milk quality: A case of Mchinji district in Malawi

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Abstract

The study was conducted to assess smallholder dairy farmer milk handling practices and animal welfare; cow and pen hygiene, contribution to quality of milk produced at smallholder farms. Specifically, the research intended to determine the effect of smallholder farmer milk handling practices on quality of milk and establish opportunities and challenges for improved production of quality and safe milk. Fifty eight smallholder dairy farms in Mchinji district in Malawi were monitored between September and October, 2013. Forty farms ably collected milk samples from their lactating dairy cows for milk composition analysis. Data was collated using a semi-structured questionnaire and a standard animal welfare system based on a visual hygiene score. Smallholder dairy farmers, primary milk buyers and the processor were the key participants in this study. Adulteration, sourness and microbial contamination were the main reported reasons for milk rejection. Despite that the majority (71%) of the farmer were using recommended and clean utensils, rarely used teat dip after milking their cows. Nine percent of the cows monitored were scored clean (no presence of manure) with majority either lightly soiled (69%) or soiled (21%). Seventy one percent of farmers reported to have had cases of milk rejection mainly due to sourness. The mean (standard error) milk fat, milk protein percentage and lactose percent in milk were 4.2 (0.3), 2.8 (0.03) and 4.2 (0.04), respectively. One-Sample T-test indicated significant statistical difference ($P<0.001$) between the mean value of the aforementioned milk components but not milk fat percentage and their respective standard values. The mean protein to fat ratio was not significantly difference from recommended ratio of 0.84. The study demonstrated that there's a need to intensify trainings on hygiene and behaviour (altitude) for improved production of quality milk under smallholder dairy farms.

Keywords: Milk hygiene, Adulteration, Milk composition

Introduction

In Malawi dairying is reckoned to be an instrument of social and economic change. About 70% of the total annual milk produced at smallholder farms is marketed either through formal or informal channels and about 30% is consumed by the producing households. Sixty five percent of the dairy farming households in Malawi consume less than 20% of the daily milk produced at a household, an indication that milk serves as a reliable source of income. Taking into account the amount of milk consumed by farming households and that which is sold through informal market; commonly in the surrounding communities, milk which is not processed and consumed can be as high as 30%. In the formal market one of the key challenges is high milk rejection by processors mainly due to quality. The Food and Agriculture Organization (FAO), (2011) and the International Dairy Federation (IDF), (2011) defined good milk as the milk characterised by low bacterial content with no chemical or physical contamination which is associated with good milking management. The objectives of this study were to a) determine the effect of smallholder farmer milk handling practices on quality of milk produced at their respective farms and establish opportunities and challenges for improved production of quality and safe milk.

Materials and Methods

The study monitored 46% (127) of the smallholder dairy farmers between September and October, 2013 who had cows and were members of *Bua* milk bulking group (MBG) in Mchinji district in Malawi. The common breeds in sue were Holstein-Friesian and Holstein-Friesian and Malawi zebu crosses. All the farmers under Bua MBG were within the radius of close to 20 kilometers from the bulking center where there was a cooling facility. Data was collected using a semi-structured questionnaires (for farmers and key informants), a standard animal welfare system based on a visual hygiene score and milk analyser. The private buyer (the processor) was also among the key participants in this study. SPSS version 20 was used to manage and analyse the data. T-test was used to compare the standard milk composition values to observed values and regression analysis was conducted to determine factors that could significantly affect milk quality. In the regression, a binary variable was used as a proxy indicator of milk quality where 1 represented a case of milk rejection and 2, else. The buyer rejected the milk after based on the alcohol and specific density tests.

Results

The study involved slightly more women (52%) than men who had an average age of above 41 years (69%). Most of them had attended school, mainly primary school (high school) (71%) and secondary (24.1%). The average [standard deviation (SD)] milk yield per day per cow was estimated at 12 (5.4), slightly above the national average of 10 and household consumption was 2 (0.8).The farmers were delivering the milk to the bulking center twice a day and others were vending though unlawfully in respect to MBGs by laws, commonly during weekends. The reasons for vending included long distance to the bulking center and low milk price when selling through MBG, the formal market channel.

Seventy one of the farmers were delivering milk using churns and their milking utensils were visually inspected to be clean. However, none of the dairy farmers reported using teat dip after milking. The farmers reported to have had training on basic animal husbandry and milk hygiene. The farmers indicated that they have had training on how best care for the milking equipment such as making sure they clean utensils after every use with warm water or cold water and non-perfumed soap or ash, dry them and store in a dry place. The results also indicated that the majority of the farmers who were monitored frequently cleaned their cow pens. Nine percent of the cows were scored to be clean (no presence of manure on the coat), 69% were lightly soiled (minor splashing of manure), 21% were soiled (plagues of manure and only 1% of the dairy cows were heavily soiled (confluent plagues of manure). Seventy six reported that they clean the cow pen twice a day and 9% three times a day.

The average (SD) milk fat, milk protein percentage and lactose percent in milk were 4.2 (0.3), 2.8 (0.03) and 4.2 (0.04), respectively. One-Sample T-test indicated significant statistical difference ($P<0.001$) between the mean value of the

aforementioned milk components but not milk fat percentage and their respective standard values. The mean protein to fat ratio was not significantly difference from recommended ratio of 0.84.

About 78% of farmers reported to have had cases of milk rejection at the bulking center and the main reported reason was sourness which was alluded to long distance to bulking center. On the other hand, the buyer and the processor added that adulteration was one of the contributing factors to milk rejection. However, the processor indicated that Bua MBG was among the groups registering low cases of milk rejection compared to other 23 MBGs and that mostly supplies high quality milk based on fat, above 3%. Age, sex and education level of the farmer, cleanliness of the utensils, cleanliness of the cow and frequency of delivering milk to the bulking center had no significant likelihood of resulting to milk rejection.

Discussion, conclusion and implications

The results on milk composition and areas trained suggested that farmers in Mchinji district in Malawi had basic knowledge on general dairy husbandry practices and ably followed some of the best practices related to production of quality milk. The ideal protein to fat ratio was an indication of good dietary protein and energy levels (Greyling, 2013) thus an indication that the farmers were able to provide enough and adequate forage. However, the potential critical causes for high milk rejection rate could be due to the long distance, adulteration and mastitis. Milk is a perishable product and it goes bad quickly. In addition farmers would want to earn more money by increasing the volumes hence some deciding to add physical material such as water and sugar. These practices could result in microbial contamination which was not assessed in this study and can render the milk unsafe for consumption (Moran, 2005). With the increased cases of informal marketing that would mean increasing the risks associated with consumption of unprocessed milk. Farmers have to understand the that there are important steps that need to be practiced on a daily basis for good quality milk production (Kurwijila, 2006). However, a decision to adulterate milk deal with farmers' altitude and in many training this component is rarely addressed. With understanding of that adulteration can be a resultant of cow factors, potentially the milk was also rejected due to mastitis. This call for a detailed understanding of the link between the distance and hygiene. The farmer demonstrated the capacity to learn and adopt technologies or practices. Therefore there's a need to intensify trainings on hygiene and incorporate aspects of behaviour change (altitude) for improved production of quality milk under smallholder dairy farms.

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Growth Performance of Two Crossbred Rabbit Genotypes Fed Two Levels of Dietary Protein

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Abstract
A study was undertaken in which two crossbred rabbit genotypes were fed two levels of dietary crude protein with the objectives of assessing and comparing their growth performances as well as investigate any possible genotype × protein level interaction. Twenty four (24) crossbred weaner rabbits (12 chinchilla × Dutch belted and 12 New Zealand white ×California) at six weeks of age were used for the experiment. The rabbits were subjected to two diets containing 12% and 17% crude proteins, respectively in a 2 X 2 factorial, using completely randomized design. Performance indices evaluated were final weight, Weight gain, feed intake and feed conversion ratio. Data collected were subjected to analysis of variance (ANOVA). Significant ($P<0.05$) genotype effect was observed in all the growth traits studied. Protein level significantly ($P<0.05$) affected all growth parameters except feed intake ($P> 0.05$). Similarly, genotype × protein level interaction was significant ($P<0.05$) affecting all the growth traits except feed intake. Both crossbred genotypes were similar in performance at 17% crude protein while the Chinchilla × Dutch belted crossbred was superior to New Zealand white × California crossbred at 12% crude protein. It is therefore, recommended that the Chinchilla × Dutch Belted Crossbred rabbit be adopted for wide spread use in Nigeria because of its high adaptability to low crude protein diet (12% CP).

Keywords: Body weight, Feed conversion ratio, Feed intake, Genotype × environment interaction

Introduction

Rabbits play an important role in the supply of animal protein (Amaefule *et al.*, 2005), are efficient converters of feed to meat and can utilize up to 30% crude fibre in their diet as against the 10% by most poultry species (Egbo *et al*., 2001). Rabbit production involves low input or cost and offers a very profitable enterprise due to the size, efficiency and simplicity of management of the animals (Rajadevan *et al.*,1987). According to Egbo *et al*. (2001), the prolific nature of the rabbit coupled with its short generation interval makes it an animal of choice for rapid increase in animal protein production for human consumption. Well over forty breeds of rabbit have been reported in the United States (LukeFahr *et al*., 1983) but only a few of these have been imported into Nigeria. Ekpeyong (1988) reported that New Zealand white, California, D'Argent, Dutch belted, Chinchilla. Pearl white, Champagne, Florida-white and Flemish giant are some of the common breeds imported into Nigeria, which have under gone indiscriminate crossbreeding to the extent that there is no exact knowledge of the genetic make-up of the rabbits in the country.

The greatest desire and goal of the animal breeder is to match the genetic potential of a given livestock breed to the prevailing or anticipated production environment. Nutrition as a component of the environment is one of the most critical factors in any livestock enterprise, accounting for about 70% of the total cost of production. Protein is one of the two critical nutrients whose requirement must be met in animal nutrition for maximum production to be attained. Two levels of protein (13 and 17%) have been recommended by Aduku and Olukosi (1990) to meet the maintenance and production requirements, respectively, of rabbits. Rao *et al.* (1977) reported a crude protein level of 12% for maintenance and 16% for production in rabbits while Sanchez *et al*. (1985) noted that protein levels above 17% fed to rabbits were not significantly beneficial. This study was, therefore, designed with the objective of evaluating the growth performance of two crossbred rabbit genotypes fed two levels of dietary protein.

Materials and methods

The experiment was conducted at the rabbitry unit of the University of Agriculture, Makurdi Teaching and Research Farm, Makurdi, Nigeria. Makurdi is located on longitude 8^0 31′ East and latitude 7^0 41′ North. Annual temperature of Makurdi ranges from 21.18^0C to 33.25^0C with an average of 22^0C. The annual rainfall is between 1500mm – 1800mm with a relative humidity of 47-85% (Abu, 2002).

Experimental Diet
The composition of the two experimental diets used in the study is as shown in Table 1 below:

Table 1. Percentage ingredient composition of experimental diets for rabbits

Ingredient	12% CP	17% CP
Maize	59.45	45.62
Groundnut cake	7.60	21.43
Brewers dried grain	6.00	6.00
Bone ash	3.00	3.00
Rice offal	23.00	23.00
Vitamin premix	0.25	0.25
Methionine	0.25	0.25
Lysine	0.15	0.15
Common salt	0.30	0.30
Total	100.00	100.00
Calculated values		
Crude protein %	12.01	16.99
Crude fibre %	12.31	12.59
Crude fat %	4.13	4.35
Calcium %	1.19	1.22
Phosphorus %	0.65	1.05
ME (Kcal/kg)	2695	2585
Analyzed value		
Dry matter	91.30	91.05
Crude protein	12.13	17.50
Crude fibre	11.95	12.20
Ether extract	7.25	7.85
Ash	6.55	7.10
Nitrogen free extract	62.22	55.35

Experimental Animals and Procedures

A total of twenty four (24) six weeks old crossbred weaner rabbits (12 Chinchilla × Dutch belted and 12 New Zealand white × California) of nearly uniform weights with average initial weight of 523 g were purchased from the rabbitry unit of Dagwom Farm of the Veterinary Research Institute (NVRI), Vom, Nigeria and used for the study. Each crossbred genotype was made up of equal number of males and females. The rabbits were weighed individually to establish initial weights and thereafter, they were randomly assigned to the two dietary treatments in a 2 x 2 factorial experiment using the complete randomized design. The animals were fed their respective diets and water was given *ad libitum.* The experiment lasted for 90 days.

Parameters Measured

Feed Intake: Each rabbit was served a weighed quantity of feed daily. Average daily feed intake was calculated by subtracting the weight of the left over feed from the weight of the feed that was served.

Daily Weight Gain: Weekly weight gain for a rabbit was obtained by subtracting the previous week's weight from the current week's weight. Daily weight gain was, therefore, obtained by dividing the weekly gain by the seven (7), that is, the number of days in a week.

Total Weight Gain: This was computed by subtracting the initial weight of a rabbit from its final weight.

Feed Conversion Ratio: The efficiency with which rabbits in the various treatment groups converted the feed consumed into body tissues was computed as the ratio of the average feed consumed to the average weight gain. This is mathematically expressed as: FCR =Average feed intake/Average Body weight gain.

Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA) using SPSS 14.0 (2004). The following linear model was implemented:

$Y_{ijk} = \mu + C_i + D_j + (CD)_{ij} + e_{ijk}$

Where:

Y_{ijk} = Single observation.

μ = Overall population mean.

C_i = Random effect of the ith crossbred genotype (i = 1, 2)

D_j = Fixed effect of the jth diet (j = 1, 2).

CD_{ij} = Fixed effect of the interaction between the genotype and diet.

E_{ijk} = Random residual error.
Where significant differences were observed, the means were separated using the Duncan multiple range test as outlined by Steel and Torrie (1980)

Results and discussion

The performance of the two crossbred rabbit genotypes fed two levels of dietary crude protein is presented in Table 2. Chinchilla × Dutch belted crossbred differed ($p<0.05$) from New Zealand white × California crossbred in all growth performance traits studied.

Table 2. Performance of two crossbred rabbits fed two levels of dietary protein (12 % and 17 %)

Parameter	Chinchilla × Dutch belted	New Zealand white × California
Initial weight	524.84 ± 4.17[a]	525.17 ± 8.17[b]
Final weight	1762.50 ± 67.51[a]	1368.00 ± 35.32[b]
Total weight gain	1237.66 ± 77.17[a]	842.83 ± 62.78[b]
Daily weight gain	13.75 ± 1.45[a]	9.36 ± 1.05[b]
Feed intake	50.45 ± 2.26[a]	41.69 ± 2.45[b]
Feed conversion ratio	3.67 ± 0.58[a]	4.45 ± 0.67[b]

The average daily weight gain obtained in the present study agrees closely with the values of 12.32 – 12.98 g reported by Odoh *et al*. (2007) but much higher than those reported by Olabanjo *et al*. (2007); 3.65 – 9.57 g and Umoren and Ojo (2007); 4.72 – 6.94 g when they fed rabbits with diets containing protein levels similar to those used in this study. Differences in weight gain as reported by various researchers could be due to differences in breed type. Similarly, average daily feed intakes obtained in this study fall within the range of 24.21 – 45.15 g reported by Umoren and Ojo (2007) but lower than 61.16 – 74.32 g reported by Akinunsi *et al.* (2007) for rabbits under similar nutritional plane. Differences in feed intake could be attributable to several factors such as age of the animal, energy concentration of the feed and differences in general management practices. The values of feed conversion ratio reported here are better than those of 4.50 – 4.73 and 5.82 – 7.12 obtained by Akinmutimi *et al.* (2007) and Umoren and Ojo (2007), respectively. Differences in feed conversion ratio reflect differences in the efficiency of feed utilization by different breeds/genotypes. The Chinchilla × Dutch belted crossbred rabbit had a lower feed conversion ratio, indicating a lower kilogram of feed intake per a kilogram of body weight gain as compared to the New Zealand white × California crossbred.

The significant ($p<0.05$) difference in growth performance observed between the Chinchilla × Dutch belted crossbred and the New Zealand white × California crossbred in this study might be due to a good breed complementarity existing between the Chinchilla breed and the Dutch belted breed than do the New Zealand white and the California breeds. In other words, there could have been a better nicking when Chinchilla rabbit is crossed with the Dutch belted breed than when New Zealand white rabbit breed is crossed with the California breed.

Table 3 shows the effect of two dietary crude protein levels on the performance of two crossbred rabbits. Crossbred rabbits on diet containing 17% CP performed higher ($p<0.05$) in final weight, total weight gain, average daily weight gain and feed conversion ration than those fed 12% CP. This could obviously be as a result of differences in the protein levels of the diets. This finding is in agreement with the report of Odi (1992) that low levels of dietary protein fed to rabbits reduced their weight gain and impaired their reproductive performance. It equally corroborates the report of Fasanya and Ijaiya (2002) who observed increase in weight gain in rabbits as their protein level in the diet increased.

Table 3. Effect of two dietary protein levels on the performance of two crossbred rabbits (Chinchilla × Dutch belted and New Zealand white × California)

Parameter	Chinchilla × Dutch belted	New Zealand white × California
Initial weight	526.84 ± 0.20	529.17 ± 4.17
Final weight	1741.67 ±109.491[a]	1389.17 ±379.09[b]
Total weight gain	1214.83 ± 77.83[a]	860.00 ± 64.95[b]
Daily weight gain	13.49 ± 1.52[a]	9.56 ± 1.01[b]
Feed intake	49.69 ± 2.61[a]	42.54 ± 2.21[b]

Feed conversion ratio	3.68 ± 0.76[a]	4.45 ± 0.04[b]

Table 4. Crossbred × protein level interaction on growth performance of two crossbred rabbits fed two levels of dietary protein

	Chinchilla × Dutch belted		New Zealand white × California		
Parameter	12% CP	17% CP	12% CP	17% CP	SEM
Initial weight	525.00	516.67	523.33	517.00	3.95
Final weight	1695.00[a]	1830.00[a]	1583.33[b]	1653.33[a]	164.85
Total weight gain	117.00[a]	1313.33[a]	1060.00[b]	1136.33[a]	14.55
Daily weight gain	13.00[a]	14.59[a]	11.77[b]	12.63[a]	2.08
Feed intake	52.83[a]	47.64[a]	45.68[b]	44.22[a]	7.08
Feed conversion ratio	4.06[b]	3.27[a]	3.88[b]	3.50[b]	1.01

The effect of crossbred × protein level interaction on the growth performance of two crossbred rabbits fed two levels of dietary protein is presented in Table 4. The outstanding performance of the Chinchilla × Dutch belted crossbred compared to the New Zealand white × California crossbred in all the studied parameters was such that while Chinchilla × Dutch belted genotype excelled the New Zealand white × California crossbred at 12% CP, it equaled the performance ($p>0.05$) of the New Zealand white × California at 17% CP. The difference in performance between the crossbreds subjected to the same nutritional condition could be due to differences in their gene assemblage (genetic make-up). Okeyo (1997) had shown that two breeds of sheep maintained under a common environment performed differently. Similarly, the performance ($p<0.05$) of Chinchilla × Dutch belted crossbred in all the growth parameters when compared with the New Zealand white × California crossbred on 12% CP, which also equaled the performance of the New Zealand white × California crossbred on 17^% CP, could be a demonstration of genotype x protein level (environment) interaction.

Conclusion and recommendation

A comparative study on the growth performance of two crossbred rabbit genotypes (Chinchilla × Dutch belted and New Zealand white × California) raised on two dietary crude protein levels (12% and 17%) revealed that the Chinchilla × Dutch belted crossbred was superior ($p<0.05$) to New Zealand white × California crossbred in final weight, total weight gain, average daily weight gain and feed conversion ratio at 12% CP. However, at 17%CP, both crossbreds performed similarly ($p>0.05$) for all the growth traits, thus demonstrating genotype x protein level interaction. It is recommended that within the limits of this study, the Chinchilla × Dutch belted crossbred rabbit be adopted for widespread use in Nigeria and perhaps the tropic because of its excellent performance on 12% CP diet considered the maintenance ration for rabbits.

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Effect of energy source on milk production and reproduction of lactating Holstein cows

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Abstract

The objective of this study was to evaluate the effect of different energy sources on the milk production and reproduction of dairy cows in a pasture-based system. Holstein cows from the Elsenburg herd were used in the study. Following parturition, cows were fed *ad libitum* cultivated irrigated kikuyu-ryegrass pastures for 22 weeks. Cows were divided into three groups according to concentrate supplementation of which the energy was provided by starch and/or fat. The P-control was a standard concentrate feeding system based on industry practice. Treatment P-HSLF was a glucogenic regime made of maize. Treatment P-HSLF-LSHF was a high starch/high fat combination treatment, whereby anglucogenic diet was offered for the first 60 days of lactation as per treatment P-HSLF and followed from 61 days by a lipogenic (low starch-high fat) diet made of wheat bran and calcium salts of palm fatty acids. Cows were milked twice a day and concentrate supplementations were fed after each milking. Heat observation was done as per usual for a dairy herd followed by standard artificial insemination procedures. Results showed that the milk yield and live weight of cows of dairy cows were affected ($P<0.05$) by the feeding concentrate programme while milk composition was not affected

(P>0.05). The number of services per conception (SPC) and the number of days from calving to first service (CFS) did not differ (P>0.05) between treatments for primi- and multiparous cows. However, the pregnancy rate (PR) of cows at 150 days tended to be affected (P<0.10) by the feeding programme, with P-HSL F and P-HSLF-LSHFL being higher. Results showed that while the milk yield was affected by concentrate feeding, fertility was not similarly affected. This is probably due to the complex and multifactorial nature of fertility of dairy cows.

Keywords: Energy, Milk production, Fertility, Pasture-based feeding system

Introduction

Intense genetic selection, enhanced dairy nutrition and herd management have significantly increased milk of dairy cows in past decades (Gilmore *et al*., 2011). However, selection of high genetic merit for milk production has led to increased nutrient requirement during early lactation. This requirement is only partially met by feed consumption, due to limitations in intake and appetite (Walsh *et al*,. 2011), with the remainder being met by mobilization of body fat reserves resulting in a negative energy balance (EB) for dairy cows in early lactation (Van Knegsel *et al*., 2007). Negative EB has been defined as an underlying causal factor of poor reproductive performance in dairy cows (Jorristsma *et al*., 2003).

Numerous nutritional approaches to reduce the severity and occurrence of metabolic upsets towards improving reproductive performances following the parturition have been study in dairy cows. Most studies pointed at reducing the extent of the negative EB by enhancing the energy intake in the transition period, hereby reducing the risks of metabolic and reproductive disorders in early lactation (Drackley*et al*., 2003). A common strategy, aiming for an increased energy intake in early lactation, is to improve the energy density of the diet by reducing the forage to concentrate ratio or by supplementation of energy dense ingredients like fat or non-fibre carbohydrates (Staples *et al*., 1998; Voigt *et al*., 2003, Van Knegsel *et al*., 2005; Gilmore *et al*., 2011). Against this background, little scientific information is available in South Africa on the effects of energy sources on production performance of dairy cows. The objective of this study was to evaluate two supplement feeding programmes made of energy dense ingredients like non-fibre carbohydrates and/or fat on the milk production and reproduction of dairy cows in a pasture-based feeding system.

Materials and Methods

Ethical clearance for this study was obtained from Western Cape Department of Agriculture, where the study was conducted at the Elsenburg Research Farm. Elsenburg is located approximately 50 km east of Cape Town at an altitude of 177 m, longitude of 18° 50' and latitude of 33° 51' in the winter rainfall region of South Africa. The area has a typical Mediterranean climate with short, cool, wet winters and long, warm, dry summers with an average annual rainfall of 650 mm.Holstein cows from 8 weeks pre-partum to 22 weeks post-partum were used. The chemical composition of feeds used in the study is presented in Table 1. During the pre-partum period, heifers and cows received oat hay ad libitum supplemented with a concentrate mixture, containing anionic salts, at a ratio of 3 kg/cow/day and 3 kg/heifer/day from 30 to 14 days pre-partum and then 6 kg/cow/day and 5 kg/heifer/day from 13 days pre-partum to calving, respectively. Following parturition, cows were fed *ad libitum* cultivated irrigated kikuyu-ryegrass pastures (IP) supplemented with concentrates of which the energy was provided by starch and/or fat. A pasture-replacement mixture (PRM) consisting of oat hay (48%), Lucerne hay (43%) and a high protein source like soybean oil cake meal (9%) was provided as additional roughage during winter when pasture availability was low. The control (P-control) was the standard pasture feeding system based on an industry best practice in the area with an allowance of a control concentrate of 7kg/day for both primi- and multiparous dairy cows.

Table 1. Chemical composition of feedstuffs

	Concentrate					
Parameters	Control	HSLF	LSHF	IP	PRM	Oat hay
DM (g/kg)	891	895	883	189	917	928
Ash (g/kg DM)	56	52	59	4	56	38
CP (g/kg DM)	140	155	153	7	134	46

Fat (g/kg DM)	35	27	66	1	17	14
NDF (g/kg DM)	150	74	159	20	420	552
Ca (g/kg DM)	12.4	9.9	10.5	0.1	4.3	2.1
P (g/kg DM)	5	7	7.4	0.2	2.7	1.8

Treatments P-HSLF and P-HSLF-LSHF aimed to improve the energy density in pasture-based system by supplementation of energy dense ingredients like fat or non-fibre carbohydrates with an allowance of 11.6 kg/day for primi- and 12.6 kg/day for multiparous dairy cows. Treatment P-HSLF was aglucogenic (high starch-low fat) diet made of maize as major energy source with aims of improving energy intake, thereby reducing the severity of the negative EB. Treatment P-HSLF-LSHF was a high starch/high fat combination treatment, whereby an glucogenic diet was offered for the first 60 days of lactation as per treatment P-HSLF to encourage cyclicity and followed from 61 days by a lipogenic (low starch-high fat) diet made of wheat bran and Calcium salts of palm fatty acids as major energy sources to promote the embryo development. Fresh drinking water was freely available at all times. Cows were milked twice a day and concentrate supplementations were fed after each milking. The daily milk yield of cows was automatically recorded at each milking. Milk samples were collected at the evening and following morning's milking sessions every 35 days and combined for analysis for fat, protein and lactose content at the milk testing laboratory of the National Milk Recording Scheme. Heat observation was done as per usual for a dairy herd followed by standard artificial insemination procedures. Milk production and fertility traits were analysed using statistical packages (SAS, 2014).

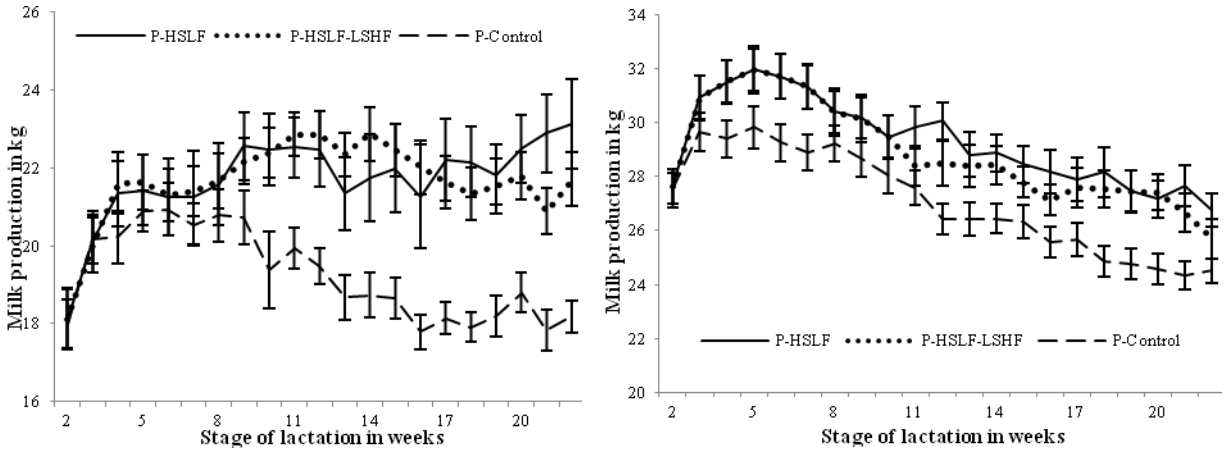
Results and Discussion

The effect of concentrate feeding on milk yield parameters of dairy cows is presented in Table 2. Results showed that the milk yield of cows were affected ($P<0.05$) by the feeding programme. With both primiparous and multiparous cows, higher milk yields were recorded for P-HSLF and P-HSLF-HFLS compared to P-control (Figure 1). In agreement to this study, reports stated that either feeding extra glucogenic nutrients orlipogenic nutrients had similar effect on kg of milk produced per day (Voigt *et al*., 2003). In the current study, no statistically significance effect of treatments was reported on milk composition for both primiparous and multiparous dairy cows (Table 2). However, other studies foundthat feeding lipogenic nutrients increased milk fat and protein levels, while adding glucogenic nutrients to the diet decreased milk fat and increased milk protein percentage (Van Knegsel *et al*., 2005).

Table 2. Least square means (± s.e.) of milk production parameters of dairy cows from 2 to 22 weeks post-partum

	Primiparous cows			Multiparous cows		
Parameters	P-Control	P-HSLF	P-HSLF-LSHF	P-Control	P-HSLF	P-HSLF-LSHF
Numbers of cows	26	19	19	67	35	35
# lactation				3.89 ± 0.18	3.50 ± 0.23	3.54 ± 0.22
Average Milk yield (kg/day)	19.2^{b} ± 0.21	21.9^{a} ± 0.25	21.7^{a} ± 0.18	31.3^{b} ± 0.77	31.1^{a} ± 0.77	28.9^{a} ± 0.75
Crude protein (%)	3.11 ± 0.02	3.14 ± 0.05	3.12 ± 0.04	3.10 ± 0.50	3.07 ± 0.53	3.12 ± 0.48
Fat (%)	3.72 ± 0.04	3.68 ± 0.06	3.66 ± 0.08	3.71 ± 0.67	3.66 ± 0.50	3.69 ± 0.51
Lactose %	4.86 ± 0.02	4.91 ± 0.02	4.89 ± 0.03	4.69 ± 0.24	4.72 ± 0.22	4.73 ± 0.19

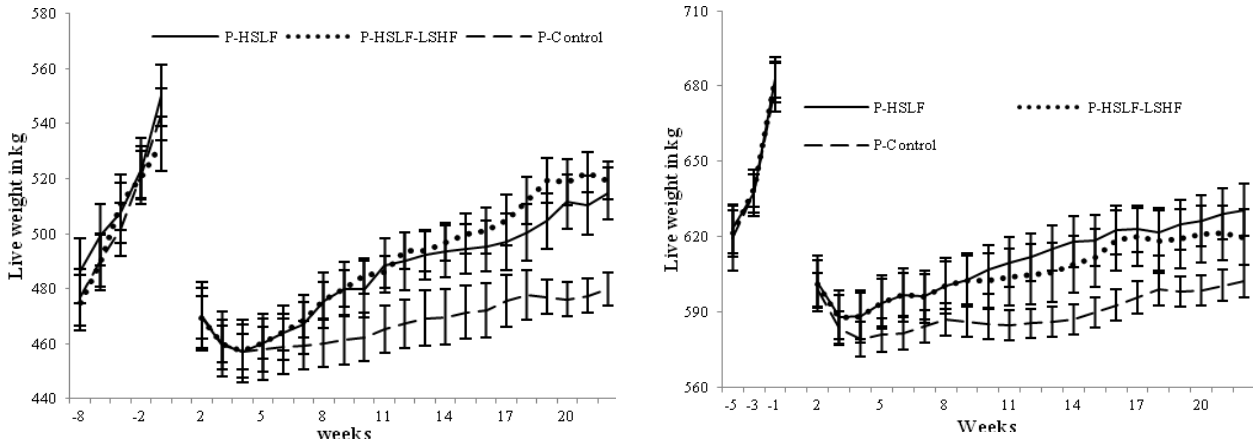
[a,b]Values with different superscripts within production system differ at P<0.05.



(a) (b)

Figure 1. Least square means (±s.e.) milk yield of primi- (a) and multiparous (b) dairy cows from 2 to 22 weeks post-partum

Both primi- and multiparous cows under P-Control were affected (P<0.05) by a live weight loss compared to their counterparts in Treatments P-HSLF and P-HSLF-HFLS (Figure 2). According to Oldick *et al*. (1997), body weight changes may not be valid indicators of the EB status in dairy cows. However, it has been indicated that live weight loss associated with a negative EB due to a prolonged low energy intake are detrimental via intermediate signals to fertility of dairy cows (Van Knegsel *et al*., 2005). In other words, cows that suffer a negative EB are prone to diseases (Evans and Walsh, 2012) and may experience alterations in endocrine, metabolic and physiological signals (Leroy *et al*., 2008) which adversely affect the reproductive performance of dairy cows, resulting in cows failing to conceive at all to be culled.



(a) (b)

Figure 2. Least square means (±s.e.) live weight change of primi- (a) and multiparous (b) dairy cowsfrom 2 to 22 weeks post-partum

Feeding effects on reproductive parameters of dairy cows are presented in Table 3. No differences were observed on the number of services per conception (SPC) as well as on the number of days from calving to first service (CFS). However, the pregnancy rate (PR) of cows at 150 days tended to be affected (P<0.10) by the feeding programme, with P-HSLF and P-HSLF-LSHFL being higher. Reports illustrates that feeding supplemental glucogenic or lipogenic nutrients has variable on reproduction parameters (Van Knegsel *et al*., 2005). Explanations can be related to nutrient factors and to limitations in animal numbers as well as in the period and protocol of the experiment (Staples *et al*., 1998; Gilmore *et al*., 2011).

With emphasis only on energy sources, the type of lipogenic nutrients (chain length and degree of saturation of long chain fatty acids) as well as the type of glycogenic nutrients (rate of fermentation in the rumen) affects the profile of nutrients

absorbed from the gastrointestinal tract which in turn may impact on reproductive parameters (Staples *et al*., 1998). Since dietary energy density has been reported to have significant effects on reproductive performance, it is important to stress out the difference isocaloric and non-isocaloric diets in different studies (Gwazdauskas *et al*. 2000; Sanz *et al*., 2004). Another factor contributing to the diversity in effects of supplemental glucogenic and lipogenic nutrients can be related to the lack of using isocaloric diets to avert the interaction with dietary energy density of fertility (Van Knegsel *et al*., 2005). Other studies found that an effect of improved energy diets can indirectly affect the fertility of dairy cows as a result of improved EB. This implies EB to be an intermediary in the effect of dietary energy source on reproductive performance (Minor *et al*., 1998; Miyoshi *et al*., 2001).

Table 3. Least square means (±s.e.) of reproductive performance of dairy cows from 2 to 22 weeks post-partum

	Primiparous cows			Multiparous cows		
Parameters	P-Control	P-HSLF	P-HSLF-LSHF	P-Control	P-HSLF	P-HSLF-LSHF
Numbers of cows	26	19	19	67	35	35
Age at calving (years)	2.24±0.04	2.15±0.04	2.24 ± 0.05	5.37±0.21	5.06±0.33	4.99 ± 0.27
SPC	2.71±0.36	2.44±0.37	2.37 ± 0.40	2.30±0.19	2.52±0.30	2.03 ± 0.27
CFS (days)	89 ± 4	82 ± 5	84 ±8	103 ± 7	99 ± 6	94 ± 5
PR at 150 days (%)	0.35^{b}±0.10	0.53^{a}±0.12	0.57^{a} ± 0.12	0.44^{b}±0.6	0.60^{a}±0.09	0.57^{a} ± 0.09

^{a,b}Values with different superscripts within production system differ at P<0.10.

Conclusion

Increase in dietary energy sources in dairy cows during lactation improved milk yield in a pasture-based system. Since the energy effects on reproduction are rather inconclusive in this study and studies on feeding different energy compounds on reproductive performance are still scarce, further investigations with emphasis on EB and metabolism are therefore needed to understand factors affecting reproduction in dairy cows.

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Ethnoveterinary practices against common parasitisms in smallholder goat farming systems in southern Cameroon

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Abstract

Goats are reared in smallholder production systems in Cameroon. Parasitic diseases have been hampering the productivity and viability of these goats. In order to understand the solutions implemented by farmers to combat these diseases, a participatory survey was undertaken in the southern region of Cameroon from October 2013 to March 2014. A majority of farmers did make use of indigenous knowledge to treat their animals by use of a total of 29 plant species belonging to 18 families: *Anarcadiaceae, Annonaceae, Asteraceae, Combretaceae, Commelinaceae, Cypereaceae, Dryopteridaceae, Euphorbiaceae, Fabaceae, Guttifereae, Hyacinthaceae, Myrsinaceae, Myrtaceae, Musaceae, Palmaceae, Sapindaceae, Solanaceae and Stertuliaceae.* Medicinal preparation recipes varied from maceration to ashes of leaves, fruits, bark or roots. The effectiveness of curative treatments was under experimental screening for better utilization at the time of this study.

Keywords: Caprine, Diseases, Husbandry, Treatments.

Introduction

Goat rearing plays a big role in the African smallholder production systems, particularly to address poverty (Ikwuegbu *et al.*, 1994) and provide animal protein (Ayissi-Mbala, 1992). Health management has been pointed out as one of the major constraints to higher productivity in dominant smallholder goat farming systems in Cameroon (Ndamukong *et al.*, 1990; Manjeli *et al*., 1996). Besides modern treatments, indigenous knowledge gives a solution for many livestock keepers (Tambi, 1989; Halewood, 2003). The essence of our present study was to contribute to the inventory of usual plants involved in goat ethnoveterinary treatments against parasitic diseases.

Materials and methods

A total of 650 goat keepers were randomly surveyed in southern Cameroon humid regions based on the information that they used in ethnoveterinary practices. Besides the local names, recipes and treatment modes, plant portions were collected, and photos taken. Species samples were formally identified using recent botanical keys and confirmed by the National Herbarium.

Results

Our preliminary findings show that goat farmers made use of diverse plant resources, derived from their cultural background and their direct environment. For a majority of the goat keepers, recipes were collected either from other farmers or from their relatives. Dosages were dependant mostly on symptomatic observations and experience of goat farmers (data not shown). Table 1 gives the list of plant species identified.

Table 1. List of families, plant species and parts used in goat ethnoveterinary treatments in Southern Cameroon

Family	Species	Parts used for treatment
Anarcadiaceae	*Pseudospondias macrocarpa* A. Rich. Engl	Leaves
Annonaceae	*Annona senegalensis* Pers	Fruits (edible) and leaves
Asteraceae	*Chenopodium ambrozoides* Linn	Leaves
	Conyza sumertrensis (Retz) E. Walker	Leaves
	Laggera pterodonta (DC.) SchumBip. exOliv.	Leaves
	Vernonia amygdalina	Leaves
	Vernonia guineensis Benth	Leaves
Combretaceae	*Terminalia mollis* M. A. Lawson	Leaves and barks
Commelinaceae	*Commelina zenkerii*	Leaves
Cypereaceae	*Cyperus articulates* Linn.	Leaves and rhizomes
Dryopteridaceae	*Dryopteris kirbi* (HR.) Alton.	Rhizomes
Euphorbiaceae	*Euphorbia hirta* L	Leaves, stem and flowers
Fabaceae	*Crotalaria* sp	Leaves
	Tephrosia vogelii Hook.F.	Leaves
Guttifereae	*Harungana madagascariensis* Lam. ex Poir.	Leaves and barks
	Psorospermum febrifugum Spach	Leaves
Hyacinthaceae	*Scilla sudanica* A. Chev	Leaves
Myrsinaceae	*Maesa lanceolata* Forssk	Leaves
Myrtaceae	*Psidium guyava*	Leaves
	Eucalyptus sp	Leaves
Musaceae	*Musa sapienta*	Leaves
Palmaceae	*Elaeias guinensis*	Nuts (edible) and leaves ashes
Sapindaceae	*Paullinia pinnata* L	Leaves
Solanaceae	*Nicotina tabacum* Linn.	Leaves
	Physalis peruviana L.	Fruits (edible) and leaves
	Solanum aculeastrum Sw	Fruits
	Solanum incanum L	Fruits (food additives)
	Solanum torvum Sw	Fruits
Stertuliaceae	*Cola nitida*	Barks

As displayed by Table 1, leaves appeared to be the mostly used, followed by fruits and barks. Roots or pseudo stems (rhizomes) were less frequent. Plants parts were used as decoction, or powder, served alone with water or barely in a combination with other mineral (salts, bicarbonates) or organic (palm oil) ingredients.

Discussion, conclusion and implications

Use of available plant resources for their animal treatments has been frequently reported in smallholder goat keeping (Ndamukong *et al.,* 1990; Ademosun, 1994; Manjeli *et al.,* 1996). Goat farmers like other livestock keepers adopt slowly new technologies when they are convinced to have better and customized solutions at hand (Tambi, 1989; Halewood, 2003). Some of their claims after laboratory screening showed very interesting and promising results against parasites (Pamo, 2002).

Cameroon smallholder goat farmers have a variety of treatments against parasitic diseases of their animals, generally developed by slow and long term experiences. Besides the better husbandry practices to improve health status of the flock, subsequent analysis the chemical composition of various plants could be useful for drug discovery and development, for better use in the rural context.

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Phenotypic features of Cameroon native goats under traditional management

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Abstract

In order to assess genetic variability of native goats under traditional conditions, a total of 511 mature goats were sampled in 2 agro ecological zones, Coastal (n=262) and High Humid Savannah (n=249) regions. According to coat color patterns polymorphisms, goat populations were highly variegated with IPa and IPs equal to 1. Coat colors varied from solid black to full white, with many black, red, brown and white combinations, with black predominant. Mean body measurements were as follows: live body weight, 22 Kg; height at withers, 50cm; body length, 57cm; horn length, 9cm; heart girth, 67cm. While goats in High Savannah region tended to be slender, those of Coastal were mostly compact. Goats were kept for meat (household consumption or sales alive). Our findings show the tendency of smallholder goat farmers to maintain genetic diversity, based on visible polymorphisms for different purposes. Further investigations will help to understand the rationale and widely management strategies applicable to domestic animals under similar conditions.

Keywords: Cameroon, Genetic resources, Husbandry, Variability visible, polymorphisms.

Introduction

Native genetic resources are seriously threatened all over the world for many reasons (Danchin-Burge, 2002). Varieties of tools have been developed to evaluate and monitor animal genetic resources, among which visible polymorphisms are

important in domestic species (Lauvergne *et al*. 2011). Based on metrics and coat variability, experimental studies were done in Africa (Bourzat *et al*. 1993; Khemeci *et al*. 1996) and in Europe (Bouchel *et al*. 1997) to estimate goats' population diversity. Our study aimed at assessing genetic variability in Cameroon native goat populations under traditional management.

Material and methods

A total of 511 mature and unrelated goats were randomly sampled in 2 agro ecological zones; Coastal (n=262) and High Humid Savannah (n=249) regions. Coat colour patterns were applied while body measurements were collected following the method described by Bouchel *et al.* (1997). An individual data sheet was used integrating collection sites waypoints.

Results

It appears from our study that the Cameroon native goats displayed all the existing coat colour patterns, with very new combinations as shown by Figure 1.


a. Eumelanic


b. Badger face


c. Spotted legs Eumelanic


d. White belly Eumelanic


e. Front mantled


f. Back mantled


g. Chamoisé


h. Wild


i. White without list


j. Phaeomelanic


k. White belly Phaeomelanic


l. Variegated

Figure 1. Coat color patterns identified in Cameroon native goats

Cameroon native goat populations are highly variegated with index to Agouti locus (IPa and IPs) equal to 1. Coat colors varied from solid black to full white, with many black, red, brown, and white combinations, with black predominant.
Mean body measurements were as follows (data not shown): live body weight, 22 Kg; height at withers, 50cm; body length, 57cm; horn length, 9cm; heart girth, 67cm. While goats in High Savannah region tended to be slender, those of Coastal were mostly compact. Goats were kept mostly for meat (household consumption or sales alive).

Discussion, conclusion and implications

Goats keepers in many tropical countries tend to maintain high visible polymorphisms in their flock (Khemeci *et al*. 1996). Some of the qualitative traits are regarded as indicators of important breeding characters (Ozoje, 2002). Thus, Cameroon goat populations are variegated and could be considered as primary or traditional populations, with a high maintenance of recent mutants (Lauvergne *et al*., 2011). The variability of body measurements could be explained by spatial and ecological conditions (Dossa *et al*., 2007). Some of the body measurements are evolution indicators and selection potential in goats (Lauvergne *et al*., 1997).
Our study shows that Cameroon native goats belong to traditional or primary populations, giving thus high possibilities to selection for development of breeds depending on targeted objectives. This study also shows that better management policies are needed for proper conservation and utilization purposes.

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Optimizing calf feeding, survival and weaning weights on smallholder farms for increased availability of replacement heifers in Kenya

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Abstract

Situation analysis is often the starting point in projects supporting interventions to improve dairy calf and heifer rearing on smallholder farms. The objective of this study was to evaluate various calf rearing practices on smallholder farms in Nyandarua County, Kenya and suggest improvements based on recommended standards. A survey was conducted on smallholder farms in Nyandarua County using questionnaires and farm visits to characterize calf rearing practices and determine factors limiting performance. Mean farm sizes was 3.5±1.8 ha. Most of the farmers were females, with a primary level of education, and majority kept 1-3 milking cows that yielded 5-10 milk/cow/day). Major dairy breeds were Friesian, Ayrshire and crosses with an average of 6 heads of cattle per farm. The study revealed that, both pre-weaning and post-weaning calf nutrition and management was poor in over 50% of the survey farms especially during the dry season. Major problems included delayed colostrum feeding, inadequate milk feeding and concentrate supplementation, poor housing and high calf mortality rates. Overall, the body condition score of the weaned calves was poor, ranging from 1.3 to 2.5 especially during the dry season an indication of weaning stress. Napier grass (*Pennisetum purpureum)*, natural pastures and forage legumes formed the major feed resource for weaned calves especially during wet season while crop residues were used during dry season. However, these feeds were low in crude protein (CP<80g/kg DM) and high in fibre (NDF >600g/kg DM) indicating that calves fed these forages could have low feed intake and poor growth. Nutritional improvement could be achieved by supplementing low quality tropical forages with forage legumes which are cheaper than concentrates and have ability to improve rumen microbial activity and animal performance for early weaned calves.

Keywords: Smallholder farms, Calf rearing practices, Milk feeding, Housing, Weaning Mortality

Introduction

Kenya is the leading milk producer in Eastern Africa and produces an estimated 4 to 5 billion litres of milk annually from a herd of about 4 million dairy cows (Wambugu *et al*., 2011). Much of this milk is produced by smallholder dairy farmers who account for 80% of the national milk production (Wambugu *et al*., 2011). Sustainability of the dairy production on the smallholder farm depends on efficiency of rearing dairy calves for replacements of low producing cows. However, smallholder dairy farmers in the tropics experience suboptimal production and high calf mortalities which can go up to 50% due to underfeeding (Moran, 2011). In Kenya, smallholder dairy farms have recorded 10-30% calf mortality (Gitau *et al*., 1994) whereas the target calf mortality in well managed herds should be less than 5% (Umoh, 1992). Lack of dairy replacements heifers is one of the major limitations to the development of smallholder dairy production in Kenya. Calf survival is paramount for increased number of replacements heifers for selection and breeding. Proper nutrition is fundamental for calf growth and for the general profitability of the dairy industry. In rearing calves, the strategy is to optimize rumen development and growth while minimizing stress and diseases. This can be achieved by proper feeding of the calf with sufficient milk, 3 to 4 litres/day depending on the body weight and concentrates to stimulate rumen microbial development (Baldwin *et al*., 2004). Successful rearing of dairy calves depends on good nutrition, housing management and control of infectious diseases (Drackley, 2005). A situation analysis in the smallholder farms is essential to tailor interventions on improving dairy performance particularly calf and heifer rearing. The development of appropriate feeding strategy for young stock requires farmer's participation and experimental trials to be conducted on their farms. Good calf rearing is important as it ensures availability of good future replacement heifers. In Kenya, young calves in most smallholder dairy farms perform poorly as most farmers have limited knowledge on proper calf feeding regimes and good management practices. Therefore, the objective of this study was to evaluate various calf rearing practices on the smallholder farms in Nyandarua County, identify constraints limiting calf performance and make recommendations for improvements.

Materials and Methods

Survey areas

The survey was conducted on smallholder farms in two divisions (Ol-Kalou and Ndaragua), Nyandarua County, Kenya using questionnaires and farm visits. Nyandarua County was selected because it is predominantly agricultural area, with dairy farming as an important economic activity and smallholders comprising over 80% of the farmers.

Questionnaire Survey
A formal survey was conducted using structural questionnaire on 85 smallholder dairy farms in Ol-Kalou and Ndaragua division of Nyandarua County. The questionnaire was pre-tested in a pilot study and modified before the main survey. The questionnaire captured household data including general farm characteristics, livestock production systems, calf rearing and feeding systems, calf management and health constraints. Feeds that were available to the calves were evaluated according to the type of forage. Different species from the forage bundles were separated and identified. Growth data of calves on selected farms were monitored monthly using body condition score on 20 randomly selected farms for comparison. The data collected from the survey farms and from the comparative study farms provided information enabling characterization of current farmers' practice and ranking of constraints.

Feed sampling and analysis
Available feeds used in the ration of dairy calves were sampled (grass, protein rich forages and concentrate supplements) during the wet and dry seasons and subjected to chemical analysis according to Association of Official Analytical Chemists (1990) and Van Soest *et al.* (1991).

Statistical analysis
The data was analyzed using Statistical Package for Social Sciences (SPPS) version 16 for Windows (SPSS 2004). Cross tabulations and chi-square analysis were used to determine associations.

Results

Farm household characteristics
Majority of the farms (53.2%) were managed by women (Table: 1). This scenario has been reported in other developing countries such as Ethiopia and Uganda which have adapted dairying (Kabirizi *et al*., 2004). Most farmers (61.2%) had primary level of education. Educated farmers were able to interpret, make informed decisions and apply technical advice. Majority (72.4%) of the sampled farmers were fulltime dairy farmers and many of them had more than 10 years of experience in dairy farming. The farmers were smallholder mixed farmers with less than 10 ha/household. Land was intensively utilized for production of food crop and livestock.

Table 1. Demographic and household characteristics of smallholder farmers in Ol-Kalou and Ndaragua divisions of Nyandarua County, Kenya

Household characteristics	Survey study sites		
	Ol-Kalou N=59	Ndaragua N=26	Overall mean
Gender of household head (%)			
Female	52.5	53.8	53.2
Male	47.5	46.2	46.8
Age of the house hold head(years)	43.5±2.2	45.3±2.2	44.4±2.26
Average land size (Ha)	2.71±1.2	4.86±3.8	3.48±1.8
Highest education attained by household heads (%)			
None	16.9	19.2	17.6
Primarily level	67.8	46.1	61.2
Secondary level	8.5	15.4	15.3
Tertiary level	3.4	11.5	5.8
Livestock farming experience (years)	8±6	12±4	10±3
Household's major activities (%)			
Full time farmers	65.2	79.6	72.4
Business and other employments	34.8	20.4	27.6

Dairy cattle were important in supplying milk, meat and household income. The cattle comprised 52% of the livestock species on the farms. Herds were composed of various cattle breeds including, Friesian (42%), Ayrshire (17%), Crosses (29%) and other breeds (12%). Other livestock species included sheep (41%), goats (7%), chicken (28%) and 4%

donkeys. The large dairy breeds (Friesian and Ayrshire) have higher nutritional demands and performed poorly under smallholder feeding conditions due to feed scarcity (Bebe *et al*., 2008). The impact of feed inadequacy resulted in low cattle performance (Kabirizi *et al*., 2004).

Basal feeds on smallholder farms

The chemical composition of the available feeds for both dairy cattle and young stock in Nyandarua are shown in Table 2. Napier, natural pasture and crop residues contributed the largest proportion of diets for weaned calves, which was in agreement with studies reported in developing countries. The feed composition varied with seasonal rainfall pattern and with plant species. Most grasses and crop residues were low in CP (43-79g/kg DM CP) and high in fibre (>600g/kgDM NDF) especially in the dry season which could cause limited feed intake and growth of young ruminants. However, protein rich forages grown as supplementary feeds contained three times as much crude protein (143-230 g/kg DM CP) compared to grass forages and were low in crude fibre (<600 g/kg DM) indicating their potential as protein supplements to low quality grasses (Norton and Poppi, 1995).

Table 2. Chemical composition of feeds fed to weaned calves during dry and wet season on smallholder farms in Nyandarua County, Kenya

	Dry season		Wet season	
Feed resources	CP	NDF	CP	NDF
Napier grass	8.6±2.56[a]	59.99±4.5[a]	11.6±3.4[ab]	51.45±8.0[a]
Pasture	6.7±1.61[b]	69.49±6.6[b]	9.4±2.78[b]	65.6±6.31[b]
Legume	20.3±1.98[c]	40.38±4.0[c]	23.7±2.81[c]	30.4±5.32[c]
Crop residue (Maize Stover)	3.4±13.0[d]	77.9±9.20[b]	5.7±2.56[d]	65.1±11.33[b]

[abcd] Means with different superscripts within a column are different (P<0.01)

Growth performance

The growth pattern of calves, measured by body condition score, during wet and dry seasons are shown in Figure 1. There was great variation in body condition score (BCS) of weaned calves with lowest score (1.3) during the dry season and improved score (2.8) during the wet seasons a reflection of seasonal variation in feed quality with rainfall pattern. Similar pattern of decline of daily gain (BW) from birth to weaning has previously been reported in other studies (Das *et al*., 1999; Kiragu *et al*., 2012). This supports our finding that, tropical forages cannot provide adequate nutrients for optimum growth of young stock unless supplemented with energy and protein rich feeds.

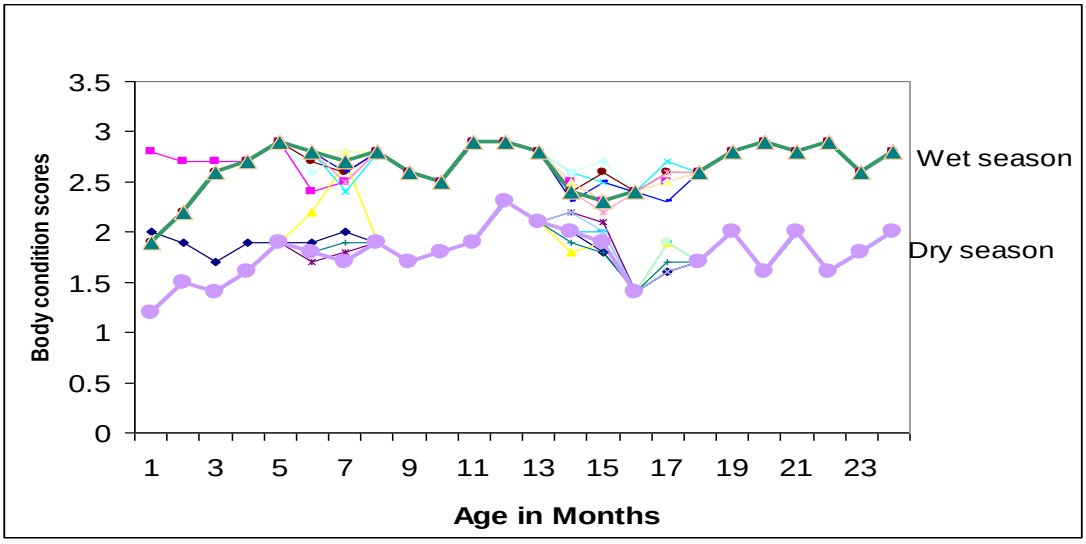

Figure 1. Body condition score of young stock on smallholder farms in Nyandarua County

Table 3. shows the nutritional, management and health practices by smallholder farmers. Majority of the farmers (76%) on average owned at least one calf while 13 and 11 % of them owned 2 or more than 3 calves respectively. This indicated the

need to rear more calves to replace old cows and herd expansion. Colostrum feeding was well adopted in (65%) as farmers fed colostrum to their calves within the first 6 hours after birth. Calves were housed separately from adult cattle on 73% of the farms. Most of calf pens were poorly maintained in majority (74%) of study farms. Majority of smallholder farmers, (98%), reared their calves artificially on whole milk. Most farmers, (88%) used bucket feeding method and fed their calves milk twice a day (76%) while 14% of them fed their calves milk thrice daily. Majority of the farmers (60%) dewormed their calves against parasites every three months. The preferred anthelminthic were broad spectrum (75%). Many farmers (79%) did not introduce solid feds to calves until the calves were 3 weeks of age because they believed that rumen was not developed. Supplementation was not common with more than 53% of the farms not supplementing and majority of the farmer who supplemented using low quality crop residues and grains. Weaning age ranged between 3 and 6 months. Majority of the farmers (76%) weaned their calves between 3 to 4 months of age. Most farmers housed calves in poorly maintained pens. Out of 22% of the farms, at least one calf had died during the past 2 years. More males (58%) than female (42%) were reported dead. The diseases that caused death, as perceived by farmers, included diarrhoea, pneumonia, East Coast fever (ECF), starvation and helminths.

Table: 3. Nutrition and management factors associated with calf performance in 85 smallholder dairy farms in Nyandarua as given in a questionnaire survey

Factor	Farm category	Number (n)	%
Number of calves on the farm	1	65	76
	2	11	13
	3	9	11
Colostrum feeding	Less than 6 hours	56	65
	After 6 hours	29	30
Type of milk feeding feeds	Whole milk	83	98
	Milk replacer	2	2
Method of milk feeding regime	Bucket	75	88
	Residual calf suckling	10	12
Amount of milk feeding	More than 4L/day	62	73
	Less than 4 L/day	25	27
Frequency of feeding milk	Three times daily	12	14
	Twice daily	73	86
Time of introduction of water and solids	Before three weeks of age	18	21
	After three weeks of age	67	79
Supplementation with concentrate	No supplements	46	53
	Legumes	20	25
	Concentrates	19	22
Weaning age of calves	Less than 3months	9	11
	3- 4 months	65	76
	5-6 months	11	13
Condition of calf house	Clean	22	26
	Poor	63	74
Calf mortality in the past 2 years	None	66	78
	Yes	19	2
Sex	Females	8	42
	Males	11	58
Age at death	0-1	9	47
	2-3	6	32
	4-6	4	21
Season	Wet	11	58
	Dry	8	42
Farmers' perception of cause of calf death	None	66	78
	Diarrhoea	5	6
	Pneumonia	8	9
	East Coast Fver	7	8
	Helminthes	2	2

Discussion

According to the study, majority of smallholder farmers were females who were mostly involved in the mixed dairy farming enterprise for economic gains. This indicates that smallholder dairy farming provided self–employment to women, contributing significantly to poverty alleviation. Farmers kept small number of dairy animals herds which could be managed with scarce feed resource. Sustainability of the dairy herds depended on well reared calves to replace low producing cows. Hence, the aim of the study was train farmers about calf rearing especially women to enable then get technical information to optimize growth and survival of future heifers productivity

Practically, all the farmers were aware of the importance of colostrum feeding to their new born calves especially for the first few days of birth. Colostrum supplies a wholesome diet to the neonate and plays significant roles in calf's host defense mechanism system. Colostrum has 14% crude protein which aids in prevention of mortality and morbidity (Fisher,

2000). Feeding colostrum immediately after calving (less than 6 hrs) to calves using the bucket was recommended. The few farmers who delayed colostrum feeding or left the calf to suckle the dam were discouraged. Godden (2009) recommended that the calf should not suckle directly from the dam to avoid contamination from pathogens on the udder.

Adequate milk intake by calves during the first 3 months of age was very important for good health and fast growth. However, it was evident that some farmers (25%) underfed (<4lt/day) their calves leading to retarded growth rates and high mortalities. It is recommended that calves should be fed 10% of their body weight as milk, together with solid feeds to stimulate rumen development (Khan *et al*., 2007). It is recommended that water and solid feed be continuously available to dairy calves by 3 day of age (Drackley, 2005).

Very few farmers (22%) indicated that they used concentrate or crushed maize grain only to feed calves which is a similar practice as recorded by Lyimo *et al*. (2004), who noted that some farmers used only maize bran as the calf concentrate. In some cases, calves were fed on contaminated maize which was milled and mixed with bran. Maize grain averaged 9-12% CP, yet dairy calves requirements was 130-160g CP/kg DM in calf concentrates (Lyimo *et al*., 2004). However, few proportion (25%) of farmers supplemented with protein rich forages such as Lucerne, vetch and sweet potato vines. The protein rich forages provided cheap protein supplement and fiber essential for stimulating rumen microbial development for early weaning (Khan *et al*., 2007). It is worrying that 53% of the farmers in both study farms did not use concentrate which they considered expensive. This was despite the fact that creep feeding enables early weaning and hence some milk saving.

Farmers fed their calves with poor-quality feeds mainly Napier grass, natural pastures, and dry crop residues. The proportion of feeds and quantities offered was determined in most farms by their availability. The nutritional value of these feed according to the analysis were lower than legumes and varied with seasonal rainfall pattern (Table 2). There was scarcity of protein as majority (53%) of farmers did not supplement with concentrates. This was disadvantageous in that most tropical forages are of poor nutritional content as well as low palatability and thus do not provide enough nutrients to meet the calf's requirements for optimal growth (Changa *et al*., 2011).

Weaning age was higher than the average (7-8 weeks) often recommended in other studies (Kehoe *et al.*, 2007; Kiragu *et al.*, 2008). Probably, this late weaning age often was due to unavailability of high–quality feeds, especially concentrate supplements. The earlier that rumen activity is initiated, the earlier the calf will utilize substantial amounts of dry feed. The overall calf mortality rate of 22% in the farms was slightly higher than the 20.7% reported in farms in Muranga (Gitau *et al*., 1994). Both values were higher than the 16% mortality reported in Zimbambwe (Moran, 2011). However, calf mortality in well-managed farms did not exceed 5% during the first 30 days of life in some farms in Nigeria **(**Umoh, 1982**)**. Diarrhoea, pneumonia, tick borne diseases and worm burden were the main diseases of young calves on the farms which agree with other reports (Gitau *et al*., 1994). These diseases have been recognized as major constraints in livestock production in Kenya.

Conclusion

The results of this study show that majority of smallholders raised their own replacements and research interventions have to focus on calf rearing methods, supplementation, weaning strategies, calf housing and health management. Cultivation of protein rich forages for improvement in feed quality is recommended.

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Population viability analysis of the Kenya Sahiwal cattle breed

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Abstract

Sahiwal cattle genetic resources are an integral part of the livelihoods of pastoral communities where they play both tangible and intangible roles. However this important genetic resource is faced with challenges that make it vulnerable to extinction and consequently threatens the livelihoods of its primary dependants. The objective of this study was therefore to conduct a population viability analysis (PVA) of the main herd of the breed at the National Sahiwal Stud (NSS) so as to predict the likely future status of the herd population under the current management practices. Population viability analysis was conducted using VORTEX version 9.98 to assess its extinction probabilities and to compare different management scenarios. The results showed that the population size was predicted to increase at a deterministic rate of 12.5% and stochastic rate of 3.2% per year before any truncation due to limited carrying capacity (K). Female mortality prolonged generation time for both males and females whereas male mortality had no effect on generation time. High proportion of breeding males improved genetic diversity of the herd while increased breeding females increased the viability of the herd. The study revealed that the Sahiwal population is stable and not going extinct, as theoretically perceived.

Keywords: Extinction, Management, National Sahiwal Stud

Introduction

An increasing number of livestock breeds are at a risk of extinction due to changes in production systems, mechanization, loss of rangeland grazing resources, drought, floods, disease outbreaks, inappropriate breeding policies and practices, and increasing human population growth (FAO, 2007a). Over the past 15 years, about 300 of 6000 breeds of farm animals identified by the Food and Agriculture Organization (FAO) have become extinct (Scherf, 2000; FAO, 2007b). Literature survey revealed that sub-Saharan Africa is home to a total of 145 cattle breeds, out of which 47 (about 32%) are considered to be at risk of extinction (Rege, 1999). Already a total of 22 breeds (about 13%) previously recognised in the continent have become extinct in the last century (Rege, 1999). According to a report by Reist-Marti *et al.* (2003), nearly half of the current cattle diversity and cattle breeds in Africa will be lost in the next 20-50 years if conservation measures to reverse this trend are not developed and implemented.

Current phenomena that include climate change and rapid population growth makes conservation of livestock species that our future food supply could someday depend upon vital. They provide important benefits and have many valuable characteristics such as disease resistance, extreme climate tolerance, high milk production, and the ability to utilize poor pastures (FAO, 2007b). It is therefore crucial to assess the extinction probabilities of livestock breeds whose statuses are not yet known so as to develop and implement management measures that would increase survival of such breeds. Populations with comparatively low effective population sizes and long generation intervals are particularly vulnerable to the risk of extinction (Zachos *et al*., 2009). Sahiwal cattle breed is one such breed with relatively small sub-populations located in Asia and Africa (Ilatsia *et al*., 2011a).

Despite its immense economic contributions to the livelihoods of pastoral communities, the breed faces several challenges that include high risks of inbreeding, drought related challenges, competition from exotics and indiscriminate crossbreeding (Ilatsia *et al*., 2011a; Ilatsia *et al*., 2011b). Therefore, the Kenya Sahiwal cattle breed is vulnerable to extinction and consequently a population viability analysis (PVA) is crucial so as to form the basis for putting in place strategies that will enhance conservation and sustainable utilization. The objective of this study was therefore to conduct a PVA of the main herd of the breed at the National Sahiwal Stud (NSS) so as to predict the likely future status of the breed population. A sensitivity analysis was also carried out to determine the most influential parameters affecting the breed viability.

Methodology

The modeling exercise required a set of parameters to describe the biological characteristics and stochastic events of the herd. The herd was chosen because it constitutes purebred Sahiwal cattle and is the leading source of breeding stock for both pastoralists and other nucleus herds. The input parameters were as follows: breeding system, age of first reproduction, age of reproductive senescence, offspring production, breeding pool, mortality, catastrophe, carrying capacity (K), population augmentation and harvest, iterations and years of projection, inbreeding depression, and initial population size.

Data analysis

Population viability analysis was conducted to assess extinction probabilities. In this study, VORTEX Version 9.98 software (Lacy, 1993) was used for the analysis. It simulates deterministic and stochastic factors affecting the dynamics of a population. Each simulation was run for 500 iterations, running 100years with quasi-extinction threshold defined as a population size less than 50 individuals. Demographic information was obtained for each projection at annual intervals.

Not all parameters included in the PVA model are likely to be equally important in influencing the population's long-term viability. Therefore a sensitivity analysis was performed to investigate the parameters most sensitive to the survival of the main herd of the Kenya Sahiwal cattle breed. The value of parameters used in baseline model and sensitivity analysis are summarized in Table 1. Each parameter was given variable levels while all other parameters were kept constant. The impact of a change of the selected parameters was assessed using VORTEX version 9.98.

Table 1. Input values for the baseline model and sensitivity analysis parameters

Parameter	Baseline model	Sensitivity test
Age of first offspring for males	2	2-10
Carrying capacity	3000	1500-6000
Initial population size	1200	250-3000
Maximum age of reproduction	15	9-20
Percent adult females breeding	85	5-85
Percent males successfully siring offspring	2.5	0.5-5
Percent mortality of females from age 0 to 1year	20	0-50
Percent mortality of females from age 1 to 2year	5	0-50
Percent mortality of females from age 2 to 3year	5	0-50
Percent mortality of males from age 0 to 1year	22	0-50
Percent mortality of males from age 1 to 2 year	5	0-50
Percent mortality of males from age 2 to 3 year	5	0-50

The sensitivity index for each parameter was calculated following Pulliam *et al*. (1992) as:

$$S_x = (\Delta x / x)/(\Delta P / P)$$

Where: Δx/x is the change in a parameter resulting from a change of ΔP/P in input variable P.

Results and discussion

The aim of the baseline model was to assess the current management scenario at NSS and to be used as a basis for conducting sensitivity tests. The prediction revealed that the Sahiwal population is stable and not going extinct, as theoretically perceived. Over the years, the population size is poised to increase gradually after which it will be constrained by the K. According to the results, the population size was predicted to increase at a deterministic rate of 12.5% and stochastic growth rate of 3.2% per year before any truncation due to limited K. However, the original heterozygosity of the population will be lost with time, an observation that is directly linked to the closed nature of the breeding programme, (Meyn and Wilkins, 1974), where there is very limited exchange of genes among the existing nucleus herds (Ilatsia *et al.*, 2011c). The basic model showed that generation length for males was shorter than for females. These results contradict an earlier preliminary study on the population structure of the breed by Muasya *et al*. (2011) that showed shorter generation length in dam lines compared to sire lines. This contradiction could be expected because the baseline model used in this study ignored the influence of progeny testing.

Sensitivity test

Carrying capacity: Increased K resulted in large population size after 100 years. Reducing K by half resulted in final population size decrease by 50.0% while doubling K increased the final population size by 62.7%. Carrying capacity had very minimal effect on population heterozygosity whereas doubling K increased heterozygosity of the population by 0.5% only. When K is fixed to a certain number of individuals, increasing the initial population size did not promote population growth. According to a field study by Ilatsia *et al*. (2011a), majority of Sahiwal genetic resources are owned by pastoralists particularly the Maasai. Thousands of hectares of land traditionally owned by the Maasai pastoralists in Kenya are being lost to commercial enterprises, mining, industries and urbanization. In addition to the frequent droughts experienced in these areas, the result would be reduced K of the land.

Initial population size: All other factors held constant, initial population size had no significant effect on both the final population size and genetic diversity after 100 years. This means that even when the initial population size is small, the genetic diversity of the initial population can be conserved reasonably well if the population growth rate and the K are large enough.

Proportion of breeding animals in the breeding pool: The simulations showed that genetic diversity of the breed population is improved when the proportion of breeding males in the breeding pool is increased. Increasing the proportion of breeding bulls by 2% increased heterozygosity of the population by 0.5%. The low percentage of breeding bulls in the NSS herd had no effect on population's viability but is not enough to sustain long term genetic diversity. Muasya *et al.*, (2011) reported low effective population size for the Kenya Sahiwal cattle breed which is also an indication of low genetic variability. Expansion and close interactions of the existing breeding farms would result in a concomitant increase in the number of available breeding bulls thus and reverse the decreasing genetic diversity. An increase in breeding females increased the viability of the herd. Reducing the proportion of adult breeding females to 30% caused a negative population growth rate and induced population extinction. Furthermore, it reduced mean final population size by 63.0% and induced loss of heterozygosity of the population.

Mortality: The sensitivity tests also revealed that changes in female mortality had strong effect on population growth rate. In contrast, male mortality (up to 50%) across all age classes had no significant impact on population growth rate. When mortality rate of females of all age groups increased, both deterministic and stochastic population growth rates decreased. Young females aged 0 to 1 year had the greatest influence on deterministic growth rate than the other age groups whereby a unit increase in mortality of this age group reduced deterministic growth rate by 8%. Also, the generation time for both males and females increased. The reduced impact of male mortality on population viability can be attributed to the polygenous mating system of the breed.

Age at first reproduction: The population losses up to 1.65% of its initial genetic variability when the age at first offspring of males is increased to ten years (i.e. progeny testing). The parameter has a significant effect on generation time for males explaining the long generation intervals in sire lines within the herd. Increase in maximum age of reproduction promotes population growth and conserves genetic variability of the population, while prolonging the generation time for males and females. The continuous use of genetically superior bulls for a long period without replacement at the NSS therefore contributes to the prolonged generation intervals of sire lines and therefore reduces the rate of genetic progress within the breed.

Conclusion

For the maintenance of the Sahiwal breed genetic diversity, it is necessary to increase the proportion of breeding males. Currently, breeding bulls are the only route for improving Sahiwals in the pastoral herds. Female survival was observed as key in ensuring persistence of the breed and therefore needs to be considered in management and breeding strategies. The most influential parameter affecting viability of the NSS population is the proportion of adult breeding females in the breeding pool. Genetic erosion of the herd can be controlled effectively through monitoring male mortality and increasing the number of available breeding males.

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Evaluating agro-ecological adaptation, farmers' preferences and on-farm socio-ecological niches of selected forage grasses and legumes in Sud-Kivu, Eastern DR Congo

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Abstract

Inadequate quantity and quality of livestock feed is a persistent constraint to productivity of mixed crop-livestock farmers in eastern Democratic Republic of Congo. Researcher and farmer managed on-farm trials were established in four different agro-ecologies, and data was collected between October 2012 and April 2014. Forage legumes included *Canavalia brasiliensis* (CIAT17009), *Stylosanthes guianensis* (CIAT11995) and *Desmodium uncinatum* (cv. Silverleaf, supplied as ILRI6765), while grasses were Guatemala (*Tripsacum andersonii*) and Napier (*Pennisetum purpureum*) French Cameroon and a local line. Agronomic performance was highly dependent on agro-ecological conditions. While all legumes showed similar performance on fertile soil (6.1-6.9 t DM ha^{-1}), herbage production was highly variable on poorer soils (0.3-4.1 t ha^{-1}). Guatemala grass produced less biomass (1.3-2.6 t ha^{-1} $season^{-1}$) than Napier (3.4-10.1 t ha^{-1}) across sites. Farmers ranked forages according to selection criteria chosen by them – mainly biomass production, animal

preference and drought tolerance. Farmers preferred *C. brasiliensis* (mid to low altitude sites) and *D. uncinatum* (high altitude site) and French Cameroon. Socio-ecological niche trials revealed that the choice of forages and integration into farming systems depend on topography, land availability and tenure. In high altitude, erosion prone sites with high population pressure, grasses were preferred over legumes and mainly grown on field contours (53-60% of farmers) and anti-erosive hedges (25-30%). Across all sites, forage legumes were most often intercropped with maize and cassava. Future research is needed to assess uptake of improved forage technologies and impact on livestock productivity and farmers' livelihoods.

Keywords:. Mixed crop-livestock systems, Napier grass, *Desmodium uncinatum*, *Canavalia brasiliensis*, *Stylosanthes guianensis*

Introduction

Farmers in eastern Democratic Republic of Congo (DRC) traditionally are mixed crop-livestock farmers. From 1996, cattle has become target of war and mixed farming was threatened with complete breakdown, lacking manure to sustain intensive cultivation (Cox, 2012). Continuous conflict has severely reduced livestock holdings to 0.2 - 0.5 Tropical Livestock Units (TLU) which is too low to satisfy subsistence or regular sale (Maass *et al.,* 2012; Ouma *et al.,* 2012). However, livestock presents a credible pathway out of poverty. Despite its low productivity, the flexible smallholder backyard production systems provide a steady source of animal protein for household consumption and sale when need arises (Maass *et al.,* 2013). Consequently, livestock property, especially cattle, is an important wealth criterion for farmers (Zozo *et al.,* 2010). In addition to a general lack of knowledge and skills in animal husbandry and lack of access to veterinary services (Zozo *et al.,* 2010), scarcity of quantity and quality livestock feed, especially in the dry season, is considered one of the main constraints for livestock production. Grazing on natural pasture and collection of roadside grasses constitute the main feeding system, while only 37% of farmers cultivated forages on small plots contributing 6% to the livestock diet (Bacigale *et al.,* 2013). Improved forages could play an important role in improving livestock production while decreasing soil erosion and improving nutrient cycling. Previous research has evaluated adaptability of forage shrubs (Katunga *et al.,* 2014a) and herbaceous legumes in Sud Kivu (Katunga *et al.,* 2014b). For this study, researcher-managed agronomic trials as well as farmer-managed socio-ecological niche trials with few shortlisted forage legumes and grasses were established in four sites with contrasting agro-ecological conditions in order to evaluate i) agro-ecological adaptation of improved forages grasses and legumes; ii) farmers' preferences for improved forage species; iii) on-farm niches for forage grass and legume cropping.

Materials and Methods

The experiments were conducted in four sites with contrasting agro-ecological conditions representative of Sud Kivu: Muhongoza and Nyacibimba (Kalehe and Kabare territoires, high altitude), Tubimbi (Walungu, mid-altitude) and Kamanyola (Walungu, low altitude) (Table 1).

Table 1. Study site characteristics

Site	Altitude (m)	Longitude	Latitude	Slope (%)	Soil fertility	Erosion
Muhongoza	1548	02°04'491"	028°54'450"	5 - 10	Medium	Medium
Nyacibimba	1955	02°29'626"	028°47'654"	>10	Low	Strong
Kamanyola	940	02°44'885"	029°01'847"	<5	High	None
Tubimbi	1100	02°47'821"	028°35'382"	<5	Low	None

The first trial, the Forage Legume Trial (FLT), tested the species of *C. brasiliensis* CIAT17009, *S. guianensis* CIAT11995 and *D. uncinatum* cv. Silverleaf. These legumes had previously been shown to perform well in the study area (Katunga *et al.,* 2014b). Seeds were obtained from Karama Research station of the Rwanda Agriculture Board (RAB) in Eastern Rwanda. *D. uncinatum* cv. Silverleaf is already naturalized in the study area and was used in this trial as local check. The second trial, the Forage Grass Trial (FGT), used three varietal materials namely *P. purpureum* cv. French Cameroon, *P. purpureum* local and *T. andersonii*. Cuttings of *P. purpureum* cv. Cameroon and of *T. andersonii* were retrieved from

INERA Mulungu while those of *P. purpureum* local were obtained from the respective sites and used as local check. The two trials were established in a completely randomized block design and lasted six months from October 2012 to April 2013. Chemical fertilizers and pesticides were not applied. Fresh biomass was harvested only once inside an area of $1m^2$ (for FLT) by cutting any green material 15 and 10 cm above the soil (for *C. brasiliensis* and *S. guianensis/D. uncinatum* respectively) whereas for FGT the fresh biomass was cut above 50cm inside a surface of $6m^2$ in order to allow regeneration of the plants. A homogeneous sample of at least 100g was collected on each of three replications for each forage variety. Samples were oven-dried at INERA-Mulungu at 75°C during 48 hours to obtain dry matter content (DM). The percentage soil cover was observed before harvest of biomass, referring to the Braun-Blanquet method (Podani, 2006). The average height of plants (in cm) was taken on five plants in each plot from the plant snare up to the top of the leaf without taking into account the floral part. Farmers individually ranked fodder they preferred according to the selection criteria provided by themselves. An additional on-farm study was carried out from October to December 2013 to assess socio-ecological niches for forages. 79 interested farmers per site volunteered to test cultivation of improved forages in their fields. Two packages were availed to each farmer: a package of forage legume seeds (*C. brasiliensis CIAT17009*, *S. guianensis CIAT11995*, *L. purpureus CIAT22759* and *Desmodium distortum*) of about 60-100 g for each species and a pack of at least 40 cuttings per speculation of grasses whose Guatemala (*T. andersonii*) and Napier (*P. purpureum*) cv. French Cameroon and the local one. Farmers were free to choose where and how to integrate this forage materials in their farming systems. Descriptive analyses and graphs were made using Microsoft Office Excel. The variance analysis was made for each parameter and the AMMI test (Additive main effects and multiplicative interaction) for GxE interactions for the FLT and ANOVA for unbalanced FGT due to the bare plots observed in Kamanyola for Napier, local variety. These analyses were effective using the statistical softwares R 2.4.0 console and Genstat Discovery Edition 3. Duncan's test based on the least significant difference (LSD) was used to separate the means.

Results

Agronomic performance

The agro-ecological conditions of different sites influenced the DM yield in FLT ($P<0.001$), without any effect between the varieties ($P=0.86$) except in Nyacibimba where we observed two yielding groups with *D. uncinatum* being the best forage (Table 2). Also for the height, the influence of the sites was very large ($p<0.001$) without any significant difference between species ($p=0.51$). Soil covering largely depended on site conditions ($p<0.001$) and the varietal genotypes ($p<0.001$) tested under the FLT. *C. brasiliensis* performed best in terms of height and soil cover, except in Nyacibimba where *D. uncinatum* was best for the two parameters.

Table 2. Dry matter yield (kg ha^{-1}), height (cm) and soil cover (%) of the tested forage legume species

	Species	Site			
		Nyacibimba	Muhongoza	Kamanyola	Tubimbi
DM yield (kg ha^{-1})	*C. brasiliensis*	2117,94b	3213,99 ^{a}	6887,49 ^{a}	1522,35 ^{a}
	D. uncinatum	5433,02^{a}	2611,50 ^{a}	6091,97 ^{a}	322,08 ^{a}
	S. guianensis	1642,28^{b}	4153,36 ^{a}	6690,96 ^{a}	2128,58 ^{a}
$LSD_{0,05}$ interaction= 1691,2	F	23,038**	3,15ns	0,19ns	2,52ns
	LSD $_{0,05}$	1689,9	1717,9	3738,5	2275,9
Height (cm)	*C. brasiliensis*	36,93^{b}	48,42 ^{a}	45,67 ^{a}	40,38 ^{a}
	D. uncinatum	61,73 ^{a}	27,62^{b}	53,33 ^{a}	15,11^{b}
	S. guianensis	30,90^{b}	42,34^{ab}	53,13^{a}	41,45 ^{a}
$LSD_{0,05}$ interaction= 11,08	F	15,85*	4,11ns	1,9ns	25,40**
	LSD $_{0,05}$	16,154	20,584	16,65	11,707
Soil cover (%)	*C. brasiliensis*	66,67^{b}	86,67^{a}	96,67^{a}	68,33^{a}
	D. uncinatum	100,00^{a}	66,67 ^{b}	68,33 ^{b}	16,67a

	S. guianensis	37,50[c]	65,00 [b]	73,33 [b]	63,33 [b]
	CV (%)	9,79	5,37	12,76	31,62
$LSD_{0,05}$ interaction= 16,14	F	66,53***	28,55*	6,68ns	9,97*
	$LSD_{0,05}$	15,094	88,608	22,982	35,443

Values within a row with different superscripts differ significantly (p<0.005)

For the FGT (Table 3), the ANOVA analysis showed that the three forage varieties behaved very differently in each site with regard to the DM yield (p<0.001), the plant height (p<0.001) and soil cover (p<0.001). Two DM yielding groups are formed across all the sites with *P. purpureum* cv. French Cameroon always in the first group. The same variety grew higher everywhere except in Nyacibimba where the local *P. purpureum* showed a best height parformance. In Muhongoza and Kamanyola, all the grass varieties covered the soil in the same way as they formed only one homogeneity group, whereas in Nyacibimba and Tubimbi two groups were observed after ANOVA analysis with *P. purpureum* cv. French Cameroon providing the best soil cover.

Table 3. Dry matter yield (kg ha^{-1}), height (cm) and soil cover (%) of the tested forage grass species

	Species	Site			
		Kabare	Kalehe	Kamanyola	Tubimbi
DM yield (kg ha^{-1})	*P. purpureum* cv. French Cameroon	5594,20[ab]	3455,17[ab]	10119,70[a]	3586,82[a]
	P. purpureum local	7479,61[a]	6203,56[a]	-	1918,16[b]
	T. andersonii	1261,63[b]	2369,82[b]	2586,18 [b]	2414,53[a]
$LSD_{0,05}$ interaction=3549	F	4,81ns	4,92ns	53,09**	0,37ns
	$LSD_{0,05}$	5710,9	3499,9		5541,9
Height (cm)	*P. purpureum* cv. French Cameroon	228,93[a]	239,10 [b]	280,80[a]	238,13a
	P. purpureum local	270,07[a]	278,83 [a]	-	183,27[a]
	T. andersonii	143,93[b]	116,90[c]	149,40 [b]	156,10[a]
$LSD_{0,05}$ interaction= 3549					
	F	23,81**	592,83***	53,49*	2,82ns
	$LSD_{0,05}$	51,601	13,623	77,461	
Soil cover (%)	*P. purpureum* cv. French Cameroon	80,00 [a]	64,00 [a]	83,33 [a]	73,33 [a]
	P. purpureum local	66,67 [b]	70,00 [a]	-	40,00[b]
	T. andersonii	66,67 [b]	78,33 [a]	86,67 [a]	86,67 [a]
$LSD_{0,05}$ interaction=14,99	F	16,00**	3,83ns	0,21ns	10,40ns
	$LSD_{0,05}$	7,5565	14,447	31,258	29,266

Values within a row with different superscripts differ significantly (p<0.005)

Participatory evaluation

Generally, the preference of these forages by farmers were guided by the following criteria: 1) FLT: biomass production, leaf size, animal preference, recovery and adaptation (drought tolerance); and 2) FGL: biomass production, animal preference, adaptation in the area, their use in erosion control, their tillering power and the newly introduced variety in the area like the *P. purpureum* cv. French Cameroon. For the FLT (Fig 1a), the first choice in high altitude was *D. uncinatum* (40% of choice in Kalehe and 70% in Kabare) and the second choice was *C. brasiliensis* (46% in Kalehe and 55% in Kabare) with a low consideration of *S. guianensis* in Kabare. In mid altitude (Tubimbi) and low (Kamanyola) altitudes, the first choice among legumes was brought on *C. brasiliensis* (61.11% and 70% respectively) and the second chosen

legume was *S. guianensis* (55.56%) and *D. uncinatum* (50%) respectively for Tubimbi and Kamanyola. In FGT farmers were much more attracted by the on-ground vigour of the different materials. Thus *P. purpureum* cv. French Cameroon, a new variety which quickly adapted to the area and produced enough biomass was the first choice across all the sites (86% in Kalehe, 70% in Kabare and 61.11% in Tubimbi) except in Kamanyola where it was second ranked (60%) after *T. andersonii* (38.89%) which is already used against erosion and for livestock feeding. Gender had no influence on the choice of forages.

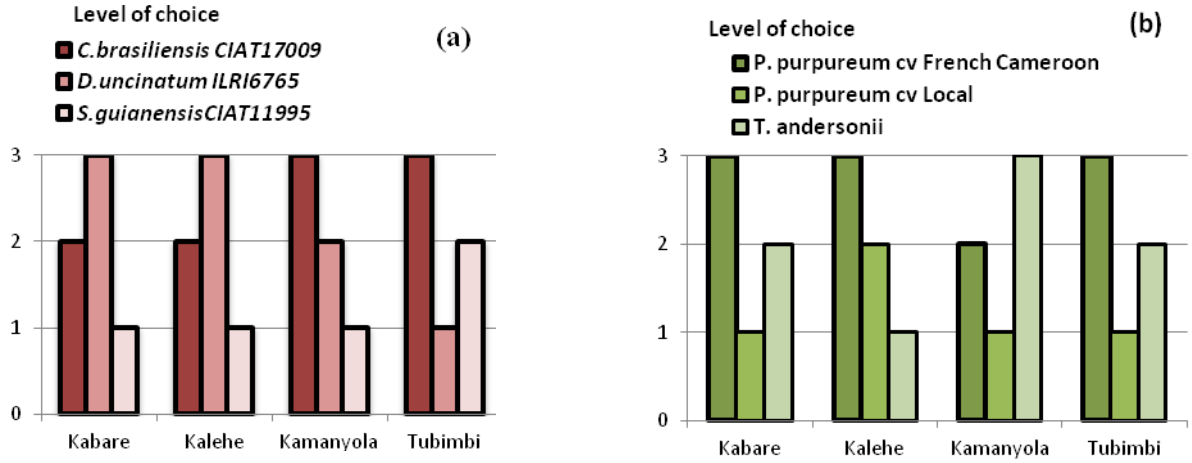

Figure 1. participatory variety selection of (a) forages legumes and (b) forage grasses

Socio-ecological niche

Overall, women were more active in on-farm experimentation of improved forages across all the sites with 73% of volunteering farmers being female. In total, 79 farmers participated in the on-farm trials (data not shown). Farmers' choice for on-farm cultivation of improved forages was different and related to land size and topography. In general, most of farmers (51%) chose to grow legume and grasses simultaneously. In Kabare and Kalehe (high altitude), the majority of farmers preferred to experiment with grasses only and those who cultivated legumes did so on small plots only (Figure 2a). This is due to the mountainous topography and the scarcity of arable land. In Kamanyola (low altitude), 75% of interested farmers grew legumes due to the land ownership system. Smallholder farmers survive through a seasonal or annual land hiring system, where cultivation of perennial grasses is not allowed by the landlords. Also, freely roaming animals in the village do not allow controlled forage cultivation around households. In Tubimbi (mid altitude), 74% of farmers decided to grow both grasses and legumes (Fig. 2a). Farmers' integration of forages into their farming system varied according to sites as well as the botanical family of these forages (Figure2b). In Kabare and Kalehe grasses were integrated around field edges (60% and 53% respectively) and in hedgerows for erosion control (25% and 30% respectively). The choice of these socio-ecological niches can be explained with scarcity of arable land due to high population pressure and the mountainous topography and high altitude of these two sites. The same trend was observed among 53% of farmers in Tubimbi, but 47% of farmers also cultivated forage grasses in pure stands near the households. Forage legumes were mostly intercropped with other crops such as maize and cassava across all sites. Especially in Tubimbi, legumes were planted on small plots around the homesteads and mixed with natural forages in order to improve nitrogen intake of animals or (Fig. 2b).

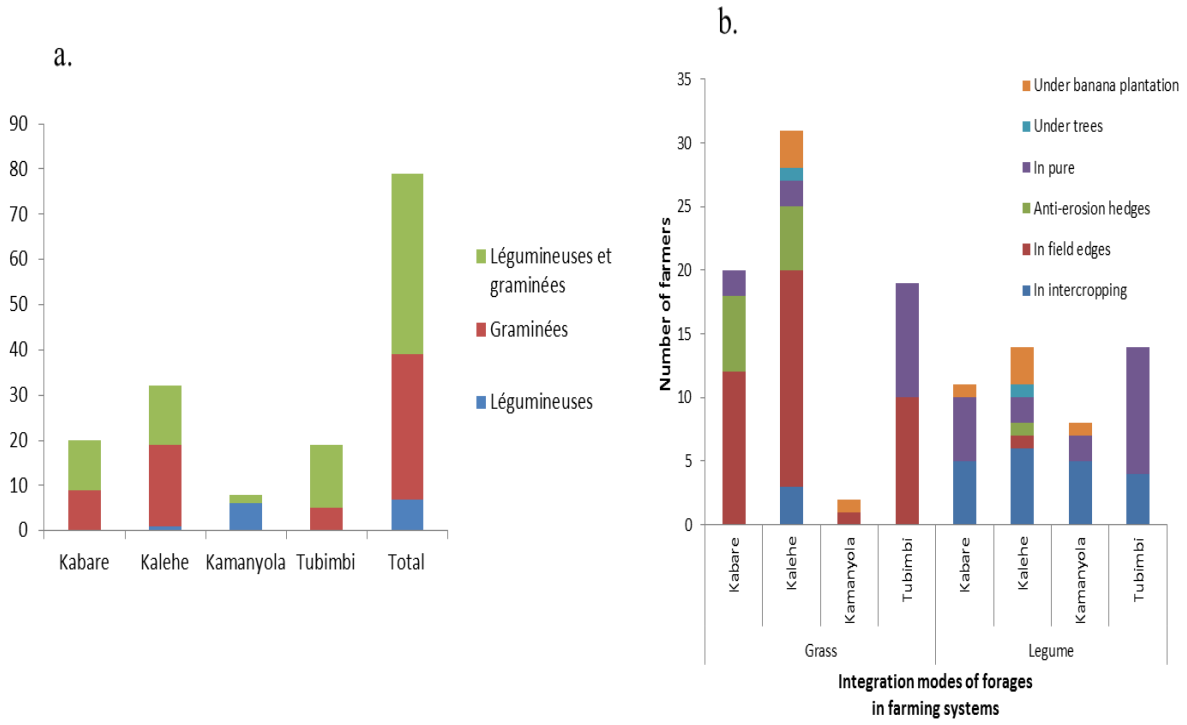

Figure 2. Types of forages cultivated (a) and integration of forages into farming systems (b)

Discussion

The results showed that forage legumes behaved differently in the different study sites. *S. guianensis* showed a stable production of biomass in all the four sites. This confirms findings from other studies which have shown that *S. guianensis* adapts well to all climates (Husson *et al*., 2008) and a variety of soil conditions (Wortman and Kirugu, 2008). However, the biomass produced in the four sites was lower than that obtained in Madagascar (Husson *et al*., 2008). Biomass yield of *D. uncinatum* varied across all the four sites although it performed well, except in Tubimbi. Highest production was observed in Kamanyola and the lowest in Tubimbi, this is probably due to the fertile soil in Kamanyola and the plant diseases and pests that are observed in Tubimbi (Katunga *et al.*, 2014b). *C. brasiliensis* covered the soil well; that is why it is also mainly used as green manure and in fallow and erosion control (Burle *et al*. 1999). The participatory varietal selection revealed that *D. uncinatum* is the first farmers' choice in high altitude sites (Kabare and Kalehe). The farmers' choice is dictated by biomass production and especially by its preference by small animals. In low and mid altitude sites (Kamanyola and Tubimbi), *C. brasiliensis* was most preferred by farmers. In these areas, the biomass production was the main selection criteria for farmers, except in Tubimbi where *S. guanensis* is second choice because of its preference by small animals.

P. purpureum yielded good biomass in all sites. However, the best yields were observed in Kalehe and Kabare (high altitude) for the local variety and in Tubimbi and Kamanyola (low and mid altitudes) for French Cameroon variety. The local variety did not perform well in Kamanyola which is probably due to the hot and dry climate (Maass *et al*., 2010). Biomass produced by *P. purpureum* within the range of observations made in other studies under non-fertilization (Mannetje, 1992). However, French Cameroon showed higher yields than those obtained when *P. purpureum* was grown in association with forage legumes in eastern Kenya (Njoka-Njuri *et al*., 2006) and less than those found in Western Kenya (Nyambati *et al*., 2010). *T. andersonii* generally covered the ground well and due to this it is an attractive option for erosion control in the area. Participatory selection of grasses revealed that *P. purpureum* cv. French Cameroon is generally the first choice by farmers, except in Kamanyola where the choice was focused on *T. andersonii*. Farmers were interested in the variety French Cameroon because it is new to the area, but also because of its high biomass production.

The socio-ecological niche trials revealed that in general women were more interested in cultivating forage crops. However, the preference of forage type and the integration into farming systems did not depend on gender, but on topography of the area, land availability, land tenure and the dominant animal husbandry systems. Therefore, in Kabare

and Kalehe (high altitude), where the topography is mountainous with land prone to erosion, farmers preferred to cultivate forage grasses at the edge of fields and on hedgerows. This result is also related to the small land average land sizes available to farmers, as is the case throughout South Kivu where households survive with an average of 0.4 ha (Ouma *et al*., 2012). On the other hand, legume forages are preferred by farmers if perennial cropping is not allowed due to land tenure, divagating animals and land without erosion problems.

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Feasibility of biogas digesters in rural farm households: evidence from cattle producers in the Tigray region of northern Ethiopia

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Abstract

Given several options of energy sources, biogas digester is one of the environment friendly technologies to address the current energy crisis particularly in developing countries. Land degradation caused by continuous deforestation for domestic traditional energy use has become by far the most crucial subject in the dryland areas of northern Ethiopia, Tigray. This study was conducted to investigate whether the biogas digesters introduced in northern Ethiopia have contributions in replacing the traditional energy sources. Panel data gathered during 2010, 2011 and 2012 from the districts of Hintalo-Wejerat and Ofla in the Tigray Regional State was used for this purpose. A total of 300 households were selected to estimate a 99% confidence interval for the mean yield of Teff. The sampled respondents were interviewed using semi-structured questionnaires enriched with ideas gathered from group discussants and key informants. The descriptive cost-benefit comparisons and econometrics results revealed that though the biogas digesters contributed in replacing the traditional energy sources, many farmers still depend on fire-wood consumption because of lack of injera stove. It was further found that the amount of bio-slurry applied on farm plots during 2010, 2011 and 2012 was 31, 47.5 and 63.3 quintals respectively. Although the bio-slurry that came from the biogas digesters was with its superior nutrient content, the farmers applied insufficient quintals per hectare on their land plots. This calls for farm-based extension services through trainings, workshops, demonstrations, information dissemination, and experience sharing to increase their knowledge on the use of biogas energy and bio-slurry.

Key Words: Ethiopia, Biogas, Bio-slurry, Fixed-effect, Fuel-wood

Introduction

In recent decades, there have been keen concerns about environmental issues mainly related to unsustainable use of biomass energy in the developing countries (Oyedepo, 2012). The research findings reported by Bystriakova *et al*. (2005) showed that 55% of the wood exploited from forests is for fuel-wood energy consumption. For example, tropical deforestation is responsible for 20 to 25% of global CO2 emissions (IPCC, 2000; Moutinho, 2005). In terms of greenhouse gases emissions, global deforestation is accountable for its consequent impacts by about 17% to 25% of the total release (Strassburg et al., 2009). Biomass energy source is particularly important for most of African countries, whereby more than 90% of the fuel-wood is extracted from natural forests (Amankwah, 2011); this is because the majority of the people do not have access to electric power (Bugaje, 2010). In the continent, the extensive use of forest land for fuel-wood energy, agricultural expansion, and the decrease in animal waste materials and plant remnants into the soil are the major causes for land degradation (Brown, 2006; Mshandete and Parawira, 2009; Arthur *et al*., 2011). Given several options of energy sources, many researchers have advocated biogas technology to address the above energy crisis particularly in Africa.

Although various research works have been done on the promising contributions of biogas technology across many parts of the world (Smil, 1993; Richard, 2008; Bakhareva, 2008; Abbasi, 2010; Chand *et al*., 2012), information regarding Africa, particularly of Ethiopia, is still at its early stage and needs further continuing study (Dawit, 2012; FAO, 2013). Besides, most of the existing researches have been done using cross sectional dataset gathered from a single year, which could not allow us to see the impacts of biogas plants on farmers' crop productivity, and energy replacement (Baltaji, 2005). So as to fill such gap, this study was intended to use panel data of three years with special reference to northern Ethiopia, Tigray. The introduction of biogas technology in Ethiopia is very crucial because the country is home to the

largest cattle population in Africa and it is one of the most biomass-energy dependent countries in the world (Dawit, 2012).

Like that of the nation, in the Tigray Regional State, many people rely heavily on biomass for cooking and lighting thereby contributing to deforestation, loss of soil nutrients, and depletion of organic matter (Zenebe *et al*., 2010). In recognition of the problem of deforestation due to unsustainable biomass use in the area, the overall purpose of this study was, to investigate the role of biogas digesters in replacing fuel-wood energy and crop productivity.

Materials and methods

Region description and sample size

This research was based on panel data gathered during the years 2010, 2011 and 2012 from the districts of Hintalo-Wejerat and Ofla in Tigray Regional State. The altitude of the study areas range 1500 to 2540 and 2100 to 2450 meters above sea level for Hintalo-Wejerat and Ofla respectively. The household survey was then carried out within each panel year (2010-2012). Data for this study was collected via survey of farmers that have installed biogas digesters through the government program. Since these two districts have been chosen by Ethiopian Ministry of Energy and Mining for pilot demonstration to the entire areas, this study was also concurrently purposed to investigate the contributions of biogas adoption to the rural farmers. Out of the total 942 cattle owners already adopted biogas digesters, 300 households were randomly taken and sampled proportionately for 36 females and 264 males.

Descriptive and econometric analyses

To analyze the contributions biogas digesters, comparisons of costs and benefits were made using descriptive statistics such as frequencies, percentages, measures of central tendency and dispersion. The strength and direction of relationships between different selected independent variables and the level of biogas contributions were examined using statistical tests. In order to identify the actual contributions of biogas digesters across the three years of panel data, fixed effect model was used to eliminate the time invariant unobserved effects. A panel data analysis is an important tool used to identify the effects of explanatory variables on the dependent variable Teff_kg in this case. Teff (scientific name Eragrostis tef.) is the major cereal crop cultivated in Ethiopia, used mainly to make flour. Teff_kg is our dependent variable which may help to see the impact of bio-slurry that comes from the biogas plant on farmers' crop production in the study areas.

Results

Socioeconomic status of the respondents

The average age of the respondents was estimated about 46.4 years with a minimum of 24 and maximum 74. On average, each household was constituted by the family members of 5.5 having a minimum of 2 and maximum 11 members. Of the total interviewed respondents, 264 were male biogas adopters whereas the remaining 36 were females. The overall land size in hectare cultivated by the respondents was about 1.97. Each respondent owned an average number of 8 cattle, where the mean cattle possessed by each farmer varied between a minimum of 5 and maximum 14.

Estimated expenses to erect biogas digesters

All expenses necessary for the construction of the biogas digester include initial costs, material costs, operating costs, and opportunity costs. While the industrial materials and skilled labor accounted for Birr 4900 was shared by the local government and was recognized as social cost since it is the incremental costs for the government, the individual farmers took part to cover 60 percent accounted for Birr 6900 of the total cost. In the study areas, the total cost required for functioning a biogas plant was estimated to be about Birr 11397. The mean annual expense saved due to the installation of biogas digester was Birr 1196 which would have been gone to purchase firewood, charcoal and kerosene.

Benefits of biogas technology for the rural people

The amount of money saved from fire-wood, charcoal and kerosene energy sources after biogas installation was Birr 294, 902 and 72 respectively. The t-test statistics revealed that the mean difference in annual expenses for energy consumption before and after biogas installation was estimated to be statistically significant at less than 1% probability level. Further, the average saved money that replaced chemical fertilizers of both urea and DAP by bio-slurry fertilizer was estimated to be 1118 birr which had statistically significant difference compared it with before adopting biogas at 1% probability level.

Financial and econometric results of biogas digesters in Tigray

The biogas digesters in the study areas were presumed to be viable economically feasible if the Net Present Value (NPV) is positive, the internal rate of return (IRR) is greater than the existing capital cost (interest rate) and a payback period of less than seven years. The major indicators whether the biogas digesters in the study area are feasible or not have been tested using the financial indicators such as benefit-cost ratio (1.72) greater than unity, Net Present Value (NPV) was 1114.03 which is greater than zero and Internal Rate of Return (IRR) about 8% exceeding the existing interest rate (5%). The regression result of fixed effect model shows that bio-slurry has statistically significant effect on the crop yield, Teff at 1% probability level.

Discussion

The disproportionate number of males and females is in agreement with the study done by Dawit (2012), in which he indicated the persistence of unbalanced share of burden of collecting and managing traditional fuels by women eventually results in disproportionate lack of access to education and income, and inability to get away from poverty. In adopting biogas digesters, the major cost components were starting capital, operation and maintenance throughout its lifetime. According to Thu *et al*. (2012) the biggest problem observed with fixed dome digesters for rural farmers is investment costs. Likewise, the big cost in the study area was the money spent on initial investment which accounted for Birr 11, 239. The annual operation cost spent during the three panel years was on average Birr 293.

In the study area, the average cattle holding was estimated about 5.2 which enabled them to adopt biogas technology which in turn promotes the replacement of firewood and charcoal by biogas energy and the use of its by-product (bio-slurry) for boosting the production of organic farming. As indicated by Chand *et al*. (2012), biogas is sustainable source of energy that can be used for an indefinite period without damaging the environment. Apart from energy consumption, the extended use of biogas technology could reduce GHG emissions and help launch low carbon-growth strategies (WB, 2011). In the study area, the amount of money saved from charcoal and fire-wood energy sources after biogas installation was Birr 294 and 902 respectively. The substitution of fuel-wood energy sources by biogas energy can mitigate climate change by sequestrating carbon in the form of conserving the natural forest (Abbasi, 2010). Moreover, the amount of money saved from kerosene energy utilization due to biogas installation was Birr 72. This finding conforms to the study made by Gautam *et al*. (2009) that in many areas where biogas has been installed, the use of kerosene has decreased considerably while it needs to be imported from outside otherwise.

The average amount of bio-slurry applied on farm land during the years 2010, 2011 and 2012 was 3100, 4750 and 6330 kg respectively. A meaning full comparison for the effects of slurry applications on Teff yield on the same plot (P1) during 2010 and 2012 shows that the amount of bio-slurry on farm plot (P1) attributed for Teff yield increment from 904 kg to 1214 kg. This finding is by far smaller than the amount recommended by FAO (2013); which was found that Indian farmers generated two tons of bio-slurry manure per year from a 1m³ of biogas digester. Furthermore, Vasudeo (2005) has indicated that the amount of bio-slurry needed to prepare one hectare of land and to entirely substitute the purchase of chemical fertilizers (DAP and UREA) is five tons of bio-slurry fertilizer per season.

Although the bio-slurry that comes from the biogas digester has superior nutrient content, the biogas adopters in the districts of Ofla and Hintalo-wejerat only applied insufficient quintals/ha of slurry fertilizer on their land plots during the three consecutive years. The increased amount in the yield of Teff implies that the application of bio-slurry fertilizer contributes to enrich the soil fertility of their plots which led to increase farm yield. This is consistent with the findings indicated by Edward (2012) in the sense that bio-slurry application on farm plots increases 60% of crop yield. Hence, the increased amount of Teff yield that comes from the increasing application of bio-slurry using the biogas digesters further shows the positive contribution of bio-slurry as organic fertilizer.

Conclusion and implications

This study has aimed to find out the feasibility of biogas digesters as source of energy for replacing fuel-wood as well as the use of bio-slurry as organic fertilizer for improving crop yield with reference to Teff crop. The study indicated that farmers have made crop yield improvements due to the application of slurry from biogas digesters across the three panels. In the case of energy contributions from biogas digesters, fire-wood saved was estimated to be 100 to 200 kg and charcoal was 300 to 500 kg. Though the annual consumption of fuel-wood decreased from 17.0 quintals to 9.8 quintals each year,

majority of the households still depend on fuel-wood consumption due to lack of injera stove. The application of bio-slurry for substituted chemical fertilizer with saved money of Birr 656 and 868 respectively for DAP and UREA. The econometric results further confirmed that the bio-slurry was statistically significant at 1% probability level and was positively related with the dependent variable teff yeild. In light of expanding the contributions of biogas technology, the following issues might help to promote its utilization among the rural dwellers and to enlarge its accessibility as widely as possible:

- Enable the farmers to be fully detached from using fire-wood and charcoal by providing cooking and injera stoves.
- Conduct farm-based experiments on the applications of compost, bio-slurry, chemical fertilizer, and mix of each aiming for demonstration and experience sharing, thereby increase crop yield.
- Famers should know how much bio-slurry is required to totally substitute the chemical fertilizers and the level of mix of bio-slurry with DAP and urea.

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Past dairy feeding interventions and lessons learnt in Tanzania

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Abstract

Seasonality of feed resources availability in terms of quality and quantity is a common feature in Tanzania. Most of the time the animals are poorly fed hence, their production potential is not realized. Therefore, increased milk production from the existing dairy herd will depend on on-farm feed interventions that ensure year-round availability of both quantity and quality of feeds offered to the animals. A number of feeding interventions have been tested in different parts of the country, some with good results. Introduced technologies included cultivation of fodder grasses that was a package with heifer in trust programs and other projects; treatment of crop residues with urea that was introduced in Kilimanjaro and Arusha regions. Strategic crop residue harvesting through stripping and topping of stover for dry season feeding was introduced in Kilimanjaro region. Supplementation of dairy animals with concentrates at different levels of offer and urea molasses mixtures have also been introduced in different parts of Tanzania. Despite their technically demonstrated usefulness, the socio-economic dimension was rarely considered and, therefore, adoption and sustainability of these interventions have been low (at about 15%) or even abandoned after the end of project. Possible causes for low adoption are suggested to be the short duration of the projects, or high capital investments and low transfer of technology from one generation to the next. This paper reviews such interventions and adoption status for teasing out the possible lessons learnt and strategies to be taken for improved uptake of dairy production technologies and innovations.

Keywords: Dairying, Feed interventions uptake, Institutional set up, Underfeeding

Introduction

Increased milk production from the existing dairy herd in Tanzania will depend on feeding interventions because most animals are underfed and, hence, their production potential is not realized. A feed intervention is a process of overcoming the barriers that prevent proper feeding of dairy animals according to their requirements in terms of quantity and quality of feeds offered. The main source of feed for dairy animals in Tanzania is from rangelands regardless of the production system used to raise them (Kimambo *et al.*, 2007). Feed availability in the rangelands is seasonal, where feed is enough for three months during the rainy seasons, while it is scarce both in quantity and quality during the dry seasons (Msangi *et al.*, 2001). Thus, the main constraint for livestock that rely on rangelands is lack of good quality feed throughout the year. Most smallholder dairy farmers do not cultivate forages but depend on natural pastures available in communal areas, forests and wetlands (Mtengeti *et al.*, 2008).

For landless smallholder farmers who rely on rangelands for feed, dry season feeding is also a big problem. Farmers can travel for long distances to search for green chop in the wetlands and riverbanks. In so doing, the cost of feeding becomes very high and, in many cases, the animals are underfed during this period. As a result, the products from such a system become expensive and often unavailable. After reviewing some of the typical feed interventions and assessing their current use, we discuss possible reasons for success or failure.

Establishment of cultivated pastures and fodder

To minimise the reliance on natural pastures as a source of feed for dairy animals, the practice of cultivating forages on farm has been introduced and adopted in some farming systems. For instance in Kilimanjaro and Arusha regions, planting of high-yielding forage plants, such as Napier grass (*Pennisetum purpureum*), *Setaria* spp. and multipurpose trees (MPTS) was driven by the high price of milk for the producers and scarcity of feeds due to land shortage. Intensive forage gardens of grass/legume intercrops in the Tanzanian highlands produce yields of more than 48 tons/ha of fresh material (Mtengeti *et al.*, 1989). This cut-and-carry system requires forage species that re-grow throughout the growing season. Thus, bi-annuals and perennials are suitable forage species and more popular than annuals because they reduce labour requirements. Project farmers to whom the technologies for increased fodder production were introduced showed a positive impact of technology adoption and milk production. However, due to limited resources in terms of project duration, money and planting materials, the technologies were not widely disseminated.

The introduction of cultivated fodder crops as contour ridges as a means of land management for controlling soil erosion in Lushoto and Amani highlands, Usambara Mountains in Tanga region, has made the adoption of the technology fairly sustainable (Teendwa *et al*., 2007). However, studies by Massawe (1998) in Mgeta, Morogoro region revealed that the uptake of cultivating high-yielding forages including Setaria (e.g., *Setaria splendida*), Guatemala *(Tripsacum andersonii*) and *Leucaena leucocephala*, accompanying the introduction of dairy goats in this area, was not evident 10 years after the end of the project, even though both the number of goat-keeping farmers and the number of goats had increased. This observation may imply that farmers found their traditional practices better than the introduced strategies due to availability of natural pasture and shrubs throughout the year in this area.

Improved use of crop residues

Crop residues as dry season feed are widely used in Kilimanjaro and Arusha regions; most commonly these are rice straw, maize stover, bean straw and haulms, and banana plant residues (Shem *et al*., 1995). Utilization of crop residues by ruminants is generally poor due to high fiber and lignin levels. Different techniques for improving the quality and, hence, utilization of crop residues as feed for dairy cattle have been introduced and tested in the 1980s and early 1990s. These techniques included chopping, partitioning and treatment with urea. Chopping was achieved through tractor-mounted chaff cutter or manual use of knife. Chopping minimises selection and facilitates blending the stover with urea-molasses mixture and treating with urea

Crop residue partitioning involves removal of the nutritious leaves and top part of the stem for feeding. While the lower part of the stem being discarded for use as fuel or left in the field for soil conservation purposes. This innovation was introduced and adopted in Kilimanjaro region in the 1980s. This technique improved intake and minimized transport costs of stover from the lowlands to the highlands (Massawe, 1999). Stripping before the leaves are totally dry, particularly for maize, produce good quality residue. Said and Wanyoike (1987) in Kenya showed that it was possible to harvest 1 ton/ha of dry matter of green maize through defoliation before the grain harvest without affecting the final grain yield. In the study in Tanzania by Shirima (1994), where different stover harvesting techniques were practiced, he reported higher nutritive value of stover stripped before grain harvest, where crude protein (CP) content and *in vitro* organic matter digestibility (IVOMD) were 10.8% and 75.3%, respectively, while that harvested after grain harvest was 3.3% for CP and 51.7% for IVOMD.

Table 1. Effect of urea treatment of different straws on crude protein (CP) content and dry matter (DM) degradability of the treated and untreated crop residues in Tanzania

Type of straw	CP content (% DM)			Source
	Untreated	Treated	Change CP (%)	
Bean straw	8.0	13.0	+5.0	Mgheni *et al*. (1991)
Bean straw	4.9	7.8	+2.9	Kimambo *et al*. (1991)
Maize stover	4.0	8.9	+4.9	Kilongozi, 1992
Maize stover large scale (Kilimanjaro)	3.0	7.2	+4.2	Kimambo *et al*. (1991)
Maize stover small scale (Kilimanjaro)	2.3	10.6	+8.3	“

Rice straw	4.3	11.6	+7.3	Mgheni *et al*. (1994)
Maize stover	5.7	14.7	+9.0	Kiangi, 1979
Wheat straw	4.7	13.8	+9.1	“
Rice straw	3.7	14.8	+11.1	“
	48 h Dry matter degradability (%)			
Bean straw	52.4	51.0	-1.4	Kimambo *et al*. (1991)
Bean straw	58.0	53.7	-4.3	
Maize stover	43.5	57.4	+13.9	Kilongozi, 1992
Maize stover large scale (Kilimanjaro)	66.4	72.1	+5.7	Kimambo *et al*. (1991)
Maize stover small scale (Kilimanjaro)	64.9	71.5	+6.6	Kimambo *et al*. (1991)
“Maize stover small scale (Kilimanjaro)	61.9	72.0	+10.1	Kimambo *et al*. (1991)
Rice straw	61.7	64.3	+2.6	Mgheni *et al*. (1994)

The improvement on the quality of maize stover and rice straw by treating them with urea was introduced and tested in Kilimanjaro and Arusha regions by the Food and Agriculture organisation (FAO) Dairy Development Programme and Dairy feeding systems Research project in Hai district, Kilimanjaro region funded by IDRC (Canada) in the1980s (Ørskov,1987). The activities were implemented by both small and large scale farmers. The effects of urea treatment on improving the CP content and 48h dry matter degradability are shown in Table 1. In addition, increased ME intake from 54.9 for untreated to 60.8 MJ/day for urea-treated rice straw by growing steers was reported by Kimambo et al. (2002) and increased stover intake by growing bulls from 72.7g/KgW0.75 for untreated to 89.4g/KgW0.75 for urea-treated maize stover was stated by Kilongozi (1992). Higher milk yield was reported for cows fed urea-treated maize stover (10.1 Kg/day) than for those fed untreated stover (9.5 Kg/day) (Masimbiti, 2001). Similarly, Kilongozi (1992) observed an increase in body weight gain from 96.0 g/day for bull calves fed untreated stover to 236.9 g/day for those fed urea-treated stover, while Shem (1993) working in Moshi obtained an increase in DM intake from 2.5 Kg/day for untreated stover to 3.67 Kg/day for urea-treated and body weight gain from 104 g/day for untreated stover to 203 for urea-treated stover.

It is clear from Table 1 that urea treatment increased the CP content of the treated materials, but its effect on DM degradability was not clear having increased the degradability of rice straw and maize stover, but not the one of bean straws. Even though it was demonstrated that, treating both rice straw and maize stover with urea improved their quality, the technology was poorly adopted after the project. The reasons for low adoption could be high labour requirement for preparation of the stover before the treatment and the small benefit in terms of increased milk yield. The cost for urea as fertilizer was subsidized by the government, which made it cheap during that time. However, currently the cost for urea (1200 Tsh/Kg) is higher than that of cotton seed cake (450 Tsh/Kg). Therefore, it is unlikely that farmers will be tempted to use urea for improving the CP content of straws. Thus, locally available and much cheaper chemicals for improving the quality of these popular feeds need to be researched.

Use of manual box baling

Maize stover is the most important crop residue fed to dairy cattle in Kilimanjaro region. This feed is normally harvested or gathered from the lowlands and transported to the highland areas where dairy cattle are kept. The main constraint in using this feed is the high transportation cost (Massawe, 1999) because it is transported in loose form. To make transport of larger loads possible, manual box baling was introduced. Baling increased the load weight in a 1 ton pickup from 160 Kg to 262 Kg air-dried weight and reduced the cost of transportation from 106 to 71 Tsh per Kg DM of stover (Massawe, 1999).

The technology of manual box baling has been adopted by individual farmers, where it was introduced and used not only for maize stover but also for other conserved forages. However, when this technology was introduced to people who were selling forage along the road side, it was not adopted (Massawe, 1999) because it decreased the bundle size, hence, lowered its value. It would appear that this technology would have been more adopted if it was introduced to the potential buyers of forage because if they demanded for baled forage then the sellers would have to bale it.

Use of urea molasses mixture/block

Urea molasses mixture to supplement poor quality roughage was introduced in Kilimanjaro region by an FAO Dairy development program (Ørskov, 1987). Urea molasses mixture was prepared in collaboration with a Sugar Company in Moshi, and the product was transported to the villages using tankers and stored in storage tanks that were installed in different villages. Farmers could purchase small amounts of the mixture according to their requirements. Feeding of urea molasses mix with bean straw during the dry season maintained high intake of straw of up to 10 Kg per day and milk yield of 5.8 Kg/day (Shem 1986). Similarly Nkya *et al*. (1999) observed an increase in DM intake from 10.1 Kg/day to 12 Kg/day and milk yield from 6.7 l to 11.2 l/day when cows receiving adlib grass hay and 6 Kg of maize bran were supplemented with urea molasses blocks, while supplementation with urea molasses mixture increased milk yield from 6.7 to 8.8 l/day. Similarly, the growth rate of grazing dairy heifers during the dry season was improved from 76 g un-supplemented to 203 g/day for those supplemented with urea molasses block. Also energy and protein intake were more than doubled (Aboud *et al.*, 1999). Uptake of the technology was good when the project was functional, but it was only maintained for three years after the project ended. The main weakness identified that led to non--sustainability of the project was the lack of an entrepreneur who would have distributed the molasses urea mixture that was previously distributed by the project as perceived by the farmers. In addition, privatization of the sugar company reduced the government control on how the company was run and increased the price of molasses. Moreover, molasses urea mixture was also used for illegal distillation of local alcohol, where the use of urea molasses mixture was considered a better raw material than pure molasses.

Supplementation techniques for increased milk production

Different supplementation techniques for increased milk production have been introduced and tested. Feeding of concentrates to dairy animals was one of the packages that were introduced with heifer in-trust projects in different parts of the country. This is probably the most widely known feeding intervention although the extent of adoption differs in respect to formulation and quantity to be offered. Mixing ratio of 3 parts energy source and 1 part protein source and feeding of 2 Kg during the morning milking and 2 Kg during the evening milking were suggested (Teendwa *et al*., 2007). The recorded increase in milk yields per cow per day were 3.5 l in Tanga, (Urassa, 1999), 2.62 in Kibaha (Urassa *et al.*, 2011) and 4.8 in Arumeru (Urassa *et al*., 2013). However, adoption rate of concentrate feeding has been low where it was introduced. A study in Tanga (Teendwa *et al*., 2007) showed that, even though more than 97% of farmers were aware of the technology of feeding concentrates to dairy cattle, only 15% were practicing it. Urassa (2012) found that farmers were feeding about 2 Kg/cow/day of concentrate in Kibaha and 2.5 Kg/cow/day of concentrate in Arusha instead of the recommended amount of 4 Kg/cow/day. The reason for this type of adoption is the perceived concept that concentrate feeding was expensive (Lyimo, 2003). In fact, sometimes the ingredients are expensive when purchased in small quantities compared to bulky purchase.

The low uptake for concentrate feeding where farmers were compounding feeds at a different ratio and feeding smaller quantity than that recommended by the experts could be due to high cost of the feed ingredients, unavailability and low price of milk, which makes it uneconomical to supplement as perceived by the farmers (Teendwa *et al*., 2007). However, studies on concentrate supplementation in Tanga revealed that increase in supplementation over what the farmers were feeding was economical with profit margins ranging from 114-184 Tsh/cow/day. Similarly, Urassa *et al*. (2011, 2013) observed a doubling in milk yield and profit margin per cow per day that ranged from 228-263 Tsh in Kibaha and 964-1229 Tsh in Arumeru, when properly formulated concentrate was fed on top of what farmers were feeding. Lack of credit facilities for purchasing inputs could also contribute to the low adoption rate and intensity of adoption. Studies in Arumeru district where the use of different cheaper sources of ingredients, such as bran of pigeon peas and green gram to replace part of maize bran (for concentrate formulation) was introduced, adoption was limited by the inability of the farmers to purchase the different ingredients individually. However, when a stockiest was encouraged to purchase and formulate the dairy concentrate, several non-project members copied the practice (Urassa *et al.*, 2013).

Use of water melon as a source of water and protein supplement

Water melon (*Citrullus vulgaris*) was tested on-station at Mpwapwa research institute (Shayo *et al.*, 1996; 1997) and its use later up scaled in some villages in Dodoma and Singida regions, and more recently in Hanang district of Manyara

region. It was found that chopped water melon in a bucket of 20 liters is equivalent to 20 liters of normal drinking water. About 1.6-4.8 tons/ha are produced equivalent to 1.6-4.8 tons of water. Water melons are used during the dry season in agro-pastoralist communities for the calves and pregnant cows that cannot walk long distances searching for water and feeds. Water melon seeds are used as protein supplements and were found to increase hay intake and milk production.

Conclusion and recommendation

Several technically sound feed interventions for improved dairy production have been introduced in Tanzania. Uptake of such technologies and innovations beyond project duration has been low. Socio-economic considerations may have lacked so that appropriateness and cost of the technologies and methods used for dissemination could have hindered uptake. There is, therefore, not only a need to change approaches or the method of dissemination of some proven technologies to farmers, but also location-specific socioeconomic conditions need to be investigated.

Lately, multi-stakeholder innovation platforms have been established in Tanzania that may help overcome most important constraints first, before feed interventions have greater chance of adoption. Finally, the scarcity of published research with focus on feed interventions for dairy in Tanzania is striking and deserves greater attention in capacity building and extension.

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Effects of season and location on cattle milk production and prices in selected villages of Tanga and Morogoro Regions, Tanzania

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Abstract

This study was conducted in four villages of Kilosa and Mvomero Districts in Morogoro Region and four villages of Handeni and Lushoto Districts in Tanga Region. The aim was to compare differences in cattle milk produced and milk producer prices based on location and seasons in the two regions. The study applied the Feed Assessment Tool (FEAST) for gathering data through focus group discussions and individual interviews. Data on rainfall patterns throughout the year, milk produced per household per day, and milk prices received in Tanzanian Shilling (TSh)/litre were gathered. The daily amount of milk produced per household was higher ($p \leq 0.05$) in Handeni (mean 28.7 litres) and Kilosa (mean 23.3) Districts than for Mvomero (mean 7.9) and Lushoto (mean 4.1) districts. There were also differences ($p \leq 0.05$) in milk producer prices, in Mvomero (mean 708 TSh), Lushoto (mean 491 TSh), Kilosa (mean 450 TSh) and Handeni (mean 425 TSh) with an overall range from 200-1000 TSh/litre of milk. Seasonality of rainfall had effects on both milk produced and milk prices. On the other hand, local feeding systems influenced milk produced per household, while marketing channels affected milk prices. More research on the use of innovation approaches to address issues of prices and seasonal milk supply, as well as training and use of improved forage technology were possible options recommended to achieve a year-round similar level of milk production.

Keywords: FEAST, Milk production, Milk price, Seasonality, Dairy value chain

Introduction

In Tanzania, like many other African countries, milk is produced mainly by small-scale farmers dispersed across the countryside, who are relatively isolated from the urban consumers. Their surplus production is small and often highly seasonal, in part owing to the low intensity of dairy production systems and their sensitivity to local weather conditions (Mdoe and Wiggins, 1996). Seasonality is reflected by large variations of milk production and supply between the months. There is a decrease in milk production and consumption levels being below domestic demands for milk and milk products in the past two decades (Swai and Karimuribo, 2011). According to Schooman and Swai (2011), privatization of the dairy sub-sector resulted in decontrolled prices for milk and milk products mainly in large cities and towns. It is within the urban and peri-urban areas where much of the marketed milk is consumed due to higher demand by the growing population (Kurwijila, 2002). Milk in rural areas is mostly consumed within the producing households, in surplus and less marketed during the rainy season; and in very low supply during dry seasons (ILRI, 2005; Schooman and Swai, 2011). The only common marketing channels exist through direct sales to consumers/neighbours and through smallscale milk vendors. This study explores seasonal variations in milk production and milk prices received among smallholder farmers, suggesting pilot options that may improve productivity and prices of milk. The general objective was to assess the influence of location and season on cattle milk production and producer prices in Morogoro and Tanga regions. The following research questions were addressed: What are effects of season on milk production and milk prices? What is the effect of location on milk production and milk prices? And what are the possible options for stabilizing milk production and producer milk prices?

Methodology

Description of the study area

The study was conducted within the MilkIT project in Kilosa and Mvomero districts of Morogoro region and Handeni and Lushoto districts of Tanga region. Selection of the districts was based on their production and marketing channels, either both production and marketing taking place in rural areas (‘rural-to-rural’ in Kilosa and Handeni districts) or production in rural but marketing to urban areas (‘rural-to-urban’ in Mvomero and Lushoto districts). Two villages were purposely selected from each district.

Sampling frame
Farmers were selected purposively representing each hamlet within a village, with reasonable representation of men and women. To assure representation of every hamlet, two focus group discussions (FGDs) were conducted in each village involving 20-25 persons per FGD; 6 to 7 farmers were selected from three wealth groups (based on land size or number of cattle) out of the FGD group for subsequent individual interviews. The interviews were done using the structured questionnaire of the Feed Assessment Tool (FEAST, version 5.3; Duncan *et al*. 2012). A total of 104 interviews were held from February to March 2013, involving 58 men and 46 women.

Data collection and analysis
The parameters assessed through individual interviews were average milk produced per day/household throughout a year and average price received for milk per litre. Data on rainfall pattern was collected through FGDs on a 0-5 scale and converted to a percentage. Collected data were compiled in the FEAST Beta data sheet and analyzed using MS Excel and SAS (2002). Pairwise comparisons between means of all variables were computed using the Duncan's Multiple Range Test (DMRT) at $p \leq 0.05$.

Results and Discussion

Annual rainfall distribution
Rainfall was highest from March to May in all districts, with the peak in April, and lowest from July to October except for Mvomero and Lushoto, where relatively high rainfall was also experienced in October and November, respectively (Figure 1).

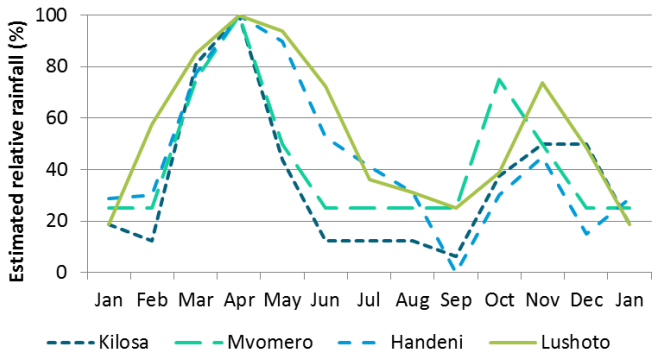

Figure 1. Average amount of rainfall throughout the year in four districts in Tanzania

Average household milk production in four districts (location effect)
Average milk produced per household per day was higher ($p \leq 0.05$) in Handeni and Kilosa than in Mvomero and Lushoto (Table 1). The difference is marked between the feeding systems practised in the areas. Zero-grazed improved cows usually produced more milk per cow (up to ten times) compared to the traditional zebu cattle, which were mainly kept under extensive systems (Kurwijila *et al*., 2012; NBS, 2007/2008). The difference between feeding systems may implicate the very different levels of milk produced (White *et al*. 2002). In addition, the districts with a dominant practice of extensive/pastoral systems (Handeni, Kilosa and partly Mvomero) had a substantially higher average milk produced per household compared to the district with semi-intensive/zero grazing systems (Lushoto) due to the large number of cows milked in the former. The increased amount of milk produced or supplied in Tanzania is mostly reflected by number of cattle, rather than improved productivity (Kurwijila, 2002).

Table 1. Estimated average daily milk production per household in four districts of Tanzania

	Milk produced (litres/ household/ day)			
District	N	Mean	SE	Range
Kilosa	311	23.8[a]	2.12	0.25 – 48
Handeni	256	28.7[a]	2.33	0.50 – 53
Mvomero	272	7.9[b]	3.09	1.00 – 12

Lushoto	146	4.1[b]	2.24	0.50 – 27

*Least squares means with different superscripts are significantly different ($p \leq 0.05$)

Average household milk production in different months of the year (seasonal effect)

The seasonal trends of milk production per household in the different districts mostly reflect the rainfall pattern, except for Lushoto (Figure 2). Smallholder dairy systems are portrayed to be highly sensitive to local weather, thus, affecting milk production (Mdoe and Wiggins, 1996). During the rainy season, milk produced was high due to availability of pasture (in terms of biomass) for grazing and water for the animals in extensive production (Handeni, Kilosa and Mvomero) as well as for animals that rely on collected fodder in zero-grazed areas (Lushoto). Currently, the milk yield level in Lushoto is below the amount of at least 15 litres per cow per day to be expected from improved cows (Msanga and Kavana, 2002).

During the dry season, the decline in milk production per household, especially in the extensive system, is highly likely due to shortage of water and pastures as shown by low rainfall and decline in quantity and quality of available feeds, which are among the major constraints towards increased milk production in Tanzania (Mdoe and Wiggins, 1996; Mtengeti *et al*. 2008; Njombe *et al*. 2011). The uniform distribution in the amount of milk produced from January to October in Lushoto, with only a slight decline in November and December, could be attributed to the feeding system where farmers who practise zero-grazing search for green chop in the flood plains and on river banks and also supplement some concentrate to their animals. Access to supplementary feeds like concentrates was unlikely in the extensive areas where the animals relied alone on grazing natural pastures.

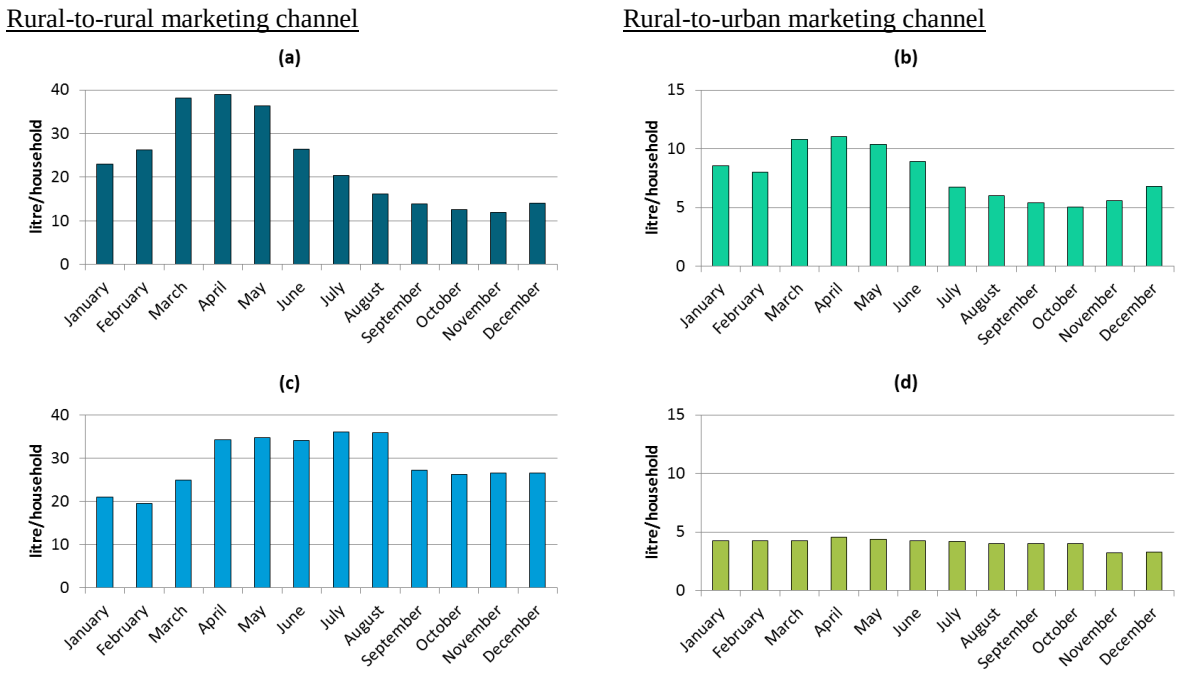

Figure 2. Estimated daily milk production in litre per household throughout the year in (a) Kilosa, (b) Mvomero, (c) Handeni and (d) Lushoto districts of Tanzania

Average milk producer prices (location effect)

There was a significant difference ($p \leq 0.05$) in milk prices among the four districts (Table 2). The higher milk prices in Mvomero could be due to the closeness to urban markets. For example, milk from Wami Sokoine village was sold to Morogoro Urban due to the short distance between the village and Morogoro Municipality. Similarly, Manyinga village, also in Mvomero, is situated in the urban surroundings of Turiani, near the settlement of people working in Mtibwa Sugar Company, which provides a market for the milk from the farmers. It has been shown that villages that are closer to urban and peri-urban market channels get higher prices and reliable markets for their milk, due to higher demand driven by urban population growth (Kurwijila, 2002; Muriuki and Thorpe, 2002). On the other hand, proximity to milk collection centres for dairy processing factories can have implications on milk price due to a monopoly-like price control (Cadilhon

et al. 2014). Farmers who sold their milk to processing factories like Tanga Fresh (Handeni, Lushoto, Kilosa and Mvomero) and Tan Dairy (Mvomero and Kilosa) claimed to receive lower prices as compared to those selling their milk directly to individuals or to kiosks. The latter had an opportunity for price negotiation, thus, likely to receive better prices than the former who had limited negotiation power. The organization of producers could complement the good practices of value chain development through their linkages and shareholding in the processing facilities, hence, the ability to effect on price control (NIRAS, 2010). The Tanga Dairy Platform, a multi-stakeholder forum, has already played a role in helping to increase the milk price for producers who deliver to Tanga Fresh Ltd. milk factory (Cadilhon *et al*., 2014).

Table 2. Mean (±SD) producer milk price in four districts of Tanzania

	Price of milk in TSh per litre #			
District	N	Mean	SE	Range
Kilosa	209	450.00[c]	8.37	200 – 700
Handeni	240	424.58[d]	7.81	200 – 1000
Mvomero	282	708.15[a]	7.21	400 – 1000
Lushoto	180	490.55[b]	9.02	300 – 600

[*]Least squares means with different superscripts are significantly different ($p \leq 0.05$)
At the time of research TZS100 ≈ US$0.06

Average milk producer prices in different months of the year (seasonal effect)

Higher milk prices in some months (Figure 3) corresponded to low milk production due to the onset of the dry season that decreases feed and water availability to the animals, thus, large numbers of cattle migrated to suitable grazing areas. This situation was severe in extensive systems. The indicated lower prices (Figure 3) during March to May reflect the season when rainfall is at the peak (Figure 1), and plenty of milk is produced (Figure 2). According to Kurwijila *et al*. (2012), seasonality of rainfall (and access to water) is extreme and reflected in producers' management of their animals' in dairy systems, resulting in severe seasonality in terms of milk volumes produced. Obviously, this affects milk price stability as well. There is still unclear information on the supply and demand of milk and the capacity of dairy processing industries to accommodate the plenty of milk available during wet seasons in Tanzania, and meet the increased consumer demand during dry seasons, on the other hand.

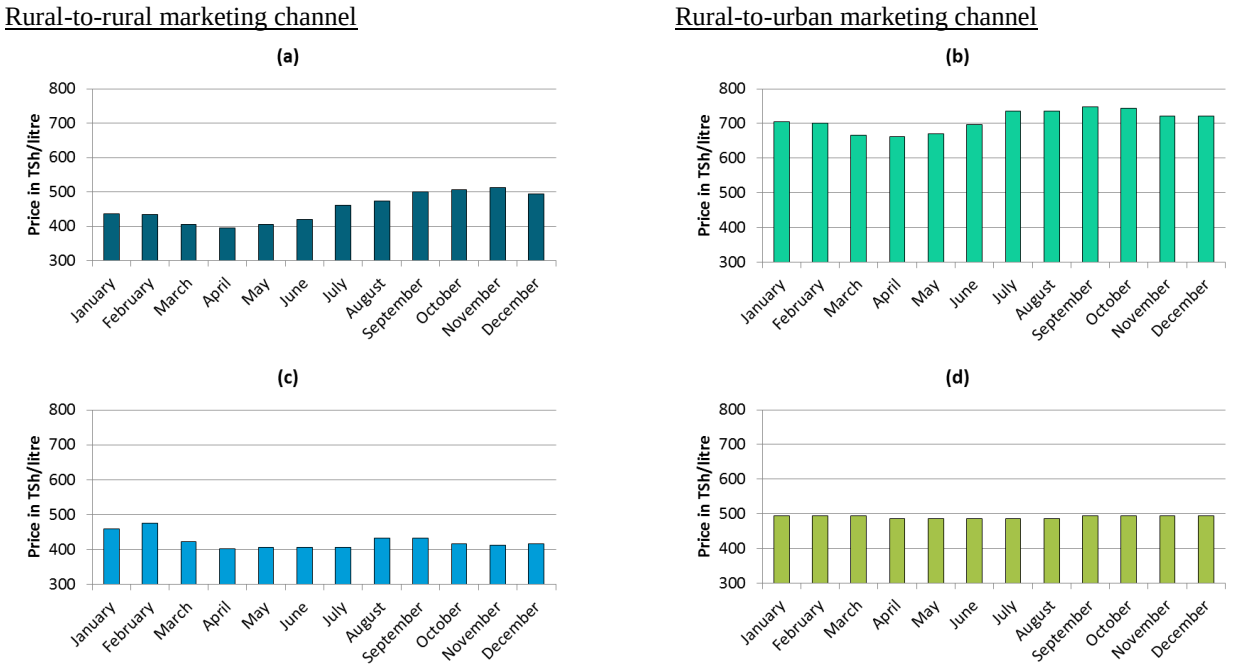

Figure 3. Average milk prices received throughout the year in (a) Kilosa, (b) Mvomero, (c) Handeni and (d) Lushoto Districts of Tanzania

Conclusions and Recommendations

Milk production per household in the four districts of Tanzania was affected by the number of milked cows relative to farming or feeding system practiced in the areas and the season of the year, while the milk producer price was influenced by marketing channels (rural-to-rural and rural-to-urban) and season of the year. The possible options recommended for optimizing milk production and stabilizing milk producer prices include; more research on how to stabilize milk prices in situations that will favour all actors along the milk supply chain, particularly producers, and ensure stable flows along the rural-to-rural and rural-to-urban marketing channels. Testing an innovation systems approach with multi-stakeholder platforms that facilitate linkages among different dairy value chain actors may be one pathway to success (Ayele *et al*., 2012; Cadilhon *et al.*, 2014). Also, drought-tolerant forages should be introduced that will reduce feed shortage, hence, help to support more uniform milk supply throughout the year and, eventually, stability of milk prices. However, research should focus more on understanding under which conditions producers are willing to take up improved feed/forage technologies than on the technology per se. Lastly, producers need regular training on how to enhance milk production and obtain marketing skills.

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Nutritional composition of sprouts/seedlings of cereal grains as feed for goats in intensive smallholder production system

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Abstract

A study was conducted with the aim of gaining information on the nutritional value of locally produced sprouts fodder from local cereal grains and the possibility of integrating it into smallholder farming systems. In this study maize/barley, maize/millet and maize/sorghum grains were grown in a hydroponic system for 7 days. The samples were analysed for their chemical composition, *in vitro* true dry matter digestibility (DMD) and minerals. Variation in chemical composition was observed among cereal sprouts and there was a difference ($P<0.01$) in DM, with maize/sorghum having the highest DM content of 250.9 g/kg DM and maize/barley having lowest DM content of 193.0 g/kg DM. There was a difference ($P<0.01$) in ash of cereal sprouts with maize/millet having highest content of 77.3 g/kg DM and lowest content was from maize/barley with 49.0 g/kg DM. Also a difference ($P<0.05$) was observed in crude protein, with maize/barley having high content of 159.6 g/kg DM and maize/millet with lowest content of 143.3 g/kg DM. Difference in NDF was highly

significant (P<0.01) with maize/barley having 71.2 g/kg DM and the lowest NDF observed from maize/sorghum with 62.2 g/kg DM. Significant difference (P<0.05) was observed on ADF of cereal sprouts (46.1, 59.8 and 37.2 g/kg for maize/barley, maize/millet and maize/sorghum respectively). Fat levels showed no significant difference (P>0.05) between the treatments. IVTDMD was not different (P>0.05; 825, 851 and 838 g/kg for maize/barley, maize/millet and maize/sorghum respectively between treatments. This results show that since smallholder farmers in Sub-Saharan Africa do not plant barley, millet and sorghum grains can replace barley in making green fodder. The quality of the sprouts or green fodder investigated here were of high quality as indexed by high digestibility. However, the management of highly wet material by smallholder farmers may be a challenge as well as competition for edible cereals between livestock and humans.

Keywords: Cereals, Crude protein, Digestibility, Fodder, Metabolisable energy, Sprouts.

Introduction

Botswana has human population of about 2.5 million and more than 80% of this population live in the rural areas and rely on Agriculture, mainly livestock production (Statistics Botswana, 2013). Botswana has a livestock population of 4.75 million ruminants (cattle, sheep and goats) of which 2.55 million are cattle, 1.7 million goats and 295,894 are sheep (Statistics Botswana, 2013). Livestock production meets only 20% of food needs of Botswana and beef exports accounts for 3% of the GDP of Botswana's economy (Statistics Botswana, 2013). Most of the farmers in Botswana prefer rearing goats as they are hardy and well-adapted to harsh climates conditions. This characteristic is desirable in poor grazing environments like natural pasture in Botswana. Sheep and goats are multi-functional animals and they play a significant role in the economy and life development of farmers (Statistics Botswana, 2013). They are important because they have the ability to convert forages, crops and crop residues into meat, fibre, skins and milk (Gutierrez-A, 1986). Also, sheep and goats can be used as security and they can also be used in ceremonial feasting like weddings and funerals.

According to Taylor and Bryant (2007), the short gestation period of sheep and goats coupled with their high frequency of multiple births allow for a rapid increase in animal numbers. This builds financial capital and allows the sale of surplus animals for cash that can be used to support families. There is increased demand of sheep and goats, which creates opportunities to improve food security of the population and alleviate poverty (FAO, 2004).

However, this system of rearing in the rural areas is faced with challenges. Drought is one of the challenges to livestock production by smallholder farmers. It affects livestock pastures and forage crop production and quality (Khan *et al.*, 2009). Coupled to drought, there is the continuous threat of feed shortage due to low and erratic rainfall. According Madibela *et al.* (2002), green forage/fodder is only available for up to a maximum of five months in a year in Botswana and livestock have to depend on cereal straws and other crop residues of poor quality for sustenance.

According to Dung *et al.* (2010), feeds given to livestock are of poor quality as it is harvested at full maturity, thus dry matter and quality are lost. About two-thirds of improvements in livestock productivity can be attributed to improved nutrition because about 70% of the total cost of that productivity is due to feeds (Gutierrez, 1986). (Khan *et al.*, 2009) stated that poor nutrition results in low production and reproductive performance which leads to slow growth rate, loss of body condition and increased susceptibility to diseases and parasites. Thus, effective utilization of the available feed resources and appropriate supplementation of poor quality natural pasture is necessary to alleviate the nutritional problems of livestock. New strategies and innovation are needed too. Some farmers are using sprouts to supplement their small stock. However, there is no research information about the nutritional attributes and animal performance after feeding grain sprouts in Botswana. This research was designed to generate information on the nutritional value of several local sprouted grains and the possibility of integrating them into smallholder farming system.

Materials and Methods

Site of study

The experimental materials were purchased at Botswana Agricultural Marketing Board (BAMB). The trial was carried out in a Bio-boost system, at Gold Star Goat Stud farm in Oodi village. The farm is located at a latitude of 24° 40'20.57 S, longitude 25° 56'02.25 E and at an altitude of 988 m. The mean rainfall for the area is 490 mm.

Sprout Production Unit

The Bio-boost system consists of non-transparent plastic trays with a series of vertical plant holding pockets filled with appropriate substrate and supplied nutrient solution. The trays are 1m in length and 0.5m in diameter with 16-18 pockets.

The space between planting pockets in rows was 0.1m. Small drainage openings are made at the bottom of each growing pocket, to allow nutrient solution to drain from pocket to the next. Light in the bio-boost system was provided by infrared lights. The irrigation system was electronically controlled and it delivered water at the optimum rate. Sprouts were irrigated for 3 minutes, in every 2 hours for 7 days. The temperature was controlled through the use of cooling system and Infrared lights depending on the temperature outside the bio-boost system.

Grain preparation

Six cereal grains were used for the experiment and these are millet, maize, Barley and Sorghum (Phofu variety).The grains were weighed into trays, with 0.5:0.5kg of each cereal grain used as a proportion for each combination of cereal grains. Combinations was of (maize: sorghum), (maize: millet) and (maize: barley).

Measurements and chemical analysis

After 7 days of germination, plant samples were randomly selected and transferred to an air oven for drying at 75°C for 48 hours. Dry matter, Ash, NDF (neutral detergent fibre), ADF (acid detergent fibre), CP (crude protein), and minerals were determined in duplicate using the Association of Analytical Chemists (AOAC, 1996) methods.

In vitro true dry matter digestibility (IVTDMD) was determined by incubating sprouts samples with rumen liquor in calibrated glass syringes (100 ml) following procedure of Menke and Steingass (1988) and using multi-layered polyethylene cloth bags, (F57 filter bags; ANKOM, Technology). At the end of the incubation (48 hours), bags were rinsed four times with distilled water, dried, weighed and placed in an ANKOM fibre analyser and boiled in neutral detergent solution for 60 minutes. IVTDMD was calculated as the difference between DM incubated and the residue after NDF analysis.

Statistical analysis

The General Linear Model (GLM) procedure SAS (2002-2008) was used to compare the differences in chemical composition and in vitro dry matter digestibility between cereals sprouts. Results were presented as mean ± standard deviation. All data from chemical composition was expressed as on dry matter basis.

Results and Discussion

Chemical composition (g/kg DM) and minerals of sprouts produced using a mixture of maize and barley, maize and millet, and maize and sorghum is shown in Table 1.

There was a significant difference ($p<0.01$) for DM between maize/barley, maize/ millet and maize/sorghum sprouts samples (Table 1). The difference in DM content may be due to large uptake of water during germination of the grains, resulting in a sharply reduction of DM content of maize/barley sprouts. Also low DM content can be beneficial to farmers who carry out small stock operations like goat farming in areas with water shortage as animals consume the majority of the water used on sprouts, along with the feed (Mansbridge and Gooch, 1985). This can reduce the required water for livestock.

There was a difference ($P<0.01$) for ash content of maize/barley and maize millet and maize/sorghum sprouts which can be attributed to the disappearance of starch which is turned into sugars during sprouting and this led to high amount of ash.

Table 1. Chemical composition (g/kg DM) and minerals of sprouted cereal grains.

Parameters (g/kg DM)	Maize/barley	Maize/millet	Maize/sorghum	STD DEV	P- value
DM	193.0^{c}	209.2^{b}	250.9^{a}	25.21	0.0024
ASH	49.0^{b}	77.3^{a}	52.3^{b}	13.43	0.0015
PROTEIN	159.6^{a}	143.3^{b}	149.3^{b}	7.23	0.0166
FAT	76.5	76.2	79.5	1.89	0.3285
ADF	46.1^{b}	59.8^{a}	37.2^{b}	10.13	0.0103
NDF	71.2^{a}	68.2^{b}	62.2^{c}	4.08	0.0024

IVTDMD	825.1	851.5	837.9	17.5	0.4010
Ca (g/kg)	2.214[c]	4.48[a]	3.593[b]	1.02	<0.0001
P (g/kg)	0.38[c]	0.48[a]	0.41[b]	0.046	<0.0001

Means with the same letter are not different at 5% level. (P>0.05)

DM = Dry matter; ADF = Acid detergent fibre; NDF = Neutral detergent fibre; IVTDMD = in vitro true dry matter digestibility.

Higher ash content in a feed is important as it represent increased amount of minerals that are contained in a feed and there will be reduced needs for mineral supplementation. According to Morgan *et al*. (2002) as cited by McCandlish and Struthers (2009), the ash content of maize and barley sprouts differ with respect to the type of nutrient solution used in the sprout system. In this experiment, nutrient solution was used to irrigate the sprouts and it contained nitrates and chlorine. According to Morgan *et al.* (2002) as cited by McCandlish and Struthers, (2009), changes in ash contents occur rapidly from day 5-7 corresponding with the extension of the radicle (root), which allows the mineral uptake. Morgan *et al*. (2002), stated that enzymes of germination and sprouting have the ability to eliminate detrimental substances such as phytic acid, therefore liberating minerals hence making them readily available.

The results show that there was a difference (P<0.05) in the crude protein content of maize/barley and maize/millet and maize/sorghum sprouts (Table 1). Maize/barley sprouts had high amount of protein compared to maize/millet and maize/sorghum sprouts due to hydrolysis of prolamins that are found in barley grains and other amino acids such as glutamic and proline which are converted to limiting amino acids such as lysine, (Chavan and Kadam, 1989). Also large amounts of protein in maize/barley sprouts can be due to complex qualitative changes that occur during soaking of grains (Chavan and Kadam, 1989). Maize/millet had low protein content compared to other cereal sprouts. This can be attributed to high dry weight, particularly of carbohydrates, hence reduced loss of dry weight through respiration during germination (Chavan and Kadam, 1989).

There was no difference (P>0.05) in fat content of maize/barley, maize/millet and maize/sorghum sprouts. Their fat content is 76.5, 76.2 and 79.5 g/kg DM for maize/ barley, maize/millet and maize/sorghum sprouts respectively.

All cereal sprouts were different (P<0.05) in ADF content. High fibre content of maize/millet sprouts when compared to maize/barley and maize/sorghum sprouts is due to structural carbohydrates being the major component of seed coat and cell wall of the plant as it grows, (Shipard, 2005). Acid detergent fibre in sprouted barley increases markedly with time. Peer and Leeson (2005) stated that in sprouted barley crude fibre, a major constituent of cell walls, increases both in percentage and real terms, with the synthesis of structural carbohydrates, such as cellulose. Chung *et al*. (1989) found out that the ADF content of barley sprouts increased from 37.5 to 46.5g/kg from day 3 to day 7 of sprout production. In un-sprouted barley grains ADF content is 60g/kg. These results reported by these researchers are similar to those observed in the present study. There was a significant difference (P<0.01) in NDF content. High NDF content in maize/barley sprouts may be due to lower energy levels of in barley grains. Hillier and Perry (1999) reported that sprouted barley cereal grains have NDF weighs of around 70.23 g/kg DM due to low starch being catabolized to soluble sugars for use in respiration and cell-wall synthesis. Decreased amount of NDF are also not desirable in cereal sprouts as fibre is required for rumen muscle toning in ruminants.

There was no significant difference (P>0.05) in dry matter digestibility. However, a study by Getachew *et al*. (1998) suggested that, great IVTDMD is related to fibre (NDF) and its digestibility (ADL). In this study maize/barley and maize/millet had high NDF content of 71.2 and 68.2 g/kg DM than maize/sorghum sprouts which had NDF content of 62.2 g/kg DM, resulting in maize/barley and maize/millet sprouts having high IVTDMD than maize/sorghum.

The results indicate a highly significance difference (P<0.001 to P<0.01) in calcium and phosphorus. Maize/barley sprouts had the lowest amounts of calcium when compared to maize/millet and maize/sorghum sprouts. Calcium is required for bone and milk formation and has a buffering effect (neutralise excess acidity in the rumen), (Shreck *et al.*, 2011). However, excess calcium in diet depresses the assimilation of manganese and iodine (Shreck *et al.*, 2011). Phosphorus (P) levels of 0.38, 0.48 and 0.41 g/kg were found in maize/barley, maize/millet and maize/sorghum sprouts respectively. According to Chung *et al* (1989), barley, sorghum and millet sprouts contain phosphorus weights of 2.64, 2.87 and 2.85 g/kg respectively which were higher than those observed in the present study. Phosphorus takes part in the synthetic functions of the body, such as the production of glycogen and aids in the storage of the energy produced and in its transfer in small packages to localities and reaction centres where it is needed (Cowieson, 2005). Consumption of more than

3.0g/kg of phosphorus can lead to poor calcium homeostasis and osteoporosis in an animal (Yang *et al.*, 2001). Therefore levels observed here may be deemed ideal.

Conclusions and recommendations

The present study show that maize/millet, maize/sorghum can be used to substitute maize/barley sprouts which have been used for past years as all contain the same amount of energy and are all highly digestible. The results of this study shows that all cereal sprouts are highly digestible, therefore metabolism trials should be conducted to see the performance of animals when being fed these cereal sprouts.

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Effects of method of planting and napier grass varieties on number of planting material, dry matter production and survival of napier grass in coastal lowland Kenya

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Abstract

A study to determine suitable planting method for multiplication of planting materials of Napier grass varieties was done at Kenya Agricultural Research Institute (KARI) Msabaha in Coastal lowland (CL) agro-ecological zone 4 (CL4). The experimental design was Split-Plot with a factorial arrangement of three Napier grass varieties, *Pennisetum purpureum* Schumach, var. Bana (Bana), var. French Cameroon (French Cameroon) and var. Gold Coast (Gold Coast) as main plot and three types of planting material consisting of stem cuttings with different number of nodes (one, two, three nodes) as sub plots which were replicated three times. Data on number of stools, number of stems per stool and total number of nodes per treatment of the three Napier varieties were collected 11months after planting (MAP). Plant counts and forage dry matter yield data was collected thereafter every two months for one year. Napier grass established using three- or two-nodes cuttings maintained 37% higher number of surviving plants and produced 43% higher forage dry matter than that of the one- node. Bana and Gold Coast produced higher ($p<0.05$) dry matter yield than French Cameroon, while Bana and French Cameron produced higher number of planting material per acre. The three-and two-node cuttings proved to be suitable planting materials for long term dry matter productivity for all three Napier grass varieties.

Keywords: Napier grass, Planting materials, multiplication methods

Introduction

In coastal lowland Kenya, farmers practice mixed farming (Waaijenbeg, 1994). They grow maize and cassava crops as staple and for food security and keep local cattle, exotic dairy / crosses and local goats (Thorpe *et al*., 1992). They mainly rely on natural pastures (Reynolds *et al.,* 1993), which are low in quality and supply, and mainly under free grazing system (Muinga *et al.,* 1998). The milk production is low, ranging from 1.0-6.4 kg day^{-1} for local and exotic/cross cattle; and 1.0-2.0 kg day^{-1} for local and exotic/cross goats respectively (Ramadhan *et al*., 2008). Despite introduction of various fodder production technologies on-farm (Mwatate *et al.,* 1998; Ramadhan *et al., 2001*), the cultivated forages contributed less than 40% and 25% of dairy cattle feeding during the rainy and dry seasons, respectively (Muinga *et al*, 1998). Bana is a popular Napier variety introduced in smallholder dairy farms in the region. The area planted with cultivated fodder has been declining (Ramadhan *et al*., 2008). Lack of planting materials contributed to low adoption of planted forages and low profitability of farm enterprises (Mureithi *et al*., 1998). A study was therefore carried out to determine suitable methods of multiplying Napier grass planting materials in order to overcome shortage of Napier grass planting material on-farm. These methods are aimed at improving profits from sale of Napier planting material and increase fodder for feeding dairy cattle.

Materials and methods

Study area

The trial was carried out at KARI Msabaha 3°16'S, 40°03'E over a five-seasons period starting from the long rain of 2011 and ending after the long rain season of 2013. The soils at Msabaha centre are well drained, deep, low in available nutrients, and have low to moderate moisture storage capacity. The topsoil texture is sandy loam to sandy clay loam with low organic matter content. The site is in cashewnut-cassava zone (Jaetzold and Schmidt, 1983). There are two distinct rainfall patterns in the area, a long rain season from April to June and a short rain season from October to December. The mean temperature ranges from a minimum of 24–27°C in May-July to a maximum of 30-32°C during January to April.

Experimental design

Three Napier grass varieties were planted using three types of nodes cuttings (one, two and three node(s)). The experiment was planted during the 2011 long rainy season. The Napier nodes cuttings were planted in 27 plots, each measuring 3 m x 2.5 m and spaced 1.0 m x 0.5 m. The experimental design was split plot consisting three Napier grass varieties, Bana, Gold Coast and French Cameroon as main plots and three types of Napier nodes stem cuttings comprised of either one, two or three node(s), as a sub plot. The experiment was replicated three times. The plots were kept free of weeds and di-ammonium phosphates (DAP) was applied at a rate of 20 kg P ha^{-1}six weeks after planting and calcium ammonium nitrate (CAN) was applied at a rate of 75 kg N ha^{-1} in two splits in a year.

Data collection methods

Data was collected to determine optimum number of nodes in Napier grass planting material that would maintain plant survival and increase dry matter production of the three Napier grass varieties. The data included the number of life (surviving) stools, number of stems per stool and total number of nodes per unit treatment plot, 11 MAP. Thereafter, data on fresh weight of Napier grasses and number of surviving stools was taken in each plot on average of every two months for a year. Data was collected from surviving plants in a net plot of 2.5 m x 3 m (a maximum of 15 plants per plot). A 200 g sample was taken, oven dried at 105°C to constant weight and percent dry matter calculated to determine forage dry matter production. Data was analyzed using SAS GLM procedure (SAS, 1997) and means separated using least significant difference (LSD).

Results

There were no interactions ($p<0.05$) between Napier grass varieties and the number of nodes per stem cutting in DM production and plants survival. Establishment of grass using two or three nodes stem cuttings resulted in higher number ($p<0.05$) of surviving plants than one node stem cutting (Table 1). Bana grass maintained higher ($p<0.05$) number of surviving ($P<0.05$) plants across all cuts, compared to Gold Coast and French Cameroon.

Table 1. Number of surviving plants across different types of nodes cuttings and varieties of Napier grass at subsequent harvestings at KARI Msabaha

	Second harvest	Third harvest	Fourth harvest	Fifth harvest	Sixth harvest	Seventh harvest	Average harvest
Number of nodes in Napier grass cutting							
Three	10^{a}	8^{a}	10^{a}	10^{a}	8^{a}	7^{a}	9^{a}
Two	9^{a}	10^{a}	10^{a}	10^{a}	9^{a}	9^{a}	10^{a}
One	6^{a}	5^{b}	5^{b}	5^{b}	5^{b}	5^{a}	6^{b}
LSD	4	3	2	3	2	4	2
CV	50	33	22	32	36	25	23
Variety of Napier grass							
Bana	11^{a}	11^{a}	11^{a}	10^{a}	10^{a}	10^{a}	10^{a}
Gold Coast	9^{ab}	8^{ab}	9^{ab}	9^{ab}	7^{ab}	6^{b}	8^{b}
French Cameroon	6^{b}	6^{b}	6^{b}	7^{b}	5^{b}	6^{b}	6^{c}
LSD	3	4	3	3	4	2	2.3
CV	50	33	22	32	36	25	23

Values with differing letters within column are significantly different ($P<0.05$).
Note: Dates of harvesting for the second= 4-Jul-2012, third= 12-Sep-2012, fourth= 21-Nov-2012, fifth= 6-Feb-2013, sixth= 11-Apr-2013 and seventh= 4-Jul-2013

Dry matter production

Interactions of Napier grass varieties and numbers of nodes per cutting did not differ ($P>0.05$). Dry matter production of Napier grasses tended to decline with time of harvests and, overall, French Cameroon produced lower cumulative DM

(P<0.05) compared to Bana (Table 2). The Napier grass with greater than two nodes cuttings produced significantly (p<0.05) higher total DM yield than that with one node cutting.

Production of planting materials.

Bana and Gold Coast produced higher (P<0.05) number of stools and number of stems per stool than French Cameroon (Table 3). While three and two nodes cutting treatments produced higher number of stools than the one node treatment. Results also indicated that French Cameroon produced higher (P<0.05) total number of nodes per ha^{-1} than Gold Coast while there were no differences (P>0.05) between French Cameroon and Bana in production number of nodes**.** The three node cutting treatment produced highest total number of nodes per ha^{-1} (Table 3).

Table 2. Dry matter yield (ton ha^{-1}) of varieties and different types of nodes cuttings of Napier grass at subsequent harvestings at KALRO Msabaha

	Second Harvest	Third Harvest	Fourth Harvest	Fifth Harvest	Sixth Harvest	Seventh Harvest	Total Yield
Variety of Napier grass							
Bana	2.4^{a}	2.1^{a}	1.3^{a}	2.1^{a}	0.6^{a}	0.7^{a}	14.4^{a}
Gold Coast	2.4^{a}	1.4^{a}	1.1^{a}	1.5^{a}	0.3^{a}	0.5^{b}	12.2^{ab}
French Cameroon	2.5^{a}	1.9^{a}	1.2^{a}	2.2^{a}	0.6^{a}	0.8^{a}	9.9^{b}
LSD	1.91	1.45	0.64	1.52	0.44	0.14	2.63
CV	50	51	55	57	48	45	14
Napier grass node(s) cutting							
Three	2.7^{a}	1.8^{a}	1.4^{a}	2.0^{a}	0.7^{a}	0.7^{a}	14.1^{a}
Two	2.6^{a}	1.8^{a}	1.2^{a}	2.1^{a}	0.5^{a}	0.7^{a}	13.8^{a}
One	2.0^{a}	1.8^{a}	1.0^{a}	1.7^{a}	0.4^{a}	0.6^{a}	8.5^{b}
LSD	1.54	0.83	0.68	0.87	0.44	0.35	1.63
CV	50	51	55	57	48	45	14

Table 3. Number of stools, number of stems per stool, nodes per stool and total number of nodes per hectare of three Napier grass varieties and three types Napier grass nodes treatments at first harvest (11MAP) at KALRO Msabaha

Treatments	Number of stools	Stem per stool	Total node counts ha^{-1} (Number in million)
Napier variety			
Bana	11^{a}	7^{b}	3.236^{ab}
Gold Coast	10^{a}	6^{b}	2.100^{b}
French Cameroon	6^{b}	17^{a}	3.466^{a}
LSD	2	7	0.129
Napier node cutting	C		
Three	11^{a}	9^{ab}	3.667^{a}
Two	10^{a}	7^{b}	2.721^{b}
One	6^{b}	13^{a}	2.412^{b}
LSD	3	5	0.818
CV	20	29	21

Values with differing letters within column are significantly different (P<0.05).
Note: Date of first cutting = 25-Apr-2012

Discussion

Napier grass selection for dry matter production

Results showed that Bana produced higher dry matter yield than French Cameroon. The low yield of French Cameroon could be attributed to low number of surviving plants during the growing seasons compared to other Napier varieties (Table 2). In contrast, Wandera (1997) reported that, production of French Cameroon and Bana were similar in Kitale but Bana out yielded French Cameroon in Embu region. He reasoned out that production potential of different fodder grasses varied from region to region as influenced by rainfall pattern and age of the stand. Bana was is the most productive grass in higher rainfall areas (Agro-ecological zones CL3 and CL5) in the coastal region but produced lower dry matter yield than drought resistant Napier grass varieties, such as ex-Matuga and Pakistan hybrid, when planted in the coastal semi-arid lands (Njunie *et al.*, 2011 and Ramadhan *et al.*, 2011). Bana produced (p=0.05) similar number of planting material as French Cameroon, although the latter had low numbers of surviving plants. It was observed that French Cameroon produced a large number of nodes per hectare, compared to Gold Coast (Table 3).

Napier planting material selection

Napier grass planted using two- or three-nodes cutting maintained higher number of surviving plants than the one that used the one-node cutting (Table 1). Sumran (2009) reported that Napier could be established using cutting of two nodes under irrigation condition, producing up to 67 ton per hectare flesh weight material. On average, number surviving plants planted with one node cutting declined by 37%. Planting Napier using one node cutting have shown long term decline in DM by 43% lower than Napier planted with three or two nodes cuttings (Table 2). Farmers should, therefore, continue to establish Napier grass using current recommended size of three nodes cutting. Although establishment of Napier grass is labour intensive, planting three nodes cutting will ensure high survival rates, sustained high DM production and high number of Napier grass planting material (Table 3).

Conclusion

Three node cutting is suitable for long term dry matter productivity for all three Napier grass varieties and for high survivability and production of planting materials. Bana and Gold Coast Napier grass varieties are recommended as they maintain higher dry matter yield.

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Influence of parity and body condition at birth on initiation of postpartum ovarian activities in Friesian cattle

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Abstract

Adverse effect of postpartum body weight loss on resumption of ovarian function may be mediated by secretion of reproductive hormones. The effects of parity and body condition score at parturition on metabolic and endocrine profiles were studied using 30 Friesian dairy cows grazing on improved pastures. Milk production was recorded daily whereas body condition score was measured every 2 weeks. Metabolites and hormonal profiles were measured 30 days prepartum to 90 days postpartum. Non-esterified fatty acids (NEFA) were measured using the NEFA (ACS-ACOD MEHA) kit. The IGF-1 was measured using the IGF-1 (ACS-ACOD MEHA) kit. Milk progesterone was determined daily for 90 days postpartum using sensitive radioimmunoassay techniques using IAEA/FAO 1999 protocol. Plasma Leptin concentration was determined every 4 days. The data collected was analysed using SAS. The statistical model included the effects of parity, BCS at parturition, days including pre-and postpartum periods and interactions. Primiparous cows had low milk yield and body condition score <3 during early postpartum periods.They also had higher concentration of NEFA than the multiparous cows. Most hormone concentrations diminished within 1 week postpartum whereas IGF-1 increased from day 42 postpartum. Leptin concentrations decreased shortly prepartum and remained low up to day 42 postpartum. Initiation of ovarian activity postpartum was early in multiparous cows of body condition score 3 as indicated by the high concentrations of progesterone 42 days postpartum. This indicated that body condition score of 3 at parturition and parity 3 and 4 influenced early initiation of postpartum ovarian activity.There was a high correlation of leptin and IGF-1, and

during this time the cows resumed their normal cycle as indicated by the levels of progesterone. Therefore leptin, IGF-1 and progesterone were good indicators of resumption of ovarian activity postpartum. Making use of and manipulating these indicators could allow for early postpartum breeding availing more replacement stocks, meat and milk in the market. This will lead to increased profit attracting youths into dairy farming.

Keywords: Ovarian activity, Postpartum, Friesian

Introduction

Genetic selection for milk production during the last decades has been associated with decreased reproductive efficiency (Lucy, 2001). The resumption of ovarian cyclicity after parturition is closely related to the negative energy balance (EB) in this period; the time to the beginning of the recovery of the EB is positively correlated with the time to first ovulation (Butler *et al*., 1981). Butler and Smith (1989) found that cows that lost less than 0.5 units of body condition score (BCS) during the first 5 weeks post-partum had higher conception rates at the first service than cows that lost more than 0.5 BCS. The physiological pathways by which the hypothalamic–pituitary–ovarian axis is informed about the energetic status of the animal are complex, and involve several metabolites and hormones, such as the growth hormone (GH)–insulin-like growth factor-I (IGF-I) system, insulin, thyroid hormones and leptin. It has been proposed that the effect of negative EB on the resumption of ovulation may be mediated by the secretion of IGF-I (Spicer *et al*., 1990). Although GH concentrations are usually high in early lactating ruminants, the intrahepatic production of its mediator IGF-I is diminished (Chilliard, 1999). Circulating concentrations of IGF-I in the peripartum period are good indicators of the capacity of energy-restricted cows to resume cyclicity after parturition (Robert *et al*., 1997). Cows with ovulatory estrogen-active follicles have higher circulating IGF-I concentrations during the first 2 weeks than cows with anovulatory follicles (Beam and Butler, 1997,1998). Both insulin and IGF-I are known to stimulate *in vitro* steroidogenesis and proliferation of bovine thecal and granulosal cell cultures (Spicer *et al.*,1993; Spicer and Stewart, 1996). Likewise, cows that ovulated within 35 days postpartum present higher IGF-I concentrations as well as higher glucose and insulin and lower non-esterified fatty acids (NEFA) and β-hydroxybutyrate (BHB) concentrations (Huszenicza *et al*., 2001). Cows in postpartum negative EB have lower concentrations of thyroid hormones induced by altering central and peripheral mechanisms (Pethes *et al.*, 1985, Capuco et *al.*, 2001) A role of these hormones in regulating steroid-ogenesis has been reported (Spicer, 2001) but data regarding their effect on ovarian function *in vivo* are limited and controversial (Huszenicza *et al.*, 2002).
The demand for nutrients during late pregnancy to support foetal growth and lactation after parturition is a major challenge in improving cattle productivity. Poor fertility in tropical cattle is a result of nutritional factors due to seasonal variation of forage quantity and quality. The shortage of protein was considered to be more critical than energy. However, it has been shown that under good nutrition average milk yields of 12-15 Kg per day can be achieved representing 140-300% increase over the median milk yield per day. Low milk production may result in below optimal calf growth (mean weight gain of 0.21 Kg per day) causing delayed age at puberty and 1st calving that averages 41 months (Odima *et al*., 1994). This may also cause a high rate of calf morbidity and mortality of 27% and 22% respectively, resulting in high reproductive wastage thus, affecting the ability of farmers to select female replacements (Gitau *et al*., 1994).

Reproductive performance has been associated with nutritional status of cows as demonstrated by its effect on puberty in heifers (Rhodes *et al*., 1996). Nutritional influence on reproductive function is mediated at the ovarian level through the effects of nutritional metabolites acting as signals that influence hormonal action on gonads to perform an appropriate reproductive activity. Negative energy balance (NEB) after parturition impacts negatively on conception due to competing needs of nutrients between reproduction and lactation, resulting in lactation anoestrus, although the physiological mechanism that a dairy cow undergoes to adapt to lactation requirement should be basically similar among different production systems, the energy demands due to grazing may modify the important transformation that take place during this period. Dry matter intake in these production systems is usually lower than in confined systems and may be insufficient to sustain the high milk yield that can be achieved with genetic potential. It has been proposed that the effect of negative energy balance on the resumption of ovarian function may be mediated by secretion of IGF-1 hormone (Lucy, 2001).

Various metabolic and endocrine blood and milk traits such as NEFA, insulin, ketone bodies, IGF-1 (Lucy *et al*., 1992), milk fat, protein, lactose, fat: protein ratio and fat: lactose ratios (Heuer *et al*., 1999) have been shown to be related to EB. Postpartum cows have low concentrations of reproductive hormones induced by altering central and peripheral mechanism (Pathes *et al*., 1985; Capuco *et al*., 2001). A role of these hormones in regulating reproduction has been reported (Spicer,

2001) but data regarding their effect on ovarian function *in vivo* are limited and controversial (Huszenicza *et al*., 2002). Therefore the objective of this study was to use levels of progesterone to determine indicators of postpartum ovarian cyclicity of Friesian dairy cows.

Materials and Methods

Study area and selection of experimental cows

The study was conducted at KARI-Lanet within Nakuru County, Kenya, which has two agro- ecological zones 3 and 4 (Pratt and Gwyne, 1977). The farm is 1600 metres above sea level and has a bimodal rainfall pattern with an annual mean of 800 mm (ranges from 534-049 mm) and 83% relative humidity. Average maximum and minimum temperatures are 26ºC and 10ºC respectively. Agro-ecological zone 3 had relatively good pastures but zone 4 had natural harsh pastures characterized by *Pennisetum catabasis* (Manyatta grass) and *Pennisetum clandesteim* (Kikuyu grass). Dairy farming in KARI-Lanet is on small scale comprising of 60 heads of Friesian dairy cows mainly ranching in zone three with *ad libitum* supplementation for water, mineral and salts.

Experimental design

A total of 30 in-calf cows (7 months) of differing parities (0-4) were randomly selected from a herd of Friesian dairy cows kept at KARI-Lanet. Selection was purposive and was based on parity; body condition score (BCS) and pregnancy status. The cows were grazed on improved pastures (Elba Rhodes) for 8 hours a day, minerals and water were given *ad libitum*. The cows were dewormed strategically postpartum using Levafax diamond (Noorbroke) to control internal worms, and they were dipped once a week using almatix (Almandine Corporation, Switzerland) distributed by Unga Feeds.

Data collection

Cows were milked twice daily and milk production recorded. Body condition score determined every 2 weeks from one month prepartum until 3rd month postpartum using a scale 1 (emaciated) to 5 (very fat) (Edmonson *et al.,* 1989). At the same time, body weight was determined using Dalton Weigh Band. Cows were classified according to BCS at parturition into lean cows (<3) or fat (>3). Estrus was checked twice a day after day 30 postpartum whereas P4 levels were checked daily 30 days prepartum to 90 days postpartum. Pregnancy diagnosis was performed using levels of milk progesterone day 21 post insemination and was confirmed at day 70 by rectal palpation.

Milk samples were aseptically collected in the evening by stripping 10 ml of milk into collection bottles each containing one tablet of sodium aside as preservative. The milk samples were immediately transferred to reproductive physiology laboratory and kept at 4˚C awaiting processing. The milk was centrifuged at 3,000 rpm for 30 minutes to separate skimmed milk which was used for determination of progesterone levels. The skimmed milk was stored in labeled 5 ml plastic vials and kept at 4ºC until assaying for progesterone. Progesterone (P4) was determined using the 'self coating' Radioimmunoassay (RIA) technique as described by FAO/IAEA, (1999). Blood samples were obtained twice a week from day 30 prepartum to 90 days postpartum. Blood was aseptically collected from jugular vein into heparinised 20 ml tubes. The blood was centrifuged at 1500 rpm for 15 minutes; plasma from the blood was stored at-20^{0}C until analysis.

Metabolite and hormone determination

Non-esterified fatty acids (NEFA) were determined every 4 days from 30 days prepartum to 3 months postpartum using NEFA kit (Randoxlab.ltd. Crumlin.co.Antrim, UK). Urea, Plasma leptin concentrations were quantified according to 125 IRIA of Delavoud *et al.* (2001). Insulin like growth factor 1 (IGF-I) was determined using IGF-I (ACS-ACOD MEHA) kit. Progesterone (P4) was determined using the 'self coating' Radioimmunoassay (RIA) technique as described by FAO/IAEA, (1999).

Statistical analysis

Milk production, BCS, metabolites and hormonal concentrations were analysed by mixed procedure (SAS, Version 9.1). The statistical model included the effects of parity, BCS at parturition. Postpartum days were categorized in the intervals of 10 days during the experimental period (day 0=day of parturition). A general linear model was used to study reproductive parameters and fixed effects were parity and BCS at parturition. Turkey Kramer tests were used to analyze differences between groups. Correlation coefficients were calculated to study relationships between variables. Factors affecting the initiation of ovarian cyclicity were evaluated by regression analysis using the Backward Eelimination procedure. The independent variable was the re-initiation of ovarian cyclicity and the dependent variables included parity, BCS at parturition, body weight, milk production, urea, NEFA, IGF-1 and leptin. Regression analysis was performed to

study the relationships between leptin and BCS, leptin and NEFA, leptin and IGF-1 before and after parturition in cows with low and high BCS at parturition.

Results and discussions

Lean (BCS<3.5) cows produced less milk as compared with fat cows and had a smaller BCS during the experimental period. The BCS was affected by parity, a finding that agreed with that of Bayram *et al.* (2012) who reported that thinner cows at calving could not achieve their genetic milk yield potentials due to lack of body reserves that would support increasing the milk yield at the beginning of lactation.
Multiparous cows had a higher BW than primiparous cows (450kg ± 7 vs 340 ± 7 kg, P = 0.0001). Parity and BCS at parturition affected BW changes during the experimental period. There was significant difference (P<0.05) in weight loss with multiparous cows losing less (0.9kg/day) weight than primiparous cows (1.4kg/day) early in lactation. A strong correlation between BW and BCS was found for primiparous cows (r = 0.89, n = 15, P < 0.0001) and multiparous cows (r = 0.84, n = 15, P < 0.0001).

The NEFA concentrations started to increase before parturition; in primiparous cows they reached peak concentrations at day 21 and in multiparous cows at day 16 and started to decrease thereafter. The increase observed in NEFA concentrations was higher for primiparous cows and levels remained high for a longer period.

Effects of parity and BCS at parturition were found in IGF-I concentrations; primiparous cows and lean cows had lower concentrations of IGF-I. Concentrations of IGF-I started to decrease 21 days before parturition in all cows to reach half of the prepartum values after parturition. The IGF-I concentration differed according to category, primiparous cows had a steeper decrease than multiparous cows and remained lower for more days but they tended to recover IGF-I concentrations faster. There was also an interaction between BCS at parturition and days postpartum: IGF-I in fat cows fell more sharply than in lean cows. Leptin levels decreased sharply before parturition and–in contrast with the pattern of the other hormones–concentrations remained low during the sampling period, BCS at parturition affected leptin concentrations. Leptin concentrations (nmol/l) during late pregnancy and the first 2 weeks of lactation were higher in cows with higher BCS. Leptin concentrations in primiparous cows presented a steeper peripartum decay than multiparous cows, P = 0.066, and reached a lower level postpartum (P < 0.01). Fat cows presented a steeper peripartum decay when compared with lean cows (P < 0.05). The leptin nadir in lean cows was reached 10 days before that in fat cows.

Conclusion

Generally this study showed that maintaining good body condition was important and Freisian cows were more productive within the first four lactations.

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Contribution of the maize-cassava intercrop system to feed availability in coastal lowland of Kenya

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Abstract

Many farmers in coastal Kenya practise maize-cassava intercropping system to address food security needs. The system produces many by-products which are not used for human consumption hence currently go to waste. These by-products offer opportunities for bridging feed availability during the deficit months of January – March through conservation in form of silage. An on centre study was conducted at Kenya Agricultural Research Institute (KARI) Mtwapa to assess the potential production of feed obtainable from a maize-cassava intercropping system. Two plots of one hectare each were planted with the maize-cassava intercrop. Plot 1 was planted under shade which is the more common farmer practice while plot 2 was without shade. Pwani Hybrid 4 (PH4) maize and cassava variety Shibe were planted in both plots and given the recommended agronomic practices. The results showed that a total DM yield of 35.16 and 34.98 t ha^{-1} for plots 1 and 2, respectively, was obtained from the maize-cassava intercrop and which did not differ significantly. Results of the study also showed that cassava produced higher leaf yield under shade than when grown in the open. One hectare of the maize-cassava intercropping system can provide sufficient material for 5-6.7 t of silage which is enough to support 4 livestock units for 120 days. The study recommends promotion of cassava–based silage among the smallholder dairy farmers who practice maize-cassava intercropping.

Keywords: Cassava, Pwani Hybrid, Silage, Intercropping

Introduction

Dairy productivity in coastal Kenya is relatively low. This has mainly been attributed to inadequate and low quality forages. Farmers in Kenya's coastal region depend on forages to feed livestock. Forage production is rain fed; and therefore feeds are plenty during the rainy season and scanty during the dry spell. The region has a bimodal rainfall pattern with long rains in April to July and short rains in October to December with the latter being unreliable. A severe dry spell occurs between January and March which reduces forage production. All year round feed availability is crucial for dairy cattle productivity. It is positively correlated to milk production; hence milk production is therefore low during the dry season when a premium price is offered due to the low supply.

Research efforts were made in coastal lowland Kenya to improve feed availability since early 1990s through promotion of Napier grass planted in leucaena or gliricidia alleys (Mureithi *et al*., 1996). However, there has been low adoption of the alley farming system. This was attributed to, among others, the farmers' preference to grow maize first at the onset of rains; then forage crops; and the seasonal availability of natural forages (Mureithi *et al.*, 1997).

Further research targeted food security through integrated crops and livestock production systems (Njunie and Wagger 2003; Saha *et al.*, 2008; Njunie *et al.*, 2013). These systems integrate food and feed production since coastal Kenya is characterized by a mixed farming system where farmers grow crops and keep livestock.

The maize-cassava intercropping system is practised by many farmers in the region (Mureithi *et al*., 2000) to address food security. Maize and cassava are the highest ranked food crops. Planting of the two crops is usually staggered such that cassava is planted between maize rows about two to three weeks after planting maize. The maize-cassava system offers potential for feed availability through the use of by-products which are not used for human consumption and which would otherwise go to waste. The by-products offer opportunities for bridging feed availability during the feed deficit months of January to March through conservation as dry maize stover, cassava leaf hay, dried cassava chips and silage.

Conventional silage making involves mixing Napier grass, leucaena or gliricidia and molasses. Maize bran is used instead of molasses due to the unavailability and high cost of the latter. Maize bran may be purchased from maize millers but it can also be generated at the household level from processing locally grown maize through pounding. Maize bran has a crude protein content ranging from 53 to 135 g kg^{-1}DM (Muinga *et al*., 2011; Juma *et al*., 2006).Useful by-products from a maize crop include: cobs, with CP content of 22 g kg^{-1}DM (Urio and Kategile, 1987) and metabolisable energy (ME) content of 10.5 MJ kg^{-1}DM (Donkoh and Attoh-Kotoku, 2009), and stover, with CP content of 52 g kg^{-1}DM (Juma *et al*., 2006).

The dry matter (DM) potential yields of cassava leaves may be as high as 34 t ha^{-1} and their CP content ranges from 167 to 399 g kg^{-1} (Ravindran, 1990; Marjuki *et al.*, 2008). The average crude protein content of 210 g kg^{-1} DM of cassava leaf, as reported by Ravindran (1990), is similar to that of gliricidia leaves used in the conventional silage making (Muinga *et al.*, 2011). Agunbiade *et al.* (2004) reported the ME content of cassava leaves as 7.6 MJ kg^{-1} DM.

Most of the leaves are currently returned to the soil as a green manure and are therefore underutilized as a feed resource. In coastal Kenya, there is limited use of cassava leaf as green vegetable. Most unmarketable cassava roots also go to waste after cassava harvesting and some of them are consumed at home. To avoid such wastage of useful material from cassava production, the leaves and unmarketable roots may be used, together with Napier grass, to make cassava-based silage.

Cassava-based silage technology would therefore be more suited to the farming conditions of the smallholder dairy farmers in coastal Kenya with a high chance of adoption and potential to improve milk production during the dry season. The cassava-based silage technology involves mixing Napier grass and cassava leaves with dried or fresh cassava chips. The cassava chips serve as the source of readily available carbohydrates, replacing maize bran or molasses in the conventional silage.

A situational analysis carried out in April 2012 to establish the status of fodder conservation in Kwale and Kilifi Counties of coastal Kenya found low uptake of silage technology by the farmers (Lewa *et al.*, 2013). The respondents attributed this to lack of skills and knowledge (63%), insufficient feed materials (13.7%) and high cost of silage making (10.1%). Among others, the study recommended the use of low-cost inputs for silage conservation, which could be addressed through the use of cassava leaf and unmarketable cassava roots. The objective of the study therefore to evaluate the contribution of the maize/cassava intercropping system to material that may be used for silage making to enhance dry-season feed availability in coastal Kenya.

Materials and methods

The trial was planted at KARI Mtwapa, which is at an altitude of 15 m above sea level, latitude 3°56'S, longitude 39°44'E, in the coastal lowland AEZ 3 (CL3). The site is characterized by light sandy soils classified as Orthic, Acrisol or Luvisol.

The general textural composition of the soil is 82.8% sand, 9.6% silt and 7.6% clay. The site receives a mean annual rainfall of 1200 mm, with relative humidity of 65- 95%, and temperatures ranging from 29 to 30ºC. (Jaetzold *et al.*, 2012). A maize-cassava intercrop was planted on 2 ha of land in two plots. Plot 1 was under shade which is common in farms where tree crops such as coconuts and mangoes are grown. Plot 2 was without shade. In both plots, Pwani Hybrid 4 (PH4) maize was planted on 14 May, 2012 at a spacing of 100 x 50cm, two plants per hill and given the recommended agronomic practices. Cassava variety Shibe was intercropped on 6 June, 2012 at a spacing of 100 x 100cm. The maize crop was harvested on 18 September, 2012, while cassava was harvested on 24 May, 2013. Harvesting data was collected and stored in Excel computer files.
During harvesting from both plots, ten rows of maize, in a plot area of 10 m^2, were harvested to determine grain yield. Four rows of maize from a net area of 4 x 10 m were used determine stover yield. The stover was harvested by chopping it at the base of the plant. In addition, two rows of cassava, from a net area of 2 x 10 m, were harvested to determine root yield.

After maize harvesting, maize grain was taken for pounding (50 kg by the traditional pestle and mortar and 50 kg by a commercial maize miller). From the commercial miller, maize siftings or dust-like fine material was obtained. The pounding by hand produced normal maize bran with visible testa, in addition to the sifted grain. After harvesting the cassava, total number of roots were recorded and weighed; marketable roots were sorted out, counted and weighed. The rest of the roots (their number and weight) were recorded as unmarketable roots. The green meristematic portion of the cassava plants (young leaves and stem) were harvested and weighed. The number of stakes per plant was recorded, to give an indication of the amount of planting material that would be available for use in the subsequent cropping season. A sample of the feed material was dried in an oven at 105ºC to constant weight to determine the DM (AOAC, 1990). The GLM procedure of SAS (2003) was used to compare the productivity of the two plots and t-test was used to compare the two maize-cassava production system at P=5%.

Results and discussion

Productivity of the maize-cassava intercropping system
Several maize and cassava products were obtained from the intercropped system (Table I). Cassava yield was generally not affected by shade. There was no difference (P>0.05) for all cassava products in both plots apart from cassava leaf yield which was higher (P<0.05) under shade. Probably the increased production of leaves by cassava under shade was the crop's mechanism of ensuring adequate capture of light through increased total leaf surface area and less senescence. In contrast, maize yield was depressed (P<0.05) under the shade conditions. However, the total DM yield (all products) from the cassava/maize intercrop was 35.16 and 34.98 t ha^{-1} for Plots 1 and 2, respectively and was not different (P<0.05). This shows that the total production of the maize-cassava intercrop was not affected by shade. The system produced between 19.12 - 21.98 t DM ha^{-1} and 1.23 - 2.38 t DM ha^{-1} of marketable cassava tubers and maize grain respectively which would ideally be used for human consumption.

Table 1. Summary yield of products from the maize-cassava intercrop (t DM ha^{-1})

Product	Plot 1	Plot 2	LSD
Total cassava tubers	30.48	28.71	6.662
Marketable cassava tubers	21.98	19.12	7.951
Unmarketable cassava tubers	8.50 (27.9%)	9.59 (33.4%)	2.924
Cassava leaves	1.67^{b}	1.25^{a}	0.393
Total DM yield of cassava	32.15	29.96	
Maize grain	1.23^{b}	2.38^{a}	0.410
Sifted maize grain (machine pounded)	1.20^{b}	2.31^{a}	0.399
Siftings (machine pounded)	0.03^{b} (2.4%)	0.06^{a} (2.5%)	0.011
Pounded maize grain (hand pounded)	1.12^{b}	2.16^{a}	0.373
Pounded maize bran (hand pounded)	0.11^{b} (8.9%)	0.21^{a} (8.8%)	0.037
Cob weight	0.28^{b}	0.53^{a}	0.200
Stover weight	1.50^{b}	2.11^{a}	0.436
Total DM yield (maize grain + cob + stover)	3.01	5.02	
Total DM (total maize + total cassava)	35.16	34.98	

Means bearing different superscripts within a row are different (P<0.05). Figures in brackets indicate a given product as a proportion of the total DM yield of the crop.

The other products – unmarketable cassava tubers and cassava leaves are often left in the farm as waste. These would be available for livestock feeding if properly processed (Table II). The feeds available for livestock from the maize-cassava intercrop system ranged from 10.88 to 18 t DM ha^{-1}. The protein and energy from these products can be estimated from their nutrient composition in Table II from data at KARI Mtwapa laboratory.

Table 2. Feed components and their protein and energy composition of the products available for livestock feed from the maize-cassava intercrop

Product	Yield (t DM ha^{-1})	CP (g kg^{-1}DM)	ME (MJ kg^{-1}DM)
Unmarketable cassava tubers	8.0 - 9.0	30	15
Cassava leaves	1.0 - 1.5	210	7.6
Homemade maize bran	0.1 - 0.2	100	12
Cobs	0.3 - 0.5	22	10.5
Stover	1.5 - 2.0	52	7.6
Total DM yield	10.9 - 18.0		

Source: KARI Mtwapa laboratory data

Number of animals that can be supported by the maize-cassava intercropping system

Silage from the above system would be limited by cassava leaf production to 5 - 6.7 t DM ha^{-1}. With an estimated intake of 3% of a cow's body weight, the requirement of a 400 kg cow would be 1440 kg for 120 days. The DM from one hectare would therefore be adequate for 3 – 4 cows during the dry season after allowing for wastage. Additionally a mature cow (400kg) with a stover intake of 1% of its live weight will consume 4 kg daily or 480 kg in the 120 days of forage scarcity. Therefore, the 1.5 t DM of stover or 1500 kg DM would be adequate for 3 cows for 120 days (1500/480) for maize-cassava production under shade. Without shading, the 2110 kg DM stover will be adequate for 2110/480 or 4 cows for 120 days. With proper feed budgeting, dairy farmers in coastal Kenya can sustain milk production during the dry season and benefit from the premium prices offered by the buyers due to milk scarcity.

Conclusion and recommendations

One hectare of the maize-cassava intercropping system can provide sufficient material for 5 - 6.7 t of silage which is enough to support 3-4 cows during the 120 days dry period and a similar number from maize stover. Thus the maize-cassava intercropping system can contribute positively to feed availability without compromising the human food requirements through the use of stover, cassava leaf and unmarketable roots.

Cassava based silage is therefore recommended for promotion among the smallholder dairy farmers who practice maize-cassava intercropping.

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Smallholder dairy cattle productivity under different production systems in Nyahera, Kisumu County, Kenya

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Abstract

Milk production has made a significant contribution to the rural economy of Nyahera farmers as it is a major source of income and employment. The objective of the study was to analyse productivity of dairy cattle in different

production systems and to identify constraints and opportunities to improve dairy cattle enterprises. Longitudinal data were obtained from 20 smallholder farmers in Nyahera division. Data and information were obtained by means of questionnaires and data sheets. Collected data included production system, breed, herd structure and size, milk yield, lactation length and calving interval. Herd structure and size were collected at the beginning and end of the year. Data were subjected to analysis of variance using GLM procedures to obtain mean estimates. It was concluded that crossbreds of Zebu with the dairy breeds, mainly the Friesian and Guernsey, had increased milk production and had threefold exceeded milk yield from Zebu cattle.

Introduction

Nyahera is in an agro-ecological zone with sufficient rainfall which is adequate and exceeds 1,000 mm per year. To increase milk production, farmers have crossbred Zebu cattle with bulls of the Friesian and Ayrshire which are kept in bull camps established by the Kenya Finland Livestock Development and Ministry of Livestock Development. Crossbreeding of Zebu cattle with dairy breeds has been found to be an efficient strategy to increase the dairy cattle population based on crossbreds with 50% genetic inheritance of the dairy breeds. These crossbreds are able to produce more milk than Zebu cattle in a tropical production environment as a result of the additive and heterotic effects due to additive breed differences (Bhat *et al*., 1978; Bondoc *et al*., 1989).

Dairy cattle genotypes consisting of purebreds and crossbreds are managed in extensive grazing, semi-zero grazing and zero-grazing systems. The basal feeds in the production systems are natural pastures and Napier grass. Minimal quantities of sweet potato vines, fodder trees, *Desmodium uncinatum* are provided when available, particularly in the wet season. Supplementary feeds of dairy meal and mineral lick are fed to dairy cattle at milking time.
Although milk production is the main economic activity there is no organised milk marketing as milk is sold to Kisumu town by individual farmers and by middlemen and milk prices are low and variable. Therefore, the objective of the study was to analyse productivity of dairy cattle in different production systems and to identify constraints and opportunities to improve dairy cattle enterprises.

Materials and Methods

Study area
Longitudinal data were obtained from 20 smallholder farmers in Nyahera division in Kisumu County. Nyahera is at an altitude of 1,200-1,500 m above sea level in marginal sugar Zone II with an average annual rainfall of 1,500 mm and distribution is bimodal with a peak in April and November. Natural vegetation is woodland savanna and the dominant natural grasses were *Hyperrhenia* and *panicum* species. Established fodders included Napier and Bana grass, *Leucaena leucocephala*, sweet potato vines and Columbus grass.

Data collection and processing
Data and information were obtained by means of questionnaires and data sheets from smallholders farmers in Nyahera. Collected data included production system, breed, herd structure and size, milk yield, lactation length and calving interval. Herd structure and size were collected at the beginning and end of the year. Daily milk yield were recorded twice a day in the morning and afternoon and summed up to obtain lactation yield. Number of days in milk were recorded as lactation length. Calving interval was derived from two consecutive dates of calving. Data were subjected to analysis of variance using GLM procedures (SAS 1996) to obtain mean estimates.

Results

Herd Management
In Nyahera area, smallholder farmers manage dairy cattle in extensive grazing (EG), semi-zero grazing (SZG) and zero-grazing systems (ZG). Of the 20 farmers selected for this study, it was found that 70% practiced zero-grazing, 10% extensive grazing and 20% semi-zero grazing. Average farm size varied across production systems. Zero-grazed farms had an average farm size of 10.84 acres, farm size under semi-zero grazing was 4.75 acres, extensively grazed farms were relatively large and the average farm size was 15.25 acres. Herd structure and size of the different sex-age groups

varied with the production system and farm size. There was a large proportion of females in the herds and they accounted for 55-88% of the herds and cows were 22-33% of the herd size. Cows in milk were 80% in extensively grazed herds, 83% in semi-zero grazed herds and 100% in zero-grazed.

In Nyahera where cattle improvement was being carried out by the Ministry of Livestock Development and Kenya Finland Livestock Development Programme extensively grazed herds had a large proportion of Zebu cattle (83.3%) and there were few Ayrshire cattle (16.7%). There was a reduction of Zebu cattle to 27% in semi-zero grazed herds. However, the proportion of the Ayrshire cattle increased to 18% and that of Friesian cattle increased to 14% in semi-zero grazed herds. It was observed that Friesian-Zebu crossbreds increased significantly to 32% and Ayrshire-Friesian crossbreds were 9%. Zero-grazed herds had a relatively large proportion of Friesian cattle which were 48%, Ayrshire cattle were 16%, Zebu cattle decreased to 16% and the proportion of Jersey cattle was 7% and it was also found that in this production system, they were low percentage of crossbreds of Friesian-Sahiwal, Friesian-Jersey and Friesian-Zebu. Since the crossbreds had 50% of the genetic inheritance of the dairy breeds, they were suitable for the production systems in this area (Osman and Russel, 1974 and Bhat *et al*., 1978). Semi- zero and zero production systems had a significant proportion of crossbreds and extensively grazed herds had no crossbreds.

Milk production

The mean lactation yield was 1,823.62 ± 1,080.81 Kg with a coefficient of variation of 59.26% (Table 1). The Friesian and Ayrshire cows had high lactation yield exceeding 2,000 Kg and this was higher than the mean lactation yield of the herds in this site. Zebu cows produced the lowest milk yield of 427.00 Kg. The crossbreds of Friesian-Zebu, Ayrshire-Zebu and Guernsey- Zebu were 2 to 3 times higher in milk yield than the Zebu milk yield and this was evidence of heterosis (Demeke *et al*., 2004). This significant increase in milk yield of crossbreds justified the upgrading programme of Zebu cattle to the exotic dairy breeds in Nyahera. The mean lactation length were 264.50 ± 86.19 with a coefficient of variation of 32.57%.

Table 1. Milk yield, lactation length by breeds in Nyahera

Breed	n	LY (Kg)	LL (days)
Zebu	1	427.00	212.00
Friesian	2	2,716.00 ± 901.19	366.00 ± 98.31
Ayrshire	2	2,121.50 ± 1,446.03	186.50 ± 43.13
Friesian-Zebu	1	1,046.00	217.00
Ayrshire-Zebu	1	1,653.00	294.70
Guernsey-Zebu	1	788.00	200.00
Mean	8	1,823.62 ± 1,080.81	264.50 ± 86.19

Herd productivity

Evaluation of herd productivity of herds in different production systems showed that there were differences in herd productivity parameters (Table 2). Extensively grazed herds had the lowest gross margin of Kes 37,840. However, the gross margin increased in semi-zero grazed herds to Kes 90,075 and slightly increased in zero-grazed herds to Kes 100,109.

Cost benefit analysis indicated that cost of inputs in the dairy enterprises was low in extensively grazed and zero-grazed herds but the cost of inputs was relatively high in semi-zero grazed herds and this correspondingly affected benefits to investment which were low in semi-zero grazed herds. In extensively grazed and zero grazed herds benefits were high. Farmers with semi-zero and zero grazing systems were able to hire workers for feeding and milking cows.

Table 2. Herd productivity parameters by production system in Nyahera

Production system	(n)	Farm size (acres)	Herd size	Offtake rate %	Cows in milk %	Calf mortality (%)	Number of workers	Gross margin	CB	BC
EG	2	3.50	5	-	80	20	-	37,840	0.21	4.12

SZG	4	6.91	9	14	83	15	2	90,075	0.45	2.17
ZG	10	4.43	6	18	100	5	2	100,109	0.23	4.36

Discussion

In Nyahera most dairy cattle were maintained in zero-grazing systems as 70% of the farmers preferred this production system. Farmers who practiced extensive grazing were 10% and semi- zero grazing were 20%. Farmers adopted the intensive production system due to small farm size so that they could increase dairy cattle productivity per unit area.

In extensive grazing systems cattle were grazed on natural pastures on the farm and common land reserve along the roadsides and in the forest. After harvesting cattle were fed on maize stover. However, since the forage grazed was of low and variable quantity and quality, cattle were fed cut natural pastures, sweet potato vines and Napier grass in the homestead. Dairy meal and mineral lick were provided to cattle but this was not done consistently. Water for cattle was obtained from boreholes, rivers and roof catchment.

In semi-zero and zero grazing systems, cattle were confined and fed on cut Napier grass, Rhode grass, Columbus grass, sweet potato vines, *Desmodium intortum* and crop residues. Dairy meal and mineral lick were provided to cattle. Water for cattle and domestic use was obtained from boreholes, piped water, roof catchment, springs and rivers. Stocking rates were variable in production systems and it was found that extensively grazed farms were under stocked with one livestock unit per 1.56 acres. In semi-zero grazed herds the stocking rate was 1.66 Lu to one acre and for zero grazed herds 1.15Lu to one acre.

In this area an attempt has been made to improve the quantity and quality of feeds across the wet and dry seasons to maintain cattle productivity. For sustainability of the dairy production systems on small farms, Napier grass, Rhodes grass, sweet potato vines and *Desmodium intortum* have been established in mixtures and in rotation with maize to provide high quality feeds for dairy cattle. Fodders are top dressed with nitrogenous fertilizers after cutting for rapid growth. Farmers have been trained to conserve surplus forage and fodder in the wet season in the form of hay (Suttie, 2000) and silage (Titterton and Bareeba, 2000). Conserved hay and silage provided good quality feed for dairy cattle in the dry season. Kevelenge (1987) reported that cattle productivity can be maintained by feeding crop by-products supplemented with forage legumes at a rate of 45-50% of the total ration.

In this area, different genotypes were kept on farms in the three production systems. Purebreds and crossbreds were in similar proportion in semi-zero and zero grazed herds. The purebreds were Friesian, Ayrshire, Jersey and Zebu. Crossbreds were Friesian-Zebu, Ayrshire-

Zebu and Guernsey-Zebu and they had 50% genetic inheritance of the dairy breeds. The half bred crossbreds were adapted and productive in this area as they showed improved milk yield, growth rate and fertility and this was in agreement with Cunningham and Syrstad (1987) and Bondoc *et al*. (1989). However, to realise the genetic potential of crossbreds it is important that they are provided with adequate good quality feeds and proper health management. In this study, it was found that purebreds out yielded Zebu cattle by 400% and whereas, the average milk yield of crossbreds exceeded that of the Zebu cattle by 300%. Milk yield was significantly variable between and within production systems due to differences in genotypes, feeds and feeding systems. Zebu cows produced the lowest milk yield of 427 Kg, crossbreds were intermediate in the range of 700-1,700 Kg, while the Ayrshire and Friesians produced the highest milk yield of over 2,000 Kg in a lactation.

The high milk yield in semi-zero and zero grazed herds was as a result of confinement and feeding cows with good quality forage and fodder and supplementing them with dairy meal and mineral lick.

Herd productivity analysis showed that there were differences between production systems. Extensive grazing systems realised a low gross margin of Kes 37,840and the gross margin of semi-zero grazing systems increased to Kes 90,076 and for zero grazing systems was Kes 100,109. The low gross margin of extensively grazed herds was due to low herd productivity because the Zebu cattle with low milk yield were predominant. Calf mortality rate of 20% was high and this reduced the number of cattle raised and as a result this decreased the number of cattle for sale.

In semi-zero grazed herds, the high calf mortality reduced the offtake rate and this affected herd productivity. Zero grazed herds were productive as all cows were lactating and producing milk for sale. Calf mortality was low and the offtake rate was high indicating that there were cattle raised for sale to generate income. Cost benefit analysis of the production systems showed that the cost of inputs was low in extensively grazed and zero grazed herds but was high in semi- zero

grazed herds. Therefore the returns to investment were high in extensively grazed and zero grazed herds. To minimise cost of inputs, it is important that inputs are obtained at an affordable price.

Analysis of herd structure and size indicated that there were more females (55-88%) than males in the herds. This is because cows were required to produce milk and calves. Female calves were retained and raised after weaning to replace old cows. Male calves were culled and sold after weaning. The predominance of more females in the herds was in agreement with a herd survey by Sands *et al.* (1982) in Western Kenya. Although bulls were used for breeding, farmers preferred using communal bulls in bull camps to reduce maintenance cost. Steers were used for ploughing and carrying fodder to cows. Heifers were raised to replace old unproductive cows.

Conclusion

It was evident from this study that crossbreds of Zebu with the dairy breeds, mainly the Friesian and Guernsey have increased milk production and they have exceeded Zebu milk yield by 300%. However, the mean lactation yield of crossbreds in this site was 1,662 Kg and this is 41% of the milk yield potential of 4,000 Kg per lactation which is expected from the F1 crossbreds. Increased milk yield can be realised by feeding of dairy cattle on a balanced ration that has adequate energy, proteins, vitamins and minerals. Crossbreds with improved growth rate, fertility and milk yield are used for milk production in the three production systems. From the analysis of the genotypes in the herds in the production systems, purebreds and improved dairy crossbreds have increased to 60% and the proportion of Zebu has decreased to 40%. Most of the productive dairy cattle genotypes were found in semi-zero and zero grazed herds. With several generations of crossbreeding, improved dairy cattle population will replace Zebu cattle in the herds. Besides feeding of dairy cattle, the other constraint noted was failure to keep pedigree and performance records of cattle by farmers. Research and extension staff should train farmers to keep records in a simplified standard format. There is no organised marketing of milk in this area. Farmers should be mobilised to form a dairy cooperative society to market milk and assist farmers get farm inputs.

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Testing technologies for sustainable pig farming systems in Busia County, Kenya

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Abstract

Pig farming in rural Kenya and pork consumption has increased substantially in the past decade but there is a threat to human health from porccine cysticercosis infections. A collaborative study funded by ASARECA was carried out to validate the *Taenia solium* Penside porccine cysticercosis diagnostic kit and *Taenia solium* vaccine **(**TSOL18) in order to provide more effective disease detection and control methods for these pig farming systems. A baseline survey was undertaken in Busia County in the months of May and June 2013. A random sample of 205 pig producing households, 14 pig traders and 5 service providers were interviewed using structured questionnaires. Lingual examination of the pigs and blood samples were collected from pigs and human subjects for validation of the vaccine and diagnostic kit. Data was analyzed using Statistical Package for Social Scientists (SPSS) version 12 for windows. Results showed that farmers kept on average 4 indigenous pigs per household. Sixty percent of the respondents consumed pork at least once per month. The main rearing systems for piglets were free range (57 %), tethering (34%) and pens (5%). Adult pigs were kept under tethering (93%), under free range (5%) and in pens (2%). Pigs were mainly fed on kitchen leftovers (75%) and 23% of respondents left them to scavenge. Ten out of 200 pig serum samples came from pigs that were positive of porcine cysticercosis on Lingual examination. Pig production was profitable but the production system needs to be improved by using better production technologies.

Keywords. Teso South sub-County, Pig production systems, Disease control, Value chain

Introduction

Pig farming in rural areas of Kenya and pork consumption has increased substantially in the past decade. Indigenous pigs are mainly kept by smallholder farmers under free range conditions in western Kenya (Githigia *et al*., 2005; Mutua *et al*., 2012). Keeping pigs under these conditions may be beneficial to farmers because they require low inputs but it is against the laws of Kenya (GOK, 1972). Also, keeping pigs under free range conditions may pose health risks to the farmers and consumers of pork produced in these production systems. For these pig production systems to be sustainable there was need to tackle issues related to animal health to reduce the risk to farmers and consumers.

The Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) is promoting technology uptake through a validation project through a partnership of institutions in six countries in the Eastern and Central Africa region. The aims of the project are to validate a vaccine (TSOL18) produced in Australia and Diagnostic Kit produced at the International Livestock Research Institute (ILRI). The vaccine and diagnostic kit trials have yielded promising results in countries such as Cameroon. The vaccine is made of recombinant larvae stage of the pig tapeworm (*Taenia solium*) and is administered to naive pigs together with an anthelmintic, oxfendazole. There were four regimes which were validated including one, which has been tried previously. In addition, the disease (porcine cysticercosis) is commonly diagnosed by lingual examination of a pig. Therefore, ASARECA is also involving the six countries in East and Central Africa (ECA) region to validate a simple rapid test, which uses antibody detection. The test was developed ILRI Kenya and uses serum. The test is quick, specific and three times more sensitive than the lingual examination. If these two technologies are successful and adopted by farmers who raise their pigs on free-range systems, the vaccine along with the test kit shall make a remarkable advancement towards reducing the threat of humans from neurocysticercosis through safe pork. The aim of this baseline study was to establish the status of pig production and value chain with emphasis on awareness, prevention, control and treatment of the disease in the study areas in Kenya.

Materials and methods

Study area

The study to validate TSOL18 vaccine and pen side diagnostic kit was undertaken in Teso South District Busia County. Teso South District is found in Busia County of western Province, Republic of Kenya. Teso South District, boarders Butula to the East, Nambale to the North and Busia to the South, Teso North to the North and the Republic of Uganda to the west. It has two Divisions, Chakol and Amukura which are divided into 13 administrative locations and 38 sub locations. The District covers 300.7 km^2 with 225.525 km^2 under various agricultural activities. The total human population is 137,924 (GoK, 2010). The district has approximately 27,372 households of which approximately 10,300 households were involved in pig farming. Teso South District was chosen for the study because it has a high population of indigenous pigs reared for pork by farmers under free range conditions and may be ideal for testing the vaccine and diagnostic kit for *T. Solium*.

Data and data sources

The study used both primary and secondary data. Primary data was collected from the various actors in the pig value chain using structured questionnaires. The actors interviewed included pig farmers, pig traders, service providers and people suffering from epilepsy in the communities. The questionnaires were structured to capture data on household demography such as level of education, age of the farmers, information on sanitation, information on management of the pig enterprise and knowledge of the disease, its transmission and control in the study area. Secondary data was collected from government ministries and other sources to provide general information on the farming systems and other relevant information to the study.

Sampling procedure, data collection and analysis

Multi-stage sampling procedure was followed. Teso South District was purposively chosen from the 7 districts that comprise Busia County because it has a high number of households keeping indigenous pigs. All the two divisions (Amukura and Chakol) of South Teso were selected for the study. Three sub-locations were randomly selected in Chakol and 2 in Amukura. In Chakol Division the three sub-locations were: Ngelechom, Amase and Adungosi Sub-locations. In Amukura Division; Apokor and Odioi/ Asurete sub-locations were selected for the study. Simple random sampling was used to select pig farmers from the lists of pig farming households provided by the assistant chiefs of the selected sub-locations. Where the selected farmer was not willing to respond or could not be found, the farmer was replaced by the name directly below or above on the list. A total of 205 households which kept pigs were randomly selected and interviewed by trained enumerators using structured questionnaires. Data entry was done using MS Excel and data analysis was carried out using Statistical Package for Social Scientists (SPSS) version 12.

Results and discussion

Household characteristics

The average farm size was 3 acres. Sixty two percent of the households were male headed whereas 38% were female headed. The education level of those interviewed was low as 12% had no formal education, 64% had primary level education and 6% had secondary level of education. The low levels of education might have an impact on the uptake of technology and especially adopting complex disease control measures. About 13% of the respondents were in the age category of 18-30, 54% were in the age category of 31-50 and 32% were over 50 years. The main occupation of the respondents was agriculture (84%), business (6%) and other off-farm occupations such as teaching, *juakali*, and sand mining (10%).

Pig husbandry and management

On average farmers kept 4 pigs per household. The maximum number of pigs kept was 17 and the minimum number was 1. The average number of piglets aged 0-3 months old was 2. All the sampled farmers kept indigenous pigs. Pig farmers tended to manage young and adult pigs differently in different seasons. In the rainy/ planting season, 57% of the respondents kept piglets by use of the free range system, 34% kept them under tethering and 5% kept them in pens. In the rainy/ planting season, 93% of the respondents kept adult pigs under tethering, 5% under free range and 2% in pens. In the dry/harvesting season, 58% of the respondents kept piglets' free range, 34% kept piglets under tethering and 5% kept them in pens. In the harvesting season, 90% of the respondents kept adult pigs under tethering, 8% under free range and 2% in pens. Scavenging pigs may destroy crops especially in cases where the farm holdings are small resulting in a lot of conflict between neighbours.

Pigs in the study sites were mainly fed kitchen leftovers and scavenging for food. Forty five percent of the respondents fed their pigs on kitchen leftovers, 30% scavenging and kitchen leftovers which implies that 75% of respondents depended on

these two forms of feeding. The remaining 30% fed pigs on a mixture of scavenging, kitchen leftovers and commercial waste products. Only 2% fed their pigs on commercial feed or commercial waste products. These results concur with those of Mutua *et al.* (2012) who reported that 83% of the 164 smallholder pig farmers they interviewed fed pigs on kitchen leftovers in western Kenya.

Information on pork consumption

Sixty four percent of respondents consumed pork at least once a month, 22% less than once a month but at least once in a year, 4% consumed pork less than once a year and 10% never consumed pork. The results indicate a high consumption of pork by the community in the study sites. About 90% of the respondents purchased pork from local butcheries and a small number (1%) indicated that they obtained their pork from home. Approximately 86% of the respondents indicated that they consumed pork in a fried state, 2% boiled and 1% barbequed.

Cost of feeding pigs

Pig producers interviewed indicated that on average it cost them Kes 795.72 to feed a pig per month. The minimum cost of feeding pigs per month was zero and the maximum cost of feeding one pig per month was Kes 4500. The pig production system in the region is low input and low cost, therefore there is room for improvement and increasing profit margins.

Fraction of piglets sold and price

Approximately 14% of interviewed farmers did not sell any of their piglets and 28% sold all the piglets born on their farms. On average 67% of piglets were sold off to other producers. The minimum number of pigs sold was zero and the maximum was 100%. The mean price of the piglet depended on the month when it was sold. The mean age at which piglets were sold was 1.78 (almost 2) months. The minimum age at which piglets were sold was 1 month and the maximum was 18 months. The mean price per piglet was Kes 926.75. The minimum price for a piglet was Kes 700 and the maximum was Kes 4,000. Pigs were normally ready for slaughter on average at the age of 4 months. The minimum number of months pigs are sold for slaughter was 4 and maximum of 113. The mean value of the pig at slaughter was Kes 3,834.41. The minimum price obtained was Kes 500 and the maximum was Kes 10,000.

Profitability of pig farming

Pig farming in the area was profitable (Gross Margin = Revenue-Cost, this translates Kes 3834.41-795.72 = Kes 3038.69 per pig) even though the nature of the management system (free range) may have negative outcomes for crop production in the study site. This enterprise could contribute significantly to household incomes and welfare if better methods of rearing pigs were introduced and farmers trained on the same. Pig meat (pork) was popular with the consumers because it was much cheaper (1Kg of pork costs Kes 200) than beef (1 Kg beef costs Kes 280). Some consumers also indicated that they preferred pork because it was soft and easier to chew.

Awareness of Porcine Cysticercosis

From the respondents, porcine Cysticercosis was not well known to the community. This implies that little was being done by the community to control it. When asked what the farmers did in case the pig is infected with the disease, 98% did not respond to the question (not applicable), 1% said they sold it and 1% said they destroyed it. This implies that infected animals may end up being slaughtered for food. Ten out of the 200 pig serum samples came from pigs that were positive of porcine cysticercosis on lingual examination which gives a prevalence rate of 5%. This figure sharply contrasts with the data obtained from the District veterinary Office which indicated zero cases of porcine Cysticercosis. The staff in the department may not have the required skills to detect the disease due to their level of qualification as the highest level of education attained by the service providers was certificate (67%) and Bachelors, (33%).

Epileptics

According to key informants, epilepsy was quite common in many parts of Teso South District but they could not link human epilepsy to pig farming. Among the farmers interviewed, approximately 4% indicated that someone in their household suffers from epilepsy. Among the pig traders approximately 28.6% indicated that someone in their household suffered from epilepsy (the sample size for pig traders was small (14 traders) resulting in higher percentages). From the results, there was reasonably high incidence of epilepsy in the study site. It was not possible to link the incidence of epilepsy to eating pork. The study team will undertake further research involving households with cases of epilepsy. The protocol on how to get human blood samples to test for the incidence of porcine cysticercosis in humans was being organized.

Adoption of the TSOL18 vaccine and penside diagnostic kit

All the service providers interviewed indicated that they would strongly recommend the vaccine and kit for use in their area and county. They suggested that the vaccine and kit could be recommended for use by vet service providers (50%), traders and meat inspectors (25%) and vet service providers, traders, meat inspectors and farmers (25%). As to who should pay for the diagnostic kit, they suggested that it should be paid for by the government (75%), government and farmers (25%) of the respondents.

Conclusions and recommendations

The study concluded that:

- Pig farming was increasing in importance in the study sites. Indigenous pigs were mainly kept by both gender but more prominently by women and youth. The pig enterprise could contribute significantly to income of women and youth in the study areas leading to improvement in income and food security of pig producing households.
- Pigs were mainly kept under free range conditions. This coupled with low levels of knowledge on Porcine Cysticercosis could be a precursor to pre-disposing communities to *Taenia Solium* infections.
- The pig enterprise could contribute more to the households' incomes and welfare if better methods of rearing pigs could be introduced and farmers' capacity build up.
- Porcine Cysticercosis was not well known to the community; therefore little is done to by the community to control the disease.
- There was low level of knowledge about the control measures of the disease. The *T. Solium* and penside diagnostic kit was not well known to all the respondents (farmers, traders and service providers).
- Majority of the respondents were willing to adopt and use the *T. Solium* vaccine and penside diagnostic kit.
- Incidences of epilepsy were quite common among the households of those interviewed. It was not possible to link the occurrence of epilepsy with pork consumption. This required more research involving human samples.

Recommendations

- There is need to build the capacity of farmers, traders and service providers on porcine Cysticercosis in Teso South sub-sounty.
- The pig value chain should be strengthened in the study area as the pig enterprise has the potential to increase incomes and food security of participating households.
- More research is required to determine the link between pork consumption and the incidences of epilepsy reported in households of pig farmers and pig traders.
- A policy recommendation on the pig farming in the study area is required.
- Research to validate the *T. Solium* vaccine and the penside diagnostic kit should proceed so that farmers, traders and service providers can be able to use it to control the disease in pigs in Teso South District and other parts of Kenya.

Acknowledgements

The authors thank ASARECA for funding the study.

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GARISSA COUNTY
East African Agricultural Productivity Project
BALAMBALA SUB-COUNTY
CAMEL MILK PRODUCTS
DAIRY GOAT ASSOCIATION OF KENYA
DGAK
P.O. BOX 1218 NYERI, KENYA
The World Bank
THE EASTERN AFRICA AGRICULTURAL PRODUCTIVITY PROJECT
BALAMBALA CLUSTER DISTRICT
OVERALL GOAL
CONTRIBUTING TO INCREASED
AGRICULTURAL PRODUCTIVITY

Appraising the extent of cavy culture in the Democratic Republic of the Congo

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For the first time, the extent of cavy culture in the Democratic Republic of the Congo (DRC) is assessed with emphasis on Sud-Kivu province. Cavy culture is defined as the raising, production and utilization of the domestic cavy (i.e., Guinea pig, *Cavia porcellus* L.) as farm animal. Although published research literature is extremely scarce, it can be estimated from various sources that more than 2 million cavies are kept as farm animals in DRC, probably contributing significantly to nutrition security and income generation of several hundreds of thousands of poor rural and urban households. This review estimates the current status of cavy populations in the country. The largest cavy populations were claimed in the Kivu provinces, which may be partly due to the inclusion of cavies in the agricultural portfolio of development agencies and in 'rehabilitation kits' of humanitarian NGOs who seek to address the challenges of widespread hunger and malnutrition in the area. Research and capacity building needs related to cavy culture are also identified. Given the dimension, we propose that cavies should generally be included in livestock census, honoring their role in the livelihoods of less endowed people, especially women. This review was undertaken within the project 'Harnessing husbandry of domestic cavy for alternative and rapid access to food and income in Cameroon and the eastern Democratic Republic of the Congo.

Improving milk production of dairy goats using locally available feed resources in semi-arid areas of central Tanzania

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In Tanzania dairy goats kept in rural areas are fed on natural pastures and cereal crop residues using the cut and carry system. These natural pastures and crop residues have low protein content and digestibility. On the other hand commercial concentrates are not readily available and/or too expensive for small-scale farmers, hence, are rarely used in goat feeding. An on-farm experiment was conducted for a period of 90 days to evaluate the effects of supplementing dairy goats with diets containing locally available protein sources on feed intake, weight gain and milk yield. Three iso-protein diets were formulated based on *Ficus thoningii* leaf meal (FLM), *Melia azederach* leaf meal (MLM) and sunflower seed cake (SFC) as sources of protein for treatments T_1, T_2 and T_3, respectively. Treatment T_4 was based on the farmers' feeding practice. A total of 24 lactating does were used and six does were randomly allocated to each treatment. Milk production of does fed T_3, T_2 and T_1 increased from 1.9 to 2.9, 1.7 to 2.5 and 1.6 to 2.3 l/day. Does supplemented with T_3 produced the highest total milk yield (230.6 ± 9.5 l) while those on T_4 had the lowest yield (140.2 ± 9.8 l). It is concluded that supplementation of MLM containing diet improved milk yield to the same level as supplementation with diet containing SFC, hence, MLM can substitute SFC in dairy goat diets and thus reduce the feed costs and increase the profits of dairy goat production.

A review of domestic goat (*C.hircus*) genetic diversity from microsatellite loci

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Characterization of genetic diversity is an important tool for sustainable management or conservation of populations. Limited diversity may hamper the long term adaptation of populations while its loss can immediately lead to decreased fitness within populations. In this review, genetic diversity of more than 120 domestic goat populations found in various parts of the world (Mediterranean region, East and South African region, Middle East, Asia, parts of Europe and Brazil) has been summarized. The review is limited to studies utilizing microsatellite loci. In all the reviewed populations, the within population genetic diversity is higher than between population variation, possibly due to random mating among the breeding flock. However, technical as well as statistical data management deficiencies, such as selection of microsatellites and other sampling biases observed in the reports might have impacted on the limited and weak variations obtained within and among populations. The genetic distance among populations was narrow, especially for breeds found within the same country. Generally, genetic variation seemed to occur within the expected range of estimates among regions though still lower than other livestock species overall.

Keywords*:* Domestic goat, genetic diversity, heterozygosity, polymorphic

PASTORAL SYSTEMS: OPTIONS FOR TOMORROW

Enhancing resilient pastoral based livelihoods in Africa in a changing world: Challenges and opportunities

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Summary
Sustainable Pastoral production system is increasingly on the decline in Africa despite the recent acknowledgement of its potential to contribute to the development of rural economy, improved livelihoods and sustainable management dryland resources. The dryland ecosystems cover about 45% of the continent. The Policy Framework for Pastoralism in Africa (AU-IBAR 2010) which aims to address the worsening situation of pastoralism through various interventions , but the major concern if whether these policy initiatives are effective to facilitate the transition of pastoralism in Africa to cope with the fast pace of national, regional and international development emerging trends. This presentation (paper) briefly explores past development initiatives, contemporary challenges and opportunities for sustainable development options in face of changing world.

Long-term monitoring of rangelands – Impacts of fire, tree cutting and livestock grazing on carbon sequestration in West Africa

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Summary
The Thirteenth Conference of the Parties (COP 13) to the United Nations Framework Convention on Climate Change (UNFCCC) and the emerging issue of REDD in 2007, has increased the interest in managing dry forests and woodlands in sub-Saharan Africa for carbon storage and sequestration. A critical pre-requisite to managing savanna woodland for carbon storage and sequestration is a good knowledge about tree and shrub biomass. Providing accurate measurements of carbon stock is difficult without precise measurements of biomass.This research aimed to estimate the amounts of carbon that can be sequestered through trees and land management options while measuring the above and below ground biomass between control and treatment in existing long term grazing, fire and selective tree cutting experiments in the rangelands of Burkina Faso. Method used for above ground biomass assessment was indirect by (i) long term monitoring of tree growth at plot level by complete inventory of the trees on each plot (measurement of dbh and height) every five year and yearly herbaceous biomassassessment since 1992 (ii)Further, allometric equations were built for estimation of trees below and above ground biomass using as predictor above ground dendrometric parameters (circumference or Dbh). (iii) For belowground biomassdirect measurement by monoliths sampling is used once after 20 year of treatment.The results show that Grazing did not affect trees basal area but affect significantly their height while fire affect significantly both basal area and trees height. Herbaceous total biomass is affected negatively by grazing about 25%. This percentage is 1% for early fire. Fire promote annual herbaceous in replacement to the perennial one.For the studies species parameters such as circumference, diameter and height could use to predict accurately above and belowground biomass with R2 ranged from 0,58 to 0,91. The main effect of treatments (grazing fire and selective cutting) was not significant on roots total biomass for plot level. Nevertheless, their cumulative effect was significant. Roots biomass ranged from 7 to 21 $t.ha^{-1}$ following the treatments. The result suggested that in dry savanna ecosystems disturbances affect mostly above ground biomass. Nevertheless, these ecosystems are adapted to the investigated disturbances since below ground root biomass is not affected by any of the treatment applied alone. Therefore, projects which aim to mitigate climate change by increasing carbon stocks in dry savanna ecosystems should pay more intention on the belowground biomass, taking care to avoid occurence of the three disturbances factors in the same landscape.

Market behaviours of Sahelian Herders

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Summary

The Agenda of many research institutions and development advocates the (re)integration of landlocked economic sectors to markets. Sahelian pastoralism is also affected. The problems of pastoral marketing systems are generally examined from the perspectives of infrastructure buildings. Based on the case of Senegal, this study shows that Sahelian pastoralists create money wealth by selling ruminants (97.9 %), dairy products (0.50 %) and crops (1.6 %). However, the distribution of sales (Gini index: 52.80) remains very unequal and linked to ecological disparities. As consumer-producer household, Sahelian pastoralists rely more on their uncertain environment (cereal/animal price fluctuations, spatiotemporal variability of ressources) and exploit occasionally market opportunities (religious feast). These reactions alternating *homo oeconomicus* and limited behaviours are exacerbated by fluctuating environment and market inefficiencies. Sahelian pastoralists use obviously livestock markets but these markets do not systematically pilot their production and marketing decisions. Although production, trade, storage and safety nets policies are useful to support producers and consumers to cope with price fluctuation impacts, it is also necessary to reduce transaction costs and information asymmetry to boost livestock marketing to satisfy growing demand of animal products.

Effects of climate and land use changes on productivity and management of mixed livestock-wildlife herds in agro-pastoral and pastoral systems

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Summary

Climate and land use changes have multiple effects on the production and management of mixed wildlife-livestock herds in pastoral rangelands of Africa. The effects are mediated through adverse effects of frequent and severe droughts, changing rainfall seasonality, deterioration, fragmentation and loss of rangelands. An increase in the frequency and severity of droughts impairs forage production, productive traits (growth, meat and milk yield and quality, egg yield, weight, and quality), reproductive performance, metabolic and health status, and immune response of animals. Reduced forage production, increased water scarcity and loss of rangelands reduce the carrying capacity and the buffering ability of agro-pastoral and pastoral systems. This results in increased risks owing to increased ecological variability, greater costs of product ion and reduced adaptability of animal genotypes. Better information and understanding of the nature and magnitude of the changes in climate (rainfall and temperature) and land use and their effects on animals are essential as a basis for developing management and selection strategies able to optimise productivity of mixed livestock-wildlife systems, improve the ability of animals to cope with environmental stress and reduce social vulnerability. Such strategies should hopefully better guide the evolution of mixed livestock-wildlife systems in the face of rising temperatures and extreme weather events. We analyze historic changes in two key components of climate (rainfall and temperature) and land use in relation to the dynamics of pastoral livestock and wildlife throughout Kenyan rangelands to understand their nature, quantify their magnitude and impacts on animals and characterize the management and productivity responses of mixed livestock-wildlife systems to the changes.

ORALLY PRESENTED

Sero-epidemiological study of camel brucellosis in Mehoni district, South Eastern Tigray, Ethiopia

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Abstract

A cross-sectional study was conducted from November 2012 - August 2013 to investigate the prevalence and risk factors of camel brucellosis in Mehoni District, Southeastern Tigray, Ethiopia. From the total of 450 sera (300 camels and 150 goats) collected, 26 animals were positive by Rose Bengal plate test (RBPT), and 11 of 19 camels and 5 of 7 goats were confirmed by complement fixation test (CFT). The overall seroprevalence of *Brucella* antibodies in camels and goats was 5.78% (26) and 3.56% (16) by RBPT and CFT, respectively. The logistic regression analysis showed highly significant association of positive antibody status with potential risk factors of age (P = 0.021, $X2$ = 9.689), history of abortion (P = 0.001, $X2$ = 129.964), and parity number (P = 0.006, $X2$ = 12.4754), and moderate associations based on herd size (p = 0.089, X^2 = 4.8487) and for keeping camels in close contact with goats (P= 0.082, X^2 = 3.0281). In contrast, seropositivity was not associated with sex (P=0.532, X^2 = 0.3897) or, species (P= 0.857, X^2 = 0.0324) or herd size (P= 0.089, X^2 = 4.8487). Questionnaire interviews indicated that most of the animal owners were not aware of the zoonotic nature of brucellosis and they drank raw milk and do not take precautions in handling aborted foetuses. Clearly, further studies need to be conducted on the risk of human brucellosis in this area, to educate herders on zoonotic disease and to devise measures for disease control.

Introduction

Camels (*Camelus dromedarius*) are vital domestic animal species that are best adapted to harsh environments and fluctuating nutritional conditions of semi arid and arid zones. These animals are endowed with extra ordinary features that enable them to survive and perform in such hard conditions. Dromedaries are versatile living assets that ensure food security even during the dry periods and also serve as means of transportation and draught power. Africa hosts 80% of the world population of dromedary (16.5 million), of which 63% attributed to east Africa (Wilson, 1998). According to the animal population census (CSA, 2004), the camel population in Ethiopia is estimated to be 2.314 million. The major ethnic groups owning camels in Ethiopia are the Beja, Rashaida, Afar, Somali and Borana. Camels are kept in the arid lowlands of Ethiopia which cover approximately 61-65% of the total area of the country and, are the homes to 12-13 % of the total human population (Beruk, 2003).

In drought stricken areas, ruminants are inferior to camels because of their physiological dependence on large amounts of water for metabolism and cooling. However, camels can retain lactation and produce high quality milk under drought conditions which makes them admirably suited to human requirements even when they are dehydrated and when other milk producing animals perish. In spite of its vital importance particularly to the marginalized communities in the dry zones of tropics and subtropics, studies about camel are very few (Schwartz and Dioli, 1992). Published information on diseases reveals that camels may be either carrier or susceptible or suffering from a vast array of infectious and parasitic diseases (Kohler-Rollefson *et al.*, 2001). Brucellosis is one of widespread infectious disease of camel that has considerable public health importance as camel milk is consumed raw (Gameel *et al*., 1993). Brucellosis was reported in camel from different countries of Africa and Asia (Abbas and Agab, 2002).

Previous serological surveys showed overall prevalence rates of 4.4% (Domenech, 1977) and 4.2% (Teshome *et al*., 2003) in different camel rearing areas of Ethiopia. However, available studies on camel brucellosis are scanty and do not provide detail epidemiological information of the disease in the particular study area. Therefore, the present study was undertaken with the objective to determine the sero-prevalence of camel brucellosis in Mehoni district and identify potential risk factors associated with the disease.

Materials and methods

Site of study

This study was carried out in Mehoni district, north eastern part of Ethiopia which is located in south eastern Tigray Regional State, near to border of Afar. Mehoni is situated approximately between 130151 and 130301N and 390301 and 390551E longitude, 200 km to south east of Mekelle, the capital of Tigray (Diress *et al.*, 1999).

Population and Sample Size Determination

Camel population in Mehoni district represented the study population. The sample size required to determine the prevalence of camel brucellosis was determined by following standard formula recommended by Thrustfield (1995). A total of 384 serum samples was supposed to be collected proportionally from three selected pastoral associations of the study district (Genete, Kukuftu and Chercher), however to increase the precision, the sample size has been increased to 450.

Sampling Procedure

Multi-stage sampling procedure was followed at three different stages to collect serum samples. The first stage is a primary sampling unit which represents each peasant association and was selected purposively based on the presence of camel population and easiness for accessibility. In the second and third stages; following proportionalization, camel herds and individual camels was selected randomly from each peasant association and herd, respectively.

Data Collection and Analysis

All sera samples collected were initially screened by Rose Benegal plate test (RBPT) using RBPT antigen by following the standard procedure recommended by Nielson and Dunkan (1990). Those positive sera with RBPT were further tested with CFT for confirmation using Standard *Brucella abortus* antigen following the procedures outlined by OIE (2004).

Different models or analytical tools were employed to analyze collected data including STATA version 16 Software. Descriptive statistics were used to analyze most of the data collected by questionnaire. Chi-square test was used to rule out whether there was significant association between prevalence of camel brucellosis and different risk factors.

Results

Overall Seroprevalence

In this study, 450 sera (300 camels and 150 goats) were collected from three peasant associations (Table 2). From the total serum sample collected, 26 animals (5.8%) were identified as seropositive reactors by using RBPT. The seropositive reactors with RBPT were subjected for further CFT confirmation. Accordingly, 16 (3.56%) overall seropositive reactors were detected by CFT (Table 1).

Table 1. Overall seroprevalence of Brucellosis in Camel and Goats by RBPT and CFT

Species	No. of Serum Test	Serological test	
		RBPT	CFT
Camels	300	19 (6.33%)	11 (3.67 %)
Goats	150	7 (4.67%)	5 (3.33 %)
Total (%)	450	26 (5.78 %)	16 (3.56%)

CFT= complement fixation test, RBPT=Rose Benegal plate test

Risk Factors and Seroprevalence

To identify the potential risk factors association with the occurrence of camel and goat brucellosis, all breeding male and female camels and goats above six months of age were included. From the total camels and goats tested, 83 were male and 367 were female, and the overall seroprevalence of brucellosis in male was 2.41% and 3.81% in females, a slightly higher seroprevalence in female than males, however; there was no difference observed (P= 0.532, χ^2 = 0.3897) (Table 3).

Table 2. Seroprevalence of Brucellosis

Peasant	Serum sample	Complement fixation test

Association	Camels	Goats	Negative	Positive	Total
Genete	50	50	99	1 (1 %)	100
Chercher	125	50	169	6 (3.43 %)	175
Kukuftu	125	50	166	9 (5.14 %)	175
Total	300	150	434	16	450

P = 0.202, χ^2= 3.1985

The potential risk factors such as age, abortion, parity number, herd size and rearing camels with goats were considered in the analysis. Logistic regression for age, abortion and parity number indicated that there was highly significant association (P = 0.021, χ^2 = 9.689; P = 0.001, χ^2 = 129.964; P = 0.006, χ^2 = 12.4754, respectively) with the occurrence of the disease in camels and goats (Table 3). The present study showed that there was slightly higher significant association with the occurrence of the disease in adult (> 4 years) than young camels (6 month to 4 years).

Table 3. Risk Factors for the occurrence of seropositivity

Risk Factors	Category		Total sample	Positive (CFT)	% Positive (95% CI)	P	OR (95% CI)
Age	Camel	6 mon -4yrs	131	0	0		
		> 4 years	169	11	6.51%	0.021	χ^2= 9.6897
	Goat	6 mon -1yr	15	1	6.67%		
		> 1 year8	135	4	2.96%		
Sex	Male		83	2	2.41 %	0.532	χ^2 = 0.3897
	Female		367	14	3.81 %		
Species	Camel		300	11	3.67 %	0.857	χ^2 = 0.0324
	Goats		150	5	3.33 %		
Parity	No parturition		99	1	1.01 %		
	Single parity		114	1	0.88 %	0.006	χ^2= 12.4754
	More than one parity		155	12	7.74%		
History of abortion	Yes		29	12	41.38%		χ^2 = 129.964
	No		338	2	0.59%	0.001	
Contact with animals	Contact		229	219	95.6%		
	No contact		71	70	98.6%	0.082	χ^2 = 3.0281
Herd size	1-9		97	1	1.03 %		
	10-19		183	5	2.73 %	0.089	χ^2= 4.8487
	>20		170	10	5.88 %		

mon = months, yr = year, P = statistical significance

Discussion, Conclusion and Implications

Brucellosis is a widespread zoonotic disease that is still of veterinarian, public health and economic concern in many developing countries including Ethiopia (Mohammed *et al*., 2011; Karthik *et al*., 2013). Camels are not primary hosts of *Brucella* organisms but they are susceptible to both *B. abortus* and *B. melitensis* (Cooper, 1991). The seroprevalence of brucellosis in camels appears to follow two distinct patterns: a low (2-5%) prevalence in nomadic or extensively kept camels and a high (8-15%) prevalence in camels kept intensively or semi-intensively (Abbas and Agab, 2002). In this study, 3.67% seroprevalence of camel brucellosis was observed which is in close agreement with Bekele (2004), Teshome *et al*. (2003a) and Domenech (1997) who reported prevalence rates of 0.4-2.5%, 4.2% and 4.4%, respectively in Borena, Oromia region and with Ghanem *et al*. (2009) who reported a prevalence of 3.1% in Somalia. As most of camels are kept by nomadic people despite the variation in region or locality where all areas practice extensive farming system which agrees with the report of Abbas and Agab (2002) that seroprevalence was low in this study.

Higher prevalence of brucellosis has been reported in females than in males (Hussien *et al*., 2005) while others in Sudan (Abu Damir *et al*., 1984) and Saudi Arabian (Radwan *et al.*, 1992) reported that male camels have high antibodies against *Brucella* infection more frequently than females. In this study, even though the logistic-regression analysis indicated that

there was no statistical significant difference between the two groups, males showed relatively higher prevalence (3.8%) than female groups (3.6%) which is in agreement with the later findings.
Infection may occur in animals of all age groups but persists commonly in sexually matured animals (Radostits *et al*., 2000). Younger animals tend to be more resistant to infection and frequently clear infection although few latent infections may occur (Radostits *et al*., 2000). The present study showed that there was slightly higher significant association with the occurrence of the disease in adult (> 4 years) than young camels (6 month to 4 years). The low seroprevalence in young camels might be because of maternal immunity. Susceptibility appears to be more commonly associated with sexual maturity and risk of infection increases with pregnancy as the stage of pregnancy increases (Crawford *et al*., 1990).

A higher seroprevalence (4.4%) was observed in camels reared with small ruminants (goats) as compared to those kept with no contact with small ruminants (1.4%) and there was statistically moderate significant association between camel groups with small ruminants and without ruminants (P=0.082, χ^2 = 3.0281). A significant association has been reported by Andreani *et al.* (1982) in Somalia where high chance of *Brucella* transmission from small ruminants to camels since they were in free range proximity in the bush and watering points. A contributing factor to the spread of the disease may be the movement of animals for grazing and watering during the dry season as aggregating animals around watering point will increase the contact between infected and healthy animals and thereby facilitate the spread of the disease (Richard, 1997).
There was an association (P = 0.006, χ^2 = 12.4754) between parity and the seroprevalence of the disease. Those female camels and goats with the history of more than one parity were 1.59 times more at risk of being seropositive to *Brucella* infection than those with no parturition (OR = 1.594; 95% CI, 0.944 – 2.694). Those with single parity were 1.25 times more at risk of being seropositive than those with no history of parturition. Higher infection rate was recorded in the camels and goats which gave birth to more than one calf and kid respectively (7.74%) than those with single parity (0.88%) and with no parity (1.01%). This is therefore, consistent with the previous study by Bekele (2004) where higher reactor rate was recorded in camels with more than one parity, compared to other group of camels.

In conclusion, the present study provided a baseline data of camel brucellosis in the study area and showed the potential risk factors that would contribute to the occurrence of the disease in camels as well as possible zoonotic implications in human beings. The different age groups, parity number and history of abortion showed statistically high significant association with the prevalence of the disease; however, the association with different peasant associations, sex and species of the animal was not significant with the occurrence of the disease except a slight significant difference with herd size and in camels co-exist with small ruminants. Lack of awareness about the zoonotic nature of brucellosis together with the existing habit of raw milk consumption and, close contact with animals can serve as means of infection to human beings. In view of the above facts, the following points should be considered in controlling of the disease: awareness about modern animal husbandry, disease prevention and risk of zoonotic diseases is quite necessary for camel pastoralists who are often neglected from public services, facilities and information; further researches that intended for the isolation of causative agents and identification of species and biotypes in Ethiopia are important to develop effective vaccines against the strains of *Brucella*; adequate brucellosis control programs in small ruminants would contribute to the reduction of the disease prevalence in camels.

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Comparison of economic benefits of pastoral and agro-pastoral households in Transmara West District of Narok County, Kenya

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Abstract

The shift from pastoral to agro-pastoral farming is ongoing among the Maasai community with traditionally strong cultural attachment to livestock assets and pro-conservation practices in TransMara West of Narok County in Kenya. The shift suggests limited success of development of livestock market opportunities in supporting sustainable livestock based livelihoods. Specific objective of the study was to compare pastoral and agro-pastoral based livelihoods for economic benefits of the farming systems associated with the shift. Data were collected from a sample of 130 households through interview schedules. An economic evaluation model was used to analyse economic benefits of pastoral and agro-pastoral farming. The findings indicated that unit net economic benefits were 2.4 times greater in agro-pastoral farming compared to pastoral farming. It was empirically justified that the shift from pastoralism to agro-pastoralism made economic sense. However there is need to hold educational campaigns, workshops and seminars on land use, planning and management in the area.

Keywords: Economic benefits, Pastoral and agro-pastoral farming systems, Transmara West, Maasai community

Introduction

Globally, pastoralism is characterised by keeping large herds of indigenous breeds. In Kenya almost 8 million people depend on pastoral livelihoods (Adeel and Uriel, 2005). Pastoralists own over 70% of Kenyan national livestock herd valued at over US$ 1.55 billion (Fineline systems and Management Company, 2010). These people live in the arid and semi arid lands (ASALS) characterised by high rainfall variability and with recurring droughts which impact on rangeland productivity. In some ASALS, where rangelands receive reliable rainfall pattern which can support crop production, pastoral households have responded by introducing commercial crop production. Consequently, the response has been associated with gradual shift from pastoral livelihoods to agro-pastoral land use systems (Gumbo and Maitima, 2007; Mwang'ombe *et al*., 2009). This kind of shift in livelihoods is ongoing in TransMara West of Narok County among traditionally pastoral Maasai community, who have had a strong attachment to livestock keeping. In the district, integration of crops and livestock systems has led to competition for land resource between livestock and crops. Adding to land pressure is higher growth rates of population and in-migration to pastoral lands (Akinwumi *et al*., 1996; Coast *et al*., 2001, 2006; Tangus, 2004). In pastoral land use, land ownership remains communal, unlike in agro-pastoral land use where, land ownership is private, which may be used for ranching and crop enterprises.

Access to communal land offering potential for grazing and water resources promote mobility in pastoral production system. Therefore, changes restricting access to these grazing resources increase pastoral vulnerability to drought and loss of livestock assets, which pose threat to sustainability of pastoral-based livelihoods (Mwangi, 2005; Coast *et al*., 2006). Faced with such threats, many pastoral communities have responded with diversification of livelihoods to agro-pastoralism (Ayantunde, 2008; Binsbergen and Watson, 2008; Freeman *et al*., 2008; Galvin, 2009). The Maasai community in TransMara West is not exceptional even though the economic benefits behind the shift have not been well understood. To mitigate some sustainability threats to pastoral livelihoods, the Kenyan government in partnership with the private sector promoted integration of pastoral economy into market economy. This has been through setting up of co-operative societies in the TransMara West to open ready market for livestock and livestock products trading in order to accommodate financial and social capital. This development strategy has however not been able to support sustainable pastoralism, evidenced by ongoing gradual shift to agro-pastoral based livelihoods (Morton and Meadows, 2000; Mochabo *et al*., 2006). The shift in livelihoods is pre-summed to be following a rational and economic decision, but empirical evidence is lacking to support this assumption. Therefore, evaluation of economic benefits associated with the shift to agro-pastoral livelihoods would inform development strategies for such areas. Further, comparative quantification of economic benefits associated with the shift would provide insight into the rationale underlying household decision making in farming systems.

Materials and methods

Data Collection

The study used Multi-stage sampling. Within the TransMara West, Kirindoni and Lolgorian divisions were purposively selected in the first stage because of having prominent pastoral and agro-pastoral farming households within the same agro-ecological zone. In the second stage was simple random selection of 8 locations among the two divisions. Lastly, random selection of the respondents within the locations was made proportionate to the population of each location to obtain the required sample size. The needed proportionate sample in a location was computed from the households in a location divided by sum of all households in eight locations them multiplied by the needed sample estimate of 130 households.

Interview schedule guided by structured questionnaire, observations and focused discussions with key informants was used in collecting the primary data. Data on input and output prices was collected from the local markets. The questionnaire was administered with the help of translators. Both large scale and small scale farmers were contacted.

Data collected included livestock live weights, inputs and outputs quantities and prices, labour requirement, sources of credit in the area and interest rates charged, household inventory of crop and livestock assets at the beginning and end of the year of survey. Because most farmers did not keep records, therefore a recall on month to month approach, field observation and field estimation was used to reduce the limitation of memory recall.

Sample size determination

The actual sample size was calculated from the approach of Anderson et al. (2007):

$$n = \frac{(Z_{\alpha/2})^2 p * q}{E^2}$$

Where;

n = Sample size, Z= confidence level (95% in this case). $z_{\alpha/2} = 1.96$, p^* = proportion of the population, q = 1- p^*, E= allowable error. In computing n, p^* = x / N, Where x is the population (households) involved in pastoralism and agro-pastoralism, N is the total population in the eight locations in Kirindoni and Lolgorian divisions. X was determined to be 1228 and N to be 14517 (MOFAP, 1999). The proportion (p^*) (x/N = 1228/14517) is thus 0.08459. With the desired margin of error (E) set at 0.05, the sample size needed was estimated at 119 as follows;

$$n = 0.08459 * 0.91541 * \left[\frac{1.96}{0.05}\right]^2 = 118.9 \approx 119$$

Additional respondents (11) were included to cater for none and invalid responses that are common with cross sectional survey interviews. Consequently, a sample size of 130 respondents was used.

Specification of the empirical model

An economic evaluation model based on the approach of Ayalew et al. (2003a, b) was adopted to compute the economic benefits from physical capital, financing and security/insurance.

The sum of monetary values of meat, milk, and honey and eggs production gave the gross output of the kth herd.

$G_k = YM_k + MM_{k+} MH_{k+} ME_k$..... (i)

Where; G_k=Monetary gross output of the kth herd, YM_k= Sum of monetary values of net meat production, MM_k= Sum of monetary values of net milk production, MH_k = Sum of monetary values of net honey production and ME_k= Sum of monetary values of net egg production.

The value of livestock kept for meat production was calculated as follows;

$Y_K = FS_k - IS_k + S_k - P_k + OT_k - IT_k + C_k$..... (ii)

Where; Y_K=Monetary net production of livestock in (kgs) of the kth herd, FS_k= body weight of livestock in (kgs) of the kth herd at the end of the year, IS_k= body weight of livestock in (kgs) of the kth herd at the start of the year, S_K= body weight of livestock in (kgs) of the kth herd sold out during the year, P_k= body weight of livestock in (kgs) of the kth herd purchased during the year, OT_k= body weight of livestock in (kgs) of the kth herd transferred out during the year, IT_k= body weight of livestock in (kgs) of the kth herd transferred in during the year, C_k= body weight of livestock in (kgs) of the kth herd slaughtered during the year.

Total value added of the kth herd will be obtained by deducting total purchased inputs (l_{kj}) from gross output in monetary value (G_K) as follows

$VA_K = G_K - \sum l_{kj}$..... (iii)

Gross margin analysis was used to get the physical economic benefits from crops. This analysis has been adopted by (Abubakar *et al*., 2007; Ajani *et al*., 2008; Cairo *et al*., 2009) and is stated as follows:-

$$GM=\sum_{i=1}^{n}(PyiYi - PxiXi) \text{ ..... (iv)}$$

Where: Yi = quantity of product (s), Pyi = unit price of the product(s). Xi = quantity of inputs (s), Pxi= Unit price of the input(s), i=1……n, Σ = Sigma

Livestock and crops help to adjust the consumption and savings of the household's income over time by balancing the current cash needs against anticipated cash needs of the future. The financing benefits associated with livestock were estimated based on the value embodied in the herd and the opportunity of using the animals for the specific purpose at the desired time without having to pay in the form of interest rate. Thus benefits for financing (F_{KL}) of the kth herd were determined as follows:-

$F_{KL}= OM_K \times f$..... (v)

Where; OM_K=Monetary value of stock outflow ($C_K+S_K+OT_K$) and financing factor (f). F represents interest rates based on the opportunity cost of borrowing credit in the locality. C_k= body weight of livestock in (kgs) of the kth herd slaughtered during the year. S_K= body weight of livestock in (kgs) of the kth herd sold out during the year. OT_k= body weight of livestock in (kgs) of the kth herd transferred out during the year.

It was assumed that some households might require liquid cash to pay school fees, medical bills and even for re-investment, thus there's a likelihood that they sell or lease out crops in the field to get cash. These financing benefits associated with crops (F_{KC}) were arrived as follows:-

$F_{KC} = OM_K \times f$..... (vi)

Where: OM_K=Monetary value of crops sold while in the field and f will be interest rates for credit in the area which was based on the opportunity cost of borrowing credit. The opportunity cost of credit was sought from the available credit service providers (Agricultural Finance Corporation (A.F.C.), Kenya commercial bank and Co-operative bank). Informal credit institutions were at reach by farmers, however, formal credit was common. There was insufficient evidence to apply estimates of interest rates from the informal credit market, as most farmers did not know the interest rates (Figure 1). The observed rate of 10% charged by A.F.C., which is the major credit provider in the area, was used. A.F.C. charged this rate (Kibaara, 2006) for short to medium term credit cash during the study period. A chi-square test was applied to determine whether there were differences in interest rate awareness and credit provision between pastoral and agro-pastoral households.

It was assumed that all livestock and crops were available to provide household security through liquidation at any time if need arises. On this assumption, the Security benefits from livestock (S_{KL}) were based on the value of sum weights of all livestock herds as follows:-

$S_{KL}=W_{KL} \times S$……..…… (vii)

Where W_K=Monetary value of weighted current stock of kth herd and S = insurance factor of the study area based on opportunity cost of insurance. The insurance benefits from crops were based on the assumption that households keep crop produce in store for quite some time before converting them into liquid cash. Thus crop insurance benefits were computed as:-

$S_{KC}=W_{KC} \times S$…….…… (viii)

Where: S_{KC} = Security benefit from crops, W_{KC}=Monetary value of unsold crop produce in store and S = insurance factor of the study area based on opportunity cost of insurance, however, an opportunity cost of insurance did not exist in the area, as insurance services were inaccessible to the farmers. This concurred with findings of Bebe *et al*. (2002); Ayalew *et al*. (2003b); Obare *et al*. (2003); Kosgey *et al*. (2004a). However, in relation to index based insurance whose aim is to protect farmers against weather related losses such as livestock mortality, Mude (2010) proposed a premium of 3.25% chargeable on the monetary value of livestock insured in the ASAL areas. This is applicable only when the predicted mortality rate is greater than 15%, implying that if the predicted mortality rate is below the strike point (15%), farmers are never compensated. So, an insurance factor of 3.25% was used in this study.

The net benefits from raising livestock were given as the sum of value added VA_K, benefit from financing (F_K) plus benefit from insurance (S_K).

$NB_{KL}=VA_K+F_{KL}+S_{KL}$…… (ix)

The net benefits from crops were given as the sum of gross margin (GM) associated with crops, benefit from financing (F_K) plus benefit from insurance (S_K).

$NB_{KC}=GM+F_{KC}+S_{KC}$…….. (x)

Unit net benefit for agro-pastoralists was the combination of unit net benefits from crops and livestock, whereas for pastoralists were unit net benefits from livestock. It is worth noting that the contribution of skins to gross benefits was negligible because a small proportion of animals were slaughtered at home that solely contributed to skins sold by the farmers, an observation already made in pastoral herds by Kosgey *et al.* (2004a).

It was assumed that for a household to get a certain level of output which is associated with different economic benefits, they used factors of production (land, labour and capital). In this case land was treated as a fixed input. Both hired and family labour were considered and assumed to have equal productivity. Also all farmers were assumed to have same production technology. Prices which were used prevailed during that production season for each of the enterprises. Thus these factors of production were accounted for in order to get the appropriate productivity measure. The per unit net benefit was arrived at by dividing the total net benefits by the average price of hiring in/lending out land in the area (Ayalew *et al*., 2003b). The obtained unit benefit values were subjected to t- test for any statistical difference in net economic benefits between the pastoral and agro-pastoral households in their livelihood sources.

Results and discussion

Comparison of interest rate awareness, sources of credit, limiting production factors and land prices among pastoral and agro-pastoral households

Economic benefits were arrived at by summing gross benefits, insurance and financing benefits in the farming systems. Moreover, the economic benefits were derived out of factors of production which had to be taken into consideration. To get financing benefits, interest rate for borrowing credit, household's awareness of the interest rates and various sources of credit were investigated. Figure 1 presents a comparison of pastoral and agro-pastoral household's awareness of the interest rates charged for the credit by various lending institutions.

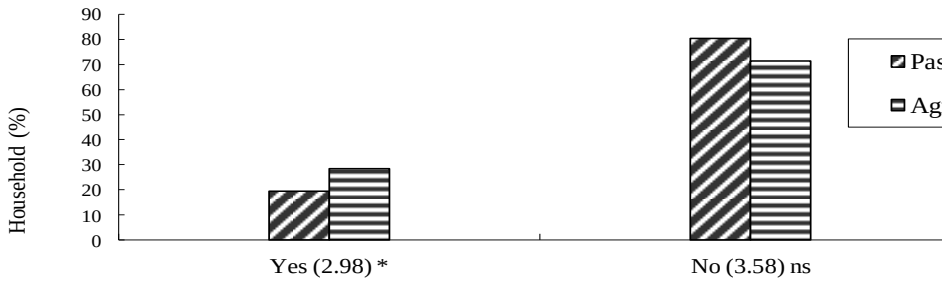


Figure 1. Awareness of interest rates among the pastoral and agro-pastoral households (in brackets are chi square values with *P<0.01; ns P>0.05)

About (81% and 71%) of the pastoral and agro-pastoral households respectively did not know the interest rates charged. Lack of awareness of interest rates charged by credit lending institutions might relate to low uptake of credit, low attendance in training and extension access. Moreover, the practice of borrowing credit from informal lending institutions (local money lenders) (Figure 2) could have contributed to low levels of awareness. Credit access was higher (P<0.05) among the agro-pastoralists. Of the four credit lending institutions, A.F.C was the major provider of credit, probably because of its low interest rate which might have attracted many farmers (Jayne and Nyoro, 1999).

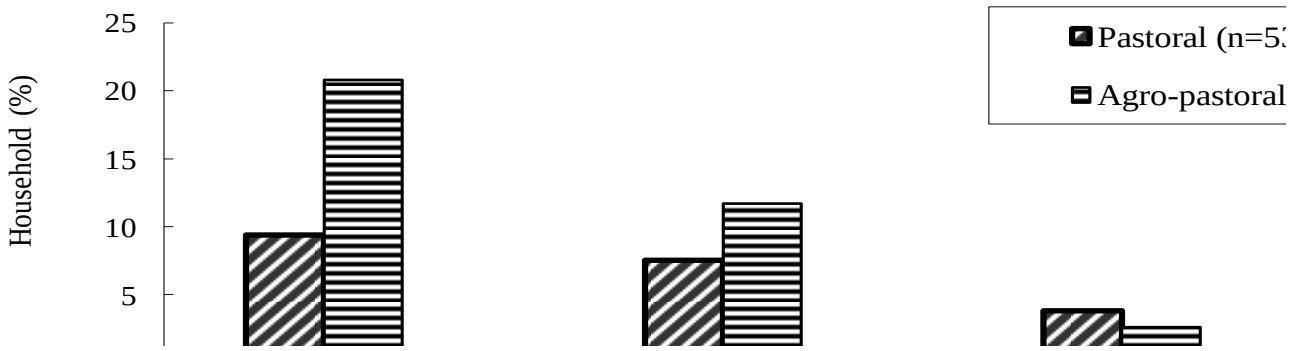
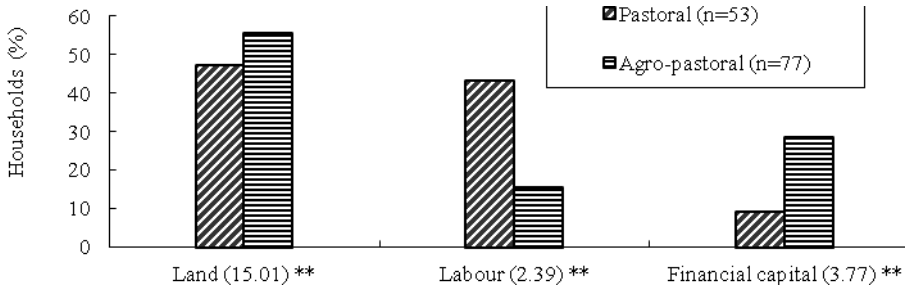


Figure 2. Household preferences for credit sources by pastorals and agro-pastorals (in brackets are Chi square values with **P<0.05; ns P>0.05)

Asked about limiting factors of production, the respondents indicated, in order of importance, land, labour and financial capital (Figure 3). Land and financial capital were more (P<0.05) limiting for the agro-pastoral households while labour was more limiting for the pastoral households. Among the factors of production, land turned out to be limiting for both pastoralists and agro-pastoralists. The results imply that shift to agro-pastoral farming was associated with smaller farm holdings and greater need for financial capital. Land limitation for agro-pastoral farming could be explained by the decision by the Kenyan government to privatize land in the rangelands (Griffiths, 2007), consequently leading to subdivision and allocation of rights for ranching and farming. This policy created pressure on pastoral lands (Coast *et al.*, 2001, 2006; Thornton, 2010) which has been accelerated further by the, high rates of population growth and in-migration



in the area.

Figure 3. Limiting factor of production among pastoral and agro-pastoral households (in brackets are Chi square values with **P<0.05)

The average price of land was not different (P>0.05) between pastoral and agro-pastoral farming systems. This was because the buying and selling price of land was not dependent on the farming systems (Herrero *et al*., 2006; Akerman, 2009). Moreover, it might happen that there existed a competitive market, where by the land prices were determined by the prevailing market forces, making both buyers and sellers be price takers.

Comparison of Economic Benefits (Revenues, costs and net benefits estimates)

Table 1 gives revenues, costs and net benefits associated with pastoral and agro-pastoral farming. The net benefits were arrived at by subtracting costs from gross incomes to get net incomes/profits. Further net incomes were added to financing and insurance benefits (obtained from equations (v) and (vi) to obtain the net benefits. The net benefits were more than twice higher for agro-pastorals as compared to pastorals (Ksh. 323306.04 verses Ksh.133890). Agro-pastoral farming enjoyed benefits from both crops and livestock, unlike pastoral farming where benefits were solely from livestock. Honey formed a substantial source of income in pastoral farming, about four times higher (P<0.05) than in agro-pastoral farming system. The reason is that bee keeping was a dominant activity among pastoralists in the area.

Table 1. Average revenues, costs, financing, insurance and net benefits from pastoral and agro-pastoral farming (KES)

Variable	Pastoral (n=53)	Agro-pastoral (n=77)	t-test statistic
Total gross income:	162485.00	442933.70	
Revenues			
Egg sales	776.60	3031.30	1.95ns
Honey sales	70452.83	28352.60	-3.03**
Livestock sales	43154.57	43259.00	0.10ns
Milk sales	48101.00	145450.00	-1.06***
Crop sales		222840.80	3.25***
Total costs:	53368.21	146694.70	
Livestock costs			
Treatment cost	3117.74	2560.39	-1.08ns
Transport cost	564.15	333.13	-1.04ns
Drug costs	3154.06	2939.81	-0.34ns
Labour cost	46532.26	27054.61	-2.12**
Crop costs			
Labour costs	0.00	77058.70	2.35**
Transport cost	0.00	468.18	4.70**
Input cost	0.00	36279.94	2.98**
Net income	109116.80	296238.40	
Financing benefits:			
Livestock	23546.34	20626.75	-0.46ns
Crops	-	1919.48	1.81ns
Insurance benefits:			
Livestock	1226.87	3854.84	1.70ns
Crops	-	666.51	4.31***
Net benefits	133890.00	323306.04	2.70**

*** P<0.001, ** P<0.01, ns P>0.05, 1 USD=KES. 86

Labour costs were 1.7 times higher for pastoral farming compared to agro-pastoral farming, a result inconsistent with several earlier observations (Akinwumi *et al.,* 1996, Kristjanson *et al.,* 2002, Adewumi *et al.,* 2009). It should be noted that livestock herding is a shared responsibility between family and hired labour on communal grazing lands, which when far away requires payments for labour services of trekking livestock. Pastoral herds are moved from place to place to access natural salt licks (Karbo, 2007; Ndumu *et al.,* 2008). Akinwumi *et al.* (1996), also supports the fact that as more people shift into agro-pastoralism through increased cropping, access to natural grazing land becomes limited due to fencing. So, more labour would be required to tether the animals carefully, thus increasing labour costs. Milk sales earned about three times more (P<0.01) revenues in agro-pastoral than in pastoral farming. The difference could be associated with better access to milk markets in market centres within proximity of agro-pastoral homes and consumption of most milk produced by the pastoral households.

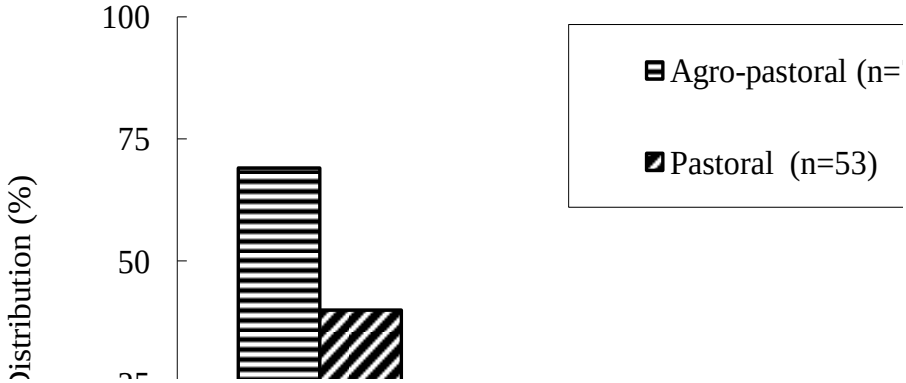


Figure 4. Distribution (%) of costs and benefits of insurance, financing and net incomes from pastoral and agro-pastoral farming

The percent distribution of the economic benefits (Figure 4) indicated that financing and insurance roles of crop and livestock were important part of economic benefits with financing benefits higher (17.6%) in pastoral while insurance higher (6.9%) in agro-pastoral farming. Financing benefits arise from liquidation of crops and livestock assets to finance cash needs requiring lump sum money like school fees and money to buy food for the household. Insurance benefits arise out of liquidation of crops and livestock assets to meet emergency cash needs such paying medical bills or settling legal court case (Awuor, 2003, *Kosgey et al*., 2004a, COMESA, 2009). Unit net benefits were arrived at after dividing net benefits by the monetary value of the most limiting factor of production in the area, which was land. Further a t-test was done to test for statistical difference in unit net benefits between pastoralists and agro-pastoralists. The results are presented in Table 2, indicating that agro-pastoral attained about 2.4 times more unit net benefits (Ksh 317.90/ha/year) compared to pastoralism (Ksh 131.65/ha/year). The reason could be that, farmers had realized that they could not achieve self-sufficiency through livestock production alone so as a response they tended to diversify to crop production so as to provide a variety of food for their families (Fratkin and Mearns, 2003; Miyuki, 2006; Adewumi *et al.*, 2009).

Table 2. Unit net benefit results

Farming system	Mean	Standard deviation	t-test
Pastoral households (n=53)	131.65	63.20	2.70***
Agro-pastoral households(n=77)	317.90	152.61	

*** P<0.001

Conclusion and recommendations

From the study, it was empirically justified that the shift made economic sense, given that agro-pastoralism exhibited greater unit net benefits associated with more enterprise diversity. However, these benefits were derived from factors of production land being one of them. It was evident that land turned out to be the most limiting factor of production. Therefore, as much as farmers will be willing to shift to agro-pastoralism, already they are constrained by land. Thus, educational campaigns, workshops and seminars on land use, planning and management should be encouraged in the area. Estimation of economic benefits was challenging. It would happen that farmers are less attracted to borrow loans from formal financial institutions when transaction and transport costs are taken into account by these institutions. Likewise the insurance premiums might be high given the fragile environmental conditions that pastoralists live in. Therefore, this study recommends further comprehensive research on ways in which farmers can cope with future uncertain financial requirements besides relevant alternative insurance options in the area.

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Climate variability and livestock marketing in the Horn of Africa: opportunities and challenges

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Abstract
The volume and value of livestock trade in the Horn of Africa has grown considerably during the past decade. Most of the livestock and livestock products for export trade originate from pastoralist areas, which are characterized by increased climate variability. In Ethiopia the Borana Zone supplies the bulk of livestock and livestock products for the country's export trade. This paper addresses some of the production and marketing challenges that affect livestock markets in Ethiopia. It draws on a current study of pastoralist households and livestock traders and suggests that the main constraints are climate-induced shocks and capacity to respond to them, limited access to formal credit supply, and fluctuations in demand and price in terminal markets. To address these constraints, we argue for policies and programs that keep more value in pastoralist areas and more equitably spread benefits from trade.
Keywords: Borana, Pastoralism, Drought, Value chain

Introduction

Pastoralism is a livelihood for millions of people in the Horn of Africa. Although pastoralism has been practiced for centuries and is well adapted to the environment, governments persistently advocate for sedentary agriculture rather than mobile pastoralism. Despite this bias, pastoralism is one of the most important sectors in the region for generating foreign currency through export of chilled meat and live animals. Ethiopia is one of the countries where live animal and chilled meat exports are rapidly growing, with the country earning more than 240 million US dollars from these exports in 2012. Most animals for Ethiopian exports originate from the pastoral (Borana) area of southern Ethiopia.

Borana Zone of southern Ethiopia is an arid and semi-arid (ASAL) rangeland characterized by erratic and unpredictable rainfall. To cope with climate variability, Borana pastoralists depend mainly on mobile herding, but also opportunistic farming and petty trade (McPeak *et al*., 2006). In recent years livestock marketing has become an important adaptive strategies for pastoralists, agro- pastoralists, and traders in the region. However, the livestock marketing value chain that connects producers to end markets operates under several challenges. Some of the challenges are local while others are national and international in nature. In this paper, we discuss the opportunities and challenges of livestock marketing value chain that originates from Borana and ends in the Middle East/North Africa. The data is drawn from a household survey and traders' interviews conducted in 2012/13, group discussions, and key informant interviews. A set of related questions addressed in the paper include: How does climate variability affect livestock marketing? How do Borana utilize marketing opportunities to cope with climate variability? What are the main challenges facing Borana livestock marketing value chains?

To answer these questions, we conducted household survey in two *Kebele* in Borana (Dikale, Yabelo woreda, and Kancharo, Dillo woreda). *Kebele* is the smallest administrative unit in Ethiopia. A total of 140 households were included. Additionally, 76 traders mainly from Borana, and some from Adama were interviewed. Data from structured interview were supplemented by key informants interview, group discussions and market observations.

Climate variability and livestock marketing

The quality and quantity of livestock from pastoral areas primarily depends on the availability of water and pasture resources. However, 95 percent of pastoral production in the Horn of Africa's rangelands operates under erratic rainfall with high spatial and temporal variability (Catley *et al*., 2012). In addition to spatial and temporal variability, frequent droughts affect range production in the Horn. Mbowa *et al*. (2008) describes rainfall as a key factor influencing the quantity and quality of water and pasture, the key resources for livestock production.

In dry regions of Africa the occurrence of drought poses risks for the production system, often creating disastrous impacts for local livelihoods. As drought approaches, pastoralists must either decide to move away from the market to distant grazing or stay nearby to sell animals (Little, *et al*., 2012). At the initial stage of drought, pastoralists may be optimistic and defer movement or rushed sales. As drought worsens, they initially move in search of pasture and water and, further into the drought, may sell some of the animals even though quality and price will have deteriorated. With the latter decision, pastoralists face additional challenges, including the distance between fallback areas and market centers and trekking weak animals to market. If their animals reach the market, sellers' bargaining power is diminished due to poor animal quality and lack of grazing options (Tiki, Field note, 2012). Furthermore, this period corresponds with the season when pastoralists must purchase foods to avoid hunger, which adds pressure on sellers to accept any price offered. LB, an Ethiopian livestock trader, describes this problem:

Since pastoralists increase their supply at the late stage of the drought, there are many factors constraining the marketing activities: the deteriorated body condition, presence of few buyers in the market, financial limitation, fear of the risk of buying weak animals, lack of transport either to move the animals or transport feed, etc.

Climate vulnerability shifts benefits from producers to traders because the latter can buy emaciated animals and feed them with purchased inputs for eventual sale once the market improves. The big traders and wealthy pastoralists transport forage from distant locations to feed animals until drought ends. Some traders also transport water to distant herds to reduce the energy expended by animals in using local water points (KA, personal communication, Moyale, 2013). Despite a heavy investment in animals and a degree of financial risk, drought presents an opportunity for large traders to buy low-priced animals and earn high profits. However, the timing of the transaction determines the level profit or loss. Transactions at a severe stage of drought may result in a "lose-lose" situation for both traders and pastoralists. During these times pastoralists sell at extremely reduced prices while traders also may lose their purchased animals.

Only wealthy traders and herders can utilize the transport and market options described above. For instance, 39 percent of traders profited from their business operation during the drought of 2010/2011. Therefore, climate variability is causing additional cost for small traders and poor pastoralists. Rich traders benefit due to their financial capacity, access to facilities, access to market and weather information, and volumes of operation that enable them manage risks. Climatic variability affects poor pastoralists more than wealthy households who have more animals, diversified species, and diversified business activities.

Indigenous and innovative coping strategies with climate variability

Borana pastoralists use various strategies to cope with climate variability. They have crafted longstanding herd management strategies to address resource scarcity and climatic conditions. Pastoralists can expand or reduce animal numbers depending on climate and resources. These coping strategies are embedded in communities' customary social structures and resource management institutions that focus on land use classification, herd splitting and mobility. The customary deep wells of Borana are centers of reference for differentiating wet and dry-season grazing regions. Accordingly, lands surrounding the deep wells are reserved for dry seasons. Animals are sent, in turn, to remote grazing regions during wet seasons. This pattern, however, has been abandoned in the past three decades. In the absence of enough animal feed for the dry season because of overuse, minor deviations of rainfall can cause widespread deaths of cattle every few years (Tiki *et al.*, 2011). Moreover, the degradation of the grazing land and changes due to private enclosures, expansion of cultivation, expansion of settlements, and bush encroachment have dramatically reduced pasture availability for communal use (Ibid).

While indigenous coping strategies are in decline, pastoralists and traders have adopted new and sometimes innovative approaches. Use of crop residue as animal feed has become common among pastoralists who own and cultivate farms. Pastoralists store crop residue for dry season and feed the animals. Unfortunately, the availability of crop residue is highly dependent on the amount and distribution of unreliable rainfall. Transporting water and hay to feed animals, increased reliance on mobile phones to receive market information, buying use rights of grazing lands, and feeding animals with selected tree leaves are new attempts to cope with climate variability, and reduce market risks.

Opportunities

In this section, we present both opportunities for improving pastoral livelihoods through improved livestock marketing and the challenges that make these changes so difficult. Ethiopia contains the highest number of cattle in Africa. It has a high potential for improving livestock production and productivity, has valuable species, and is located close to the Middle East and North Africa, the regions that import the majority of live animals and chilled meat from the Horn of Africa. In these regions, demand for meat is growing fast. According to Hamito (2011), the annual total demand of Middle Eastern countries is about 207,000 tons of meat and 12 million head of sheep, goats, cattle and camels. Based on existing export data from 2009/10, the market share of Ethiopian exports was only 3.4 % and 1.4 % of the Middle East's meat and live animal markets, respectively (Ibid). These data suggest high potential to expand Ethiopian exports to these regions if constraints can be addressed.

Another possible advantage for Ethiopia lies in the growing market for organic meat products. However, the country has done little to promote the trade. Ethiopia's competitors, such as Australia and Brazil, have undertaken what a USAID report describes as an 'aggressive promotional campaign' (2013). Improving product and price competiveness in international markets would enable Ethiopia to reap its clear locational and animal species/quantity advantages. Expanding domestic market options also will benefit Ethiopian small holders, traders, and the government. This requires identifying the challenges and addressing them.

Challenges

With the current dependence on livestock markets in the Middle East/North Africa countries, a key question is: what would be the fate of pastoralists if Middle East or North African countries markets close down temporarily or permanently? This happened when Saudi Arabia banned imports in the 2000s due an outbreak Rift Valley Fever in the region (Aklilu, 2008). We posed this question to traders in Borana. One replied, 'People will be robbers, while another trader replied, 'We will be impoverished and finished'. In the following section, we present some of the main challenges to livestock marketing value chains that source animals from Borana.

Informal Credit arrangements

The livestock marketing chain from Borana to export markets is characterized by informal credit operations. Sources of credit for this trade are diverse. Some traders take cash advances from large-scale traders, while many others take animals on credit from pastoralists at lower ends of the market chain. A trader makes a partial payment to the herder and promise to pay back later the remaining balance.

The credit operation is driven by two important factors: (1) distress sales from pastoralists or small traders due to climate and (2) shortages of finance from buyers. Pastoralists and traders may sell animals on credit during droughts to minimize feeding costs and avoid animal losses. The second factor is unavailability of formal credit. Since informal credit lacks proper documentation and legally binding contractual agreements, there is less accountability on part of the borrower than in formal credit arrangements. When a pastoralist/trader is forced to sell due to drought, he/she tends to accept whatever

price is offered. If the credit is due to shortage of finance from the buyer, the seller has a relatively strong bargaining position, even though he/she may have no control over the repayment period.

In practice current credit operations are considered by traders to be the best options available in the absence of formal sources of finance. Many traders will buy and sell without ever having the required amount of money. From 76 traders we interviewed, 33.33% of them report buying animals on credit, while 78.67% indicate selling animals on credit. Moreover, sixty-eight percent of traders who buy on credit report repaying credit immediately after selling animals, while 28% report repaying a few days after the animal(s) is sold(Table 1). Moreover, 39% of the traders who report selling on credit said that they recover the money back whenever the buyer gets enough money, while 22 % said they obtain the money back immediately after the borrower sells the animals.

Table 1. Recovery of credit money as reported by traders

Time of repayment	Get back from debtor (N=59)		pay back to your creditors(N=25)	
	Frequency	Percent	Frequency	Percent
Immediately after reselling	13	22.03	17	68
Few days after reselling the animals	9	15.25		
Few weeks after reselling the animal	7	11.86	7	28
Whenever the buyer gets money	23	38.98	1	4
Others	7	11.86		
Total	59	100	25	100

However, since the big traders also partly or fully sell on credit, the repayment at the lower level is delayed by multiple factors: personality of the trader, inefficient banking transfers, and the delay with money transfers from importing countries. In general, those at lower levels of the market chain bear most of the cost of credit transactions.

The most disappointing part of the credit transaction is the frequency and amount of default recorded by traders (Some of the traders are foreigners from Arab countries and others are feedlot operators who take credit from Borana, sell on credit to Arab traders and fail to get the money back. In such cases, both the feedlot operator and traders in Borana are significant losers). Of the 59 traders who reported selling on credit, 51% have encountered at least one default where the credit recipient did not pay. Only 33% of them partly or fully recovered the loan and a few traders even taking their cases to court. The loss of money ranges from about 1,000 birr to well over one million birr (Table 2). Data from traders' interview show that each trader encountered on average 1.8 defaults on loans.

Table 2. Amount of money lost to credit default, frequency of default, and number of defaulters

	N	Minimum	Maximum	Mean	Std. Deviation
Amount lost (birr)	30	1300	3000000	315709	670379.76
Times defaulted	28	1	5	1.64	1.061
Number of defaulters	30	1	5	1.8	1.21

Source: Traders' interviews, 2012-2013, CHAINS Project. USD=19.60 birr -June 2014

The problem is not only lack of money to repay credit, but also a lack of awareness by small traders and pastoralists of their legal rights. Credit transactions also involve local butchers and hotel owners who purchase goats and bulls on trader credit and plan to pay back after selling the meat. Similar credit arrangements have been observed among traders and butchers is Nairobi (McPeak *et al*., 2012). These transactions are also prone to default.

Seasonality and fluctuation in demand, supply, and prices

Livestock trade in Ethiopia experiences significant annual and intra-annual fluctuations in demand, supply, and price, which increase uncertainty for many market actors. Volatility may be related to political instability in the area, the occurrence of religious holidays in the Middle East and North Africa, weather conditions in Borana and Adama, bureaucratic constraints on trade, disease prevalence, and other factors (Group discussion, October 2013). Demand for meat and live animals in domestic and Middle Eastern markets are especially affected by the timing of religious holidays.

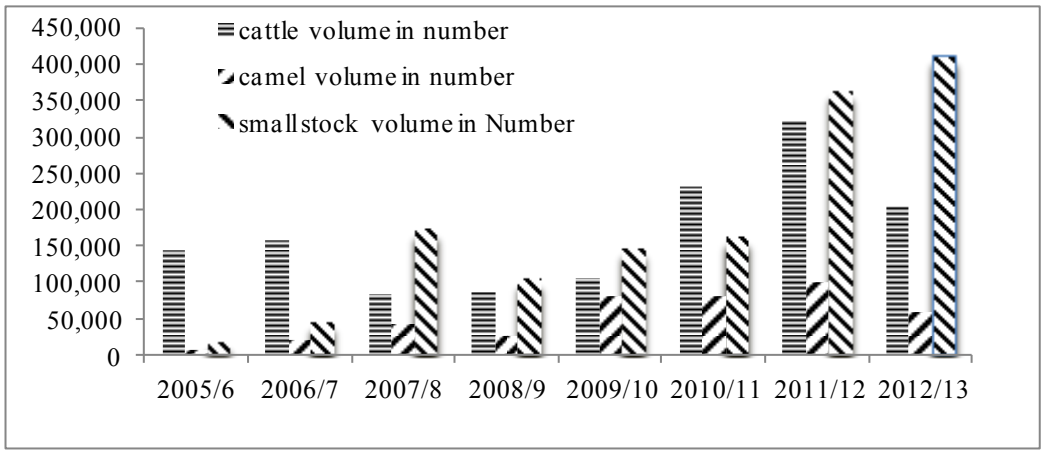
According to one exporter, the annual haji pilgrimage to mecca accounts for about 70% of annual small stock exports from the Horn region. During the 2012 Eid al-Adha holiday exporters could only meet about 50% of the demand for small

stock (MA, March 2013, Adama; also see Majid 2010). Demand in local markets also rise sharply during the Ethiopian New Year, *Meskel* (public holiday among the Orthodox Christians), Christmas, and Easter holidays, and then drops dramatically during fasting observances by orthodox Christian followers.

Seasonal factors also affect supply response among producers/pastoralists. During wet seasons, the producers may hold to cattle and fulfill their cash requirements from small stock sales. During dry seasons herders generally are more motivated to sell animals because of high cash requirements to purchases food. Most pastoralists sell animals when they are compelled to because of family need or external factors, such as a prolonged dry season or drought (see Little, 1992, Little, 2006). Only a few rich pastoralists take advantage of favorable prices by timing their sales to take advantage of market opportunities. From our data, major sales were reported during the main dry season of December to February, with 42.4% of respondents reporting selling animals in those months.

Livestock export market chain and challenges

There are different export routes for Ethiopian livestock. The most frequently used routes are via Moyale to Kenya and via Adama to the Middle East, but it is only the latter market channel that the government recognizes to be export. To a limited extent, there also are formal and informal exports to Sudan, especially of camels and cattle. The volume of and prices for exports of live animals varied over the last couple of years, with a decline in the export of beef and live bulls in 2012/13(Figure 1). While government experts and abattoir owners blame informal cross-border trade for the decline, many traders point to increased competition from other countries (e.g., Pakistan, Australia and Brazil) and a lack of price competitiveness for Ethiopian exports. One trader explains that 'sometimes meat prices are the same at Cairo [Egypt] and Haro Bake (Borana) markets'. Market assessment by USAID team in different importing countries confirms that some Middle East countries are shifting from Ethiopia to other suppliers (USAID Ethiopia, 2013).



Source: Meat and Dairy Technology Institute

Figure 1. Volume of livestock exports from Ethiopia, 2005-2013

A long market chain, inappropriate and expensive transport, high costs of feed and feedlot operations are some reasons behind high prices of Borana bulls (USAID-Ethiopia, 2013:20). An earlier study showed feed price as a major constraint that impedes Ethiopia's access to competitive world market (Rich *et al*., 2009). Another important market constraint is limited access to market information at the local level. In particular, pastoralists lack clear and detail information on the characteristics of animals that are required for export and animal health requirements.

Conclusions

Livestock marketing is a source of livelihood for many actors in Ethiopia. It is also an important source of revenue to local governments and the federal government of Ethiopia. However, this sector operates under multiple constraints. Climate-induced vulnerability and consequent shortage of animal feed puts pastoralists in a position where they must sell on a devalued market, especially in cases where herd mobility is not a viable alternative. For traders, however, financial constraints are a key challenge and most of them lack access to forma credit. Instead, they rely on informal sources of

credit that lack proper contractual agreements and legal protection. Fluctuation of demands and prices on the basis of local and international events increase volatility in the sector. Despite these and other constraints described in the paper, there are opportunities to improve Ethiopia's livestock markets and its competitiveness in international market. This means improving product quality, meeting specifications of importing countries, and responding to favorable demands. Solving livestock feed shortage and its seasonality require a concerted effort and would reap major benefits both for producers and traders.

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Challenges to pastoralism and potential strategies for support of small ruminant production and pastoral livelihoods in the rangelands of Kenya

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Abstract

Kenya has an estimated population of 17.1 million sheep and 27.7 million goats, majority of which are found in the semi-humid to arid zones of Eastern, North Eastern and Coast province which are mainly rangelands often classified as arid and semi-arid lands (ASALs); cover an estimated 511,000 km^2 (88%) of Kenya's landmass and are populated primarily by some 30% of Kenya's population, mainly traditional, transhumant pastoralists. Although the ASALs spread across 18 of the 20 poorest constituencies in the country with the populations experiencing the lowest development indicators and highest incidence of poverty, it is recognized that a vibrant livestock industry, with small ruminants (sheep and goats) being predominant, can play a key role in reversing the poverty levels and contribute not only to the ASAL's but to the nation's economic growth. Since the mid 1970s there have been major changes to the basic production systems on these rangelands which have had an impact on their productivity. A number of factors have together contributed to these changes including population growth; loss of herding lands to private farms, ranches, game parks, and urban areas; increased commoditization of the livestock economy; out-migration by poor pastoralists; and periodic dislocations brought about by drought, famine, and civil war. This paper reviews some of these change drivers and proposes potential strategies for ensuring a sustained small ruminant production in the Kenyan pastoral rangelands. These strategies include identification and characterization of the predominant livelihood scenarios and current strategies; undertaking comprehensive livelihoods and market chain analysis; empowering pastoralists to engage with markets more effectively and strengthening their business linkage with other entrepreneurs; and putting in place measures for managing the environmental risks and reducing vulnerability of the pastoralists.

Keywords: Cropping pressure, Climate change, Land markets, Property rights.

Introduction

Kenya has an estimated population of 17.1 million sheep and 27.7 million goats, majority of which are found in the semi-humid to arid zones of Eastern, North Eastern and Coast regions. These areas are mainly rangelands characterized by moisture index (annual rainfall expressed as a percentage of potential evaporation, E_o) of less than 50%, mean annual rainfall of less than 1100 mm, altitude below 1200 m and mean annual temperatures ranging from 22° to 40°C.

These rangelands are often classified as arid and semi-arid lands (ASALs); cover an estimated 511,000 km^2 (88%) of Kenya's landmass and are populated primarily by some 30% (about 12 million) of Kenya's population (who are mainly traditional, transhumant pastoralists) and has 50% of its livestock and 75% of wildlife. The ASALs spread across 18 of the 20 poorest constituencies in the country with the populations experiencing the lowest development indicators and highest incidence of poverty. It is however, recognized that a vibrant livestock industry, small ruminants (sheep and goats) being major, can play a key role in reversing the poverty levels and contribute not only to the ASAL's but to the nation's economic growth.

It is important to recognize the fact that since the mid 1970s there have been major changes to the basic production systems on Kenya's rangelands where most of the small ruminants are found and which have had an impact on their productivity. Factors that have contributed to these changes include agricultural development- the need to produce more food from marginal lands, population growth and global climate change.

The potential impact of these drivers of change on livestock systems and the resource-poor people who depend on them is considerable. Taken together, these trends signal a fundamental switch in production strategies across the rangelands from an extensive, mainly pastoral production system to a more intensive agro-pastoral system (Norton-Griffiths and Said, 2009)**.** It is the result of population growth; loss of herding lands to private farms, ranches, game parks, and urban areas; increased commoditization of the livestock economy; out-migration by poor pastoralists; and periodic dislocations brought about by drought, famine, and civil war (Fratkin,1997)**.** This paper reviews these drivers of change and proposes potential strategies for ensuring a sustained small ruminant production in the Kenyan pastoral rangelands.

Materials and methods

Information and data used in the preparation of this paper has been gathered through a comprehensive review of papers published in journals, review articles and technical reports. The publications cover local, regional and international experiences. These sources are complemented by information gathered by the authors through informal exploratory survey of several small ruminant markets and discussions with livestock extension officers, pastoralists and private ranchers in over ten counties in Kenya.

Results

The major drivers of change in the pastoral rangelands

Pastoralism is often defined as a livelihood in which at least 50% of the household's food and income is derived from livestock and is characterized by mobility and in particular, the seasonal movement of livestock to access grazing resources and water (PACAPS, 2009). Other authors have defined pastoralists as people who depend on livestock or the sale of livestock products for most of their income and consumption, where livestock is mainly grazed on communally-managed or open-access pastures, and where there is at least some tendency for households or individuals to move seasonally with livestock (Morton, 2008; Broekhuijsen, 2013). In the present circumstances where there are pastoralists who are in transition struggling with different options and those who have lost their livestock and taken up alternative livelihoods in response to a variety of drivers, these definitions seem to be rather restrictive. However, as a way of life and economic activity in Africa, pastoralism as we know it, is one of the oldest, most resilient and most adaptive livelihoods strategy which is well suited to arid and semi-arid environments. However, the traditional and often sustainable pastoral practices are now being threatened by a number of factors including agricultural development, the need to produce more food from marginal lands, population growth and global climate change. Against this background, the traditional ways of pastoralists continue to change, and many are settling (or are settled) and diversifying their income-generating activities into crop production, wage labour and other activities, while other family members continue to herd the family stock and move to follow the availability of forage (Reid *et al*., 2005)**.** This paper analyzes these drivers of change, their impacts particularly on small ruminant production and suggests potential strategies for mitigation.

Expansion of crop production into rangelands

Over the years, patterns of land-use have changed in the ASALs from, principally, nomadic pastoralism to sedentary pastoral and agro-pastoral production, or to pure cultivation mainly as a result of unprecedented population growth, excessive cropping pressure and overgrazing. The human population growth of some 3.1% per annum has been accompanied by an 8.6% per annum growth in the area under cultivation, a trend seen in all ASAL Districts (Norton-Griffiths and Butt, 2006). According to Boserup (1965, 1981), population growth has been the driving force for intensifying agriculture in preindustrial societies. The increased population density has thus led to both intensification of production and the search for wage labour and the concomitant change in food consumption patterns from milk, meat and blood to cereal grains. Incidentally, the highest rates of poverty have been observed among those who are no longer directly involved in pastoralism, particularly those without livestock who depend on casual labour or petty trade in towns (REGLAP, 2012). As more land is opened up for agriculture, the loss of vegetation on which small ruminants thrive is inevitable.

Subdivision of ranches and the evolution of individual property rights

Agricultural development in East Africa was much influenced in the 1970s by a paper published by Hardin in *Science* in 1968 titled "The Tragedy of the Commons" in which he intimated that land degradation was occurring due to the overstocking of livestock arising from a traditional system in which land was owned communally, leading to a lack of incentives to manage it properly in the long run. This seems to have had an influence on the Kenyan Government since it took the first major step towards privatization in 1968 with the introduction of the Land (Group Representatives) Act Cap. 287 of the Laws of Kenya, which provided for the adjudication of group ranches (Bekure *et al*.,1991; Rutten, 1992) and subsequently promoted private and individual land titles since the 1980s, leading to a scramble for land (Galaty,1994). Prior to the formation of group ranches, access to grazing was obtained through membership in a section or sub-tribe. In the Kajiado District, for example, the average section was over 2000 km^2. In normal years, producers tended to use only a portion of their section; in times of drought, however, even cross section movement was facilitated. The Kaputiei section, which was about 3100 km^2, and divided into two subsections of roughly 1000 and 2100 km^2 , with the latter having three socially distinct locations, has been subdivided to the extent that today the mean size of the 15 Kaputiei group ranches is

only about 160 km^2. Perhaps the most striking example of this is on the high potential agricultural land around the Maasai Mara Game Reserve where the original 42 group ranches of an average size of 35,000 hectares have been transformed into some 30,000 private land holdings of around 50 hectares each (Norton-Griffiths and Said, 2009).

The rapid evolution of property rights and the sub-divisions from large parcels of land under group or communal tenure to small parcels of land under private tenure across Kenya's rangelands are happening at an alarming rate. Indeed much of Kenya's southern rangelands have been subdivided into individual parcels, including the high potential areas which are critical dry season grazing reserves for traditional livestock keepers. Areas which have not yet been officially subdivided have on the other hand, undergone a parallel process of sedentarization. Even in the more arid and less populated conditions of Kenya's Marsabit District, pastoralists are experiencing land crowding and, in highland locations including Marsabit Mountain, they are beginning to privatize land and secure titles (Adano and Witsenburg, 2005). This reduction in grazing area has important implications for production considering East Africa's highly erratic and scattered rainfall.

The process of urbanization and emergence of land markets

It is thought that urbanization is one of the major factors creating and driving the new and powerful incentives to sub-divide land throughout Kenya's rangelands, specifically the influence of growing urban markets and peri-urban settlements. Although the massive transfer of wealth from urban to rural areas due to purchases of agricultural and livestock produce from the surrounding agricultural lands and rangelands contributes significantly to poverty reduction, a secondary effect is to inflate the value of land in response to the growing demand for both quantity and quality of produce, which in turn creates further incentives to invest in land sub-division, conversion and production (Tiffen, 2006). There are those Maasai pastoralists who believe today that fences, roads, quarries, cement works, flower farms and new buildings which hinder their movement are graver threat to their survival more than droughts (ILRI, 2012). Ironically, although rapid urbanization is expected to continue in developing countries, the global demand for livestock and livestock products will continue to increase significantly in the coming decades as a result of the urbanization, population growth and income increases. Certainly this increased demand has to be met from somewhere and most likely from the same rangelands depending on how the producers will benefit from this potential demand-led income opportunity.

Effects of Climate change and Global warming

Droughts are not a unique phenomenon in the ASALs to the extent that it can be said managing drought is a normal part of pastoralism. The only unique situation is that in the past, drought came in ten-year cycles, enabling pastoralists to build up their herds and regenerate pasture and water resources to withstand the next drought (REGLAP, 2012). Over the past 30 years, however, drought cycles have been shrinking to every five years and now every two years– and the droughts are more prolonged. These short drought cycles hinder pastoralists' traditional drought management strategies, making them less resilient (Erasmus *et al*., 2012). The prolonged drought of 2008-9, which is thought to have been extreme not only in meteorological and rangeland production terms, but also in terms of its devastating impacts on livestock resources, is being at least attributed to climate change (Fratkin *et al*., 2011).

While reducing the country's economic performance, recurring droughts particularly erode the assets of the poor, who herd cattle, camels, sheep and goats over the more marginal drylands. This regular erosion of animal assets is undermining the livelihoods of Kenya's pastoral herding communities, provoking many households into a downward spiral of chronic hunger and severe poverty (ILRI, 2010).

Discussions

A number of strategies for improving and sustaining small ruminant productivity and creating secure livelihoods for pastoralists in response to the changing trends in the pastoral rangelands of Kenya exist but logically it would require to first identify the predominant livelihood scenarios and current strategies.

Identifying appropriate pastoral Livelihood strategies for small ruminant production

A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living while livelihood strategies are "the range and combination of activities and choices that people make in order to achieve their livelihood goals' (Carloni, 2005). In its policy brief, '*Pastoralism in the Horn of Africa: Diverse livelihood pathways'* the Comprehensive Africa Agriculture Development (CAADP) recognizes four simplified livelihoods strategies with different levels of resource and market access and shows how the access to these are in turn affected by a number of drivers of change (CAADP, 2012). The first livelihood strategy which is the traditional mobile

pastoralism which although is still an important scenario is characterized by poor market access, with limited options for commercialization but still has relatively plentiful resources. It is becoming rare and only a few examples may be found such as in parts of the 'Karamoja cluster' of north-western Kenya. In other areas outside these a second type of livelihood has emerged propelled by the growth in commercial trade and markets which has in turn created numerous livelihood opportunities. In such a scenario pastoralists are taking advantage of greater incorporation into national and regional economies to move livestock and goods across geopolitical and land-use boundaries. Households are consequently adopting a mixed strategy– maintaining herds on the range and developing trade, business or services with the women engaging in value-addition and gaining an independent source of income in return. Since not everyone is able to profit from the increasing market opportunities, those who cannot, drop out of the traditional pastoral system and either move into other livelihoods (as laborers, small-scale entrepreneurs or service providers) or become reliant, in increasing numbers, on aid agency support. The fourth category of an elite commercial class is emerging within pastoral societies, well connected economically and politically at the centre, often losing their connections with the 'margins'. Broekhuijsen (2013) similarly identifies four livelihood responses of pastoralists in times of stress. The first response is '*hanging on*' to systems of largely subsistence pastoral production. The second option which is open to few as it requires significant support from stakeholders to add value, is '*stepping up*' to a more commercial livestock production system, where profits can be made. The third response, opted by many pastoralists, is '*branching out*'. In this scenario, livestock rearing is supplemented by a variety of other livelihood activities, often with poor and inconsistent economic returns. The fourth and final option is that of '*moving away*' out of pastoralist systems for altogether different livelihoods (*dropouts*).

Given the above situation, it is logical to suggest that in terms of improving and sustaining small ruminant production, more focus should be on CAADP's second type of livelihood which is propelled by the growth in commercial trade and markets which has in turn created numerous livelihood opportunities. This livelihood falls within the '*branching out*' livelihood response option described by Broekhuijsen (2013) which is already becoming predominant in the southern rangelands of Kenya. According to Broekhuijsen (2013), the '*branching out'* group should be given support to identify and undertake alternative economic activities that support, complement, or at least do not undermine pastoral production. At present, their livelihood diversification is forced and driven by desperation rather than by emerging opportunities appropriate to this subpopulation in the pastoral areas. Through Sustainable Livelihoods Framework analysis as suggested by Carloni, (2005), it is possible to further understand how household livelihood systems interact with the outside environment- both the natural environment and the policy and institutional context.

Identifying appropriate Strategies for meeting future market demand for small ruminants

The traditional forms of agriculture in which farmers made all the decisions with regard to production, home consumption and sales at the market place, have changed with modernization. According to Lundy *et. al*. (2008), through processes of urbanization, generally fostered by industrialization, demand for food from urban dwellers becomes dependent upon more sophisticated arrangements that require aggregation of farm produce, transportation, storage, wholesaling, processing, and retailing. As cities expand, food supply systems develop into increasingly longer and more complex market chains with many market channels and specialization of roles in the market chain based on product type, levels of added value and market segmentation.

For pastoralists to actively participate and benefit from such markets requires that they be empowered to engage with markets more effectively and strengthen their business linkage with other entrepreneurs. By engaging the identified pastoral livelihood group in a participatory market chain analysis, researchers and development agencies can build a clear understanding of local marketing conditions and how best to work with farmers to resolve critical points in a particular market chain. Developing this knowledge with farmers is a key element in developing sustainable and competitive agro-enterprises. According to Lundy *et al.* (2008), the goal of such an engagement would be to upgrade the level of competitiveness for all actors within a market chain and thus enable rural producers, traders, and processors to make the shift from opportunistic and irregular market linkages to being systematic players within growth value chains. In Southern Ethiopia, for example, a project operating under the auspices of the Global Livestock Collaborative Research Support Program (GL-CRSP), working with the Borana pastoralists have created a livestock marketing chain from the Borana Plateau to export outlets largely serving the Gulf States. One goal of the project was to enable pastoralists to acquire knowledge on how best to position themselves for profitability in the livestock marketing industry. Following a number of aggregated activities a positive market response has occurred and a new marketing chain has been created (Desta *et al*., 2006). The experiences from this project show that:

linking producers and buyers directly in a marketing chain, and enabling pastoralists to eventually manage some marketing functions themselves, could put all parties in a stronger position;

Unless pastoralists are organized to handle some of the market functions in the value chain, a large proportion of the profit will continue to primarily benefit middlemen, who tend to be urban-based traders.

It is estimated that in the Isiolo-Nairobi small ruminant trading market in Kenya, for example, brokers take home an accumulated income of over KES 600 ($ 7.06) per animal. This additional margin contributes to price build up leading to the final consumer paying higher prices per kg of the meat (Onyango, 2013). A similar situation was recently observed in Ol' Olunga' market, Narok South (Figure 1) where a middleman buys a goat at KES 3,000 ($ 35.30) from a pastoralist and sell the same at KES 4,500 ($ 52.94) in the market to another middleman, making a profit of KES 1,500 ($ 17.65) per animal.

Figure 1. A small ruminant market in Ol'Olunga', Narok South, Kenya, Nov. 2013

The second level middleman would then sell the goat within the same market to traders from a bigger market at Kikopey at KES 4,800 ($ 56.47) in turn making a profit of KES 300 ($ 3.53) per animal. These traders buy in bulk and thus may be making more profit from economics of scale when they sell to butchers or sell in the final market.

Exploratory survey of several small ruminant markets and discussions with pastoralists and private ranchers in Laikipia, Trans mara, Narok and Kajiado during the year 2013 show that there is a thriving market for breeding stock of Dorper sheep and Galla goats and for mutton and chevon and the market is expanding. In terms of the slaughter animals (mutton and chevon product chains), the focus should thus be on how to enhance those traits that seem to be the major drivers of the market. These include carcass yield (dressing percentage), body conformation, growth rates and meat quality. From the discussions during the surveys, it emerged that the market is demanding for animals with higher carcass-cutting yield and this is phenotypically expressed as body conformation. This is where the Dorper and Galla are having an edge over the traditional Red Maasai sheep and the Small East African goat respectively. Growth rates as assessed through average daily gains is an important factor too since producers want faster growth so that the animals achieve market weights in the shortest time possible using the least amount of inputs/cost so that they can receive the highest price. The most cost-efficient (optimal) feed conversion and the highest average daily gain are the primary factors determining efficiency of production. The current challenge is lack of access to elite breeding stock for the two preferred sheep and goat breeds. This is where the pastoralists need to be assisted if they have to access and engage with the small ruminant markets more effectively.

Managing environmental risks for sustained small ruminant production

The two main elements that give rise to risk are *hazards* and the *vulnerability* of populations to these hazards. In recent years the effects of climate change have become unavoidable for (agro-) pastoralists living in the Horn of Africa. Prolonged droughts and excessive rains cause problems to secure their already marginal livelihoods. Due to the increasing frequency of these extreme weather events, communities can no longer recover from the intense effects climate has on their livelihoods. Furthermore, due to scarcity of natural resources, conflicts often arise and are bound to intensify (Broekhuijsen, 2013). Although historical records indicate that there has been an increase in rainfall over the last century

in East Africa (Hulme *et al.*, 2001; IPCC, 2001), one thing that is generally agreed on by many is that climate change will have significant negative consequences for pastoralists. It is for this reason that pastoralists will need to be prepared to either mitigate/reduce the negative impact of climate change or to enjoy the potential benefits of climate change.

In order to reduce the vulnerability of people, the Dutch Catholic Organization for relief and Development Aid (Cordaid), has developed and uses the Drought Cycle Management (DCM) and Community Managed Disaster Risk Reduction (CMDRR) in a combined approach to reduce the vulnerability of people (Figure 2).

Figure 2. Drought Cycle Management approach (Erasmus *et al*., 2012).

The key elements of the DCM/CMDRR approach are *preparedness, mitigation, reconstruction* and *relief assistance*. The specific CMDRR activities are designed to reduce poor communities' risk and vulnerability to drought and enable them to prepare for future drought by strengthening traditional coping mechanisms. While in most cases past efforts have been directed towards relief assistance and reconstruction with minimal impact, a number of efforts need to be directed towards preparedness and mitigation. According to Cordaid's model, a number of activities can be undertaken to enable the pastoralists prepare for future droughts and some of these have been tried in a number of places with success and only need to be upscaled and outscaled. It is worth noting also that the activities undertaken by Concern Worldwide in Moyale District in Northern Kenya where Livestock account for 70% of household income, and 67% of the population live below the poverty line, showed that by diversifying livelihoods, switching to more drought-resistant livestock species and breeds, improving rangeland management, mitigating resource-based conflicts and lengthening the water availability period, the ability of pastoralists in Moyale District to withstand the 2011 drought affecting Northern Kenya was enhanced (Erasmus *et al.*, 2012). Droughts have eroded household assets and further reduced the coping mechanisms available to the pastoralist residents of the District. Although Moyale town benefits from a booming petty trade market with a strong cross-border element and a vibrant international and regional livestock market, this well-developed market infrastructure has resulted in fewer pastoralists being completely dependent on livestock and livestock products. Concern Worldwide noted that the poor pastoralists do not necessarily interact with these markets and thus it is important to create conditions that enable poor pastoralists to interact with markets by strengthening the livestock product value chain and encouraging and supporting livelihood diversification.

Historically, tradition and sometimes local legislations are known to have played a prominent role in regulating timing of herd movements, routes of migration, rights of use and maintenance of sound grazing systems that would compete in technical standards with any modern up-to-date range management approaches. It may thus be necessary to re-look at such mechanisms as a way of managing pastoral areas and ensuring survival of small ruminants. The "Hema" system of grazing, for example, which was developed in Syria several years ago and has been revived in the Arab world is such a mechanism that is receiving fair attention (Sidahmed,1986). The system protects rangelands through complete prohibition

of grazing but with cutting of grass allowed at certain times and places; allowing yearlong grazing with the kind of animals and numbers specified; grazing and cutting at certain times of the year; prohibition of grazing until after flowering for bee keeping purposes; and grazing restriction to protect trees. Some efforts are being made along similar lines by the Food for the Hungry-Kenya (FH-Kenya) which works with communities– elders, environmental management committees, community leaders and local administrations – to develop tools to manage pastures in grazing areas (Tuke, 2011). In such an arrangement elders organize meetings before every wet and dry season to determine the ways forward in grazing management and by creating seasonal grazing calendars, this allows communities to plan when to move animals to a particular site and what species of animals are allowed. Another useful approach is that practiced by the Mbororo nomadic and semi-nomadic herders in parts of Cameroon, Central African Republic, Chad, Niger and Nigeria, who observe the rotational use of pasturelands, which then allows pasture to recover after intense grazing. In Ethiopia, the Borana pastoralists on the other hand have learnt that cattle and sheep are especially vulnerable to drought, but goats and camels are less affected by pasture degradation and bush encroachment, since they are 'browsers'. They thus invest in goats and camels to make pastoralists less vulnerable to drought or pursue alternative livelihood activities such as casual labour in the construction industry, the sale of livestock products (such as milk), beekeeping, and the production and sale of vegetables in the lowlands. People also gather firewood and make charcoal, and collect water, minerals (such as gold, marble and granite), incense and natural gum to sell. It is also worth considering the role of private ranches as strategic feed reserve areas so that formal engagements can be made with the owners on how best they can assist in terms of in-situ feed conservation or making of hay. It has been observed in Narok, Kenya for example, that in areas where there are fenced private ranches, the effect of drought is minimal on grazing pastures (Figure 3) compared to communal grazing areas (Figure 4).

Figure 3. Dry season grazing by sheep in a fenced private ranch in Narok

Figure 4. Dry season grazing by sheep in a communal grazing area in Narok

However, inspite of the effectiveness of some of the community initiatives, it may be important to enhance these efforts through appropriate landuse policy frameworks. The Athi-Kaputiei land-use 'master plan', launched in 2011, provides such an example of a policy framework which gives the local council the legislative power it needs to ensure that large expanses of land remain free of fencing, and that new developments are confined to specific areas (ILRI, 2012).

Promotion of diversified livelihoods is evidently inevitable in the rangelands since being solely dependent on livestock has become a risky livelihood strategy. In their study of the recently settled Rendille and Ariaal (mixed Rendille/Samburu) communities in Marsabit District in northern Kenya, Fratkin *et al*. (2011) found that alternate livelihoods have been accompanied by greater food security (buying food, access to relief foods, or growing of crops), improved health care particularly vaccinations and malaria interventions, and increased participation for children in formal education which can result in salaried employment. In this part of northern Kenya, alternative livelihoods are based on a variety of strategies, including the marketing of livestock, dairy products, hide and skins, and cultivated crops; a variety of wage-earning occupations ranging from professional to manual labor; and entrepreneurial activities including shop keeping, craft production and sales, and transportation. Women also play a key role in petty commodity trade activities, particularly the sale of garden vegetables, tobacco, and *mira'a*, (*khat*). Although there are obvious benefits of such alternative livelihoods, there are also negative aspects. Market integration may have both positive and negative consequences on child health and nutrition. As observed among the Rendille, children in the nomadic pastoral community were heavier and taller than their same-aged counterparts in the sedentary communities. Children in settled communities suffered both short term malnutrition (resulting in wasting) and long term malnutrition (stunting). These differences were accounted for as fundamentally related to protein deficiencies brought about by a greatly reduced access for children to milk and a higher reliance on *posho*s grains in all settled communities. It would thus be important to undertake comprehensive evaluation of the recent or on-going livelihood diversifications in order to have evidence-based changes in financial capital and health before recommendations for further development in pastoral areas can be made.

Pastoralists protection against climate related risks such as drought-induced livestock losses through the implementation of the index-based livestock insurance schemes should be considered. However, lessons coming from pilot livestock insurance schemes should be considered before repeating and up-scaling. This is important since many pastoralists do not understand the concept of insurance and have little or no previous experience with it. Due to this confusion, some demand payouts when they lose their livestock even if their animals' death was not caused by drought (Kisiangani and Aziz, 2011).

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Dry season supplementation of lactating Small East African goats using processed and none processed acacia tortilis and local grass in Northern Kenya

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Abstract

This paper presents the findings of an on-farm feeding trial conducted to evaluate the nutritional value of processed (milled *Acacia tortilis* pods and chopped grass hay) and none processed (whole *Acacia tortilis* pods and long grass) dry season supplementary feeds and the effect of feeding these supplements on milk yield of lactating goats and on growth response of suckling kids. Twenty multiparous Small East African goats from one herd weighing 28.3±0.7 kg live weight were divided into five groups of four animals each and randomly assigned to one of the five treatment diets in a randomized block design. The treatment diets comprised of chopped mixed grass hay (chopped MGH), long mixed standing grass (long MSG), milled *Acacia tortilis* (milled ATP), whole *Acacia tortilis* (whole ATP) and control (no supplement). The results showed that daily intakes of chopped grass (309.5 g), whole ATP (413.1 g) were higher than long standing grass (165.4 g) and milled ATP (186.4 g). Of the supplement diets, whole *Acacia tortilis* was the most consumed (87.7%) followed by milled ATP (67.3%) and chopped grass (51%). With the exception of ether extract, the DM (dry matter), ash, CF (crude fibre), CP (crude protein), NDF (neutral detergent fibre), ADF (acid detergent fibre) and ADL (acid detergent lignin) contents varied ($P<0.05$) among the diets. Macro (P, Mg, K, Na) and micro (Fe, Zn, Mn) mineral contents differed ($P<0.05$), while Ca was similar ($P>0.05$) among the supplements. In five prescribed incubation periods, the diets showed marked differences ($P<0.05$) in dry matter degradability. Milled ATP and whole ATP were degraded faster, followed by chopped grass hay, while long grass was the least degraded. Diet treatment significantly ($P<0.05$) influenced the milk yield of goats. Supplementation increased milk production in the range of 6.3-45.3%. ADG (average daily gain) of kids were similar ($P>0.05$) among the treatment groups. This study showed that processing by milling of *Acacia tortilis pods* improved digestibility, while chopping of grass hay increased intake. Inclusion in the diet of good quality supplements such as mixed grass hay, milled and whole *Acacia tortilis* pods can alleviate nutritional constraints in the dry season and increased milk yield of lactating goats in the arid rangelands.

Key words: Lactating goats, *Acacia tortilis* pods, Chopped grass

Introduction

Sheep and goats are the most widespread livestock raised by pastoralists world-wide, with goats being able to penetrate more arid regions than sheep (Degen, 2006). In the arid and semi arid areas (ASALs) of Kenya, goats score second to camels in terms of drought resilience, ability to survive in dry environments with feed and water scarcity and year round production of high quality animal protein. In these areas, small ruminant producers mainly depend on Small East African (SEAG) and Galla goats for milk, meat and cash income. However, output per animal unit was reported to be below optimum level (Harry, 1999). The low productivity is further exacerbated by kidding of does in the dry season coinciding with periods of inadequate pasture production. Thus, animals that depend on natural vegetation for their nutrition suffer heavy losses during the dry season which coincides with the productive performance (Deaville *et al*., 1994). Inadequate nutrition particularly during the dry season is a major constraint in pastoral livestock production. Diets during the dry season are fibrous, low in digestible protein, energy, minerals and vitamins do not meet goat nutrient requirements. Pastoral producer responses to inadequate nutrition include herd division, movement to dry season pastures, extended grazing hours and supplementation of milking herds. Dry season supplementation is an alternative to rectify nutrient deficiencies and improve goat productivity.

As dry season feeding strategy, pastoralists in northern Kenya practice supplementary feeding of livestock by use of local forage resources. The overall percentage of pastoralists in northern Kenya supplementing animals was about 10% (Ndikumana *et al.*, 2000). The most common supplementary feeds were local grasses, leave of browse plants and *Acacia* pods (Kariuki and Letitiya, 1996). These forages are traditionally stored in open shades, tree branches and living huts, which affect their quality and shelf life (Lengarite and Mbuvi, 2003). Leaves of browse trees and grass forages drastically decline in quality due to heat and smoke produced in the living hut. Stored whole *Acacia* pods are known to have a short life span due to infestation by insect pests and moulds (Keya, 2001). Pods of leguminous plants such as *A. tortilis* are valuable source of protein with moderate to high dry matter degradability and rich in macro and micro-minerals (Ngwa *et al*., 2000). However, substantial proportions of ingested seeds of *Acacia* species are lost through faeces and mouth during the process of rumination. The undigested seeds represent loss of nutrients which is important during periods of feed scarcity (Shamayo and Uden, 1998). Processing of *Acacia* pods by milling reduces nutrient loss, incidence of pests that target the seeds of whole pods, increases the rate of passage and protein digestibility.

Grasses are the second most preferred forages by goats after browse. The productivity of grass in the rangelands is strongly influenced by precipitation. The changing climatic patterns, which results in excess and decline of rainfall in some years calls for baling of grass in favorable periods for feeding animals during the dry season. In periods of feed shortages chopping of grass will minimize refusals and wastage.

In the arid rangelands of northern Kenya, lack of suitable feed processing and storage technologies are to blame for lack of supplementary feeds for feeding goats, damage of limited feeds by pests, reduction in shelf life and feed quality. The objectives of this study were to determine the quality of processed, none processed and stored *Acacia tortilis* pods and assess the performance of lactating goats and kids supplemented with processed and none processed *Acacia tortilis* pods and local grass.

Materials and Methods

Study site

The study was conducted at Olturot village in Loiyangalani District, Marsabit County of northern Kenya. The site is located 50 km East of Lake Turkana at the foot slopes of Mt.Kulal. It lies at an altitude of 600 m above seas level, between latitudes ($2^0$46.5'E) and Longitudes ($37^0$14.5'E).

The annual rainfall and temperatures ranged between 160-330 mm and 23^0C-39^0C, respectively. It has stratified sandy to sandy loam soils, strongly calcareous, slightly sodic with moderate soil fertility and high availability of phosphorus (Lusigi, 1984). The vegetation types are wooded bushland and shrubland dominated by the tree layer of A*cacia tortilis, Acacia reficiens, Acacia mellifera* and ground layer of *Duosperma eremophilium, Indigo fera spinosa, Salsola dendroides* and grass species.

Animals and Experimental design

Twenty lactating SEA goats managed by a pastoral producer with an average body weight of 28.3±0.7 kg, at the same stage of lactation and 3rd and 4th parities were used for the study. The animals were divided into five groups of four animals each balancing for weight and parity and allocated to one of the five dietary treatments in randomized block design. The treatment diets were chopped mixed grass hay (Chopped MGH), long mixed standing grass (Long MSG), milled *Acacia tortilis* (Milled ATP), whole *Acacia tortilis* (Whole ATP) and control (no supplement).

Animal management and feeding

At the onset of the experiment the goats were ear tagged, dewormed using 10% albendazole, the does and their suckling kids at birth were weighed and thereafter on a weekly basis. Weighing of does and kids was done in the morning before grazing and suckling, respectively using a mobile scale. The differences in weekly body weights were used to determine growth rates (ADG) of kids. In the first month of life the kids were allowed to stay at night with the mothers and only separated during the day of milk measurement. In the second month the suckling kids were introduced to browse feed through cut and carry. Milk yield of the does was initially recorded at the end of first week post- partum and thereafter once a week. During milking the kids were allowed to suckle one teat to stimulate milk let down. One teat was hand stripped in the morning and the other in the evening and total daily and weekly yields were computed. The animals were allowed seven days for conditioning to the feeding protocol and offered supplements daily in the morning between 07:00- 08:00 hours and then released for grazing. The animals grazed for 8 hours in communal pastures and had free access to water in the village water pan. Feed supplements were initially offered at 2.5% of body weight (BW) and adjusted to actual amounts consumed. Feed offered and refusals were measured using an electronic balance. Does on *Acacia tortilis* diets were individually fed using mobile plastic troughs, while those on grass based diets were feed using polythene sheets spread on the ground. The daily feed consumed was computed from the differences between feed offered and left over. The on-farm feeding trial conducted between August and October 2013, lasted for 9 weeks.

Feed processing and storage

Ripe pods of *Acacia tortilis* were collected (January-February 2013) in the communal grazing land and sorted to remove foreign materials and damaged pods. Some of the pods were packaged in polythene bags, while others were milled using a portable manual grinder. A coarse meal consisting of seeds and husks was prepared by adjusting the screen size of the grinder. The bags containing milled and whole pods were stored in a cool and dry storage shed. Local grasses, mainly *Bracharia leersiodes, Dactyloctenium aegyptium, Tetrapogon cenchriformis, Cenchrus ciliaris* and *Aristida mutabilis* were harvested and baled. Dry standing grass produced in previous seasons was collected and stored in a separate storage shed with hay grass.

Chemical composition and in sacco analysis of diets

Duplicate samples of chopped grass hay, long grass, milled and whole Acacia tortilis pods were submitted for chemical and *in sacco* dry matter degradability determination. To account for undigested seeds (Shayo and Ude'n, 1998), 24% of the seeds were removed from pods and the remaining empty pods and whole pods were ground together. Chopped grass hay, long grass, milled and whole *Acacia tortilis* pods (24% of seed removed) were analyzed for dry matter (DM), ash, crude protein (CP), crude fibre (CF) and ether extract (EE) using the methods described in AOAC (1995). The cell wall polysaccharides of neutral detergent fibre, acid detergent fibre and acid detergent lignin (NDF, ADF, and ADL) were determined according to Van Soest *et al*. (1991). The samples for mineral determination were digested according to AOAC (1998). The concentration of Ca, Mg, Fe, Zn, and Mn were analyzed by use of an atomic absorption spectrophotometer while K and Na were determined by use of flame photometer and P concentration was analyzed calorimetrically using spectrophotometer.

The *in socco* (ruminal) dry matter degradability (DMD) of chopped grass, long grass, milled and whole (intact seeds and husks) *Acacia tortilis* diets were measured using the nylon bag technique described by Ørskov *et al*. (1980). Duplicate samples in nylon bags containing 5 g of feed were incubated in the rumen of cattle bull for 24, 32, 48, 72 and 96 hours before removal at a prescribed time. Dry matter degradability was calculated using the formula described by Jansen *et al*. (2007).

Data analysis

Data on diet intake, milk yield, growth rates of kids, chemical composition and *in sacco* DMD of diets were entered in Microsoft excel. The chemical composition and *in sacco* of diets were subjected to one way analysis of variance, while milk and growth rate data were analyzed according to a randomized block design using the GenStat program

(2010). When treatment was significant means were separated using the least significant difference procedure (LSD0.05).

Results and Discussion

Dietary intake

The mean body weights of goats and daily intake of treatment diets expressed as percent of body weights are presented in Table1. The daily intakes of chopped grass (309.5 g), whole ATP (413.1 g) were higher than long standing grass (165.4 g) and milled ATP (186.4 g). The intake of chopped MGH, long MSG, whole ATP and milled ATP correspond with 1.12, 0.58, 1.52 and 0.66% of body weight dry matter intake of goats, respectively (Table1). Of the supplement diets, whole *Acacia tortilis* was the most consumed (87.7%) followed by milled ATP (67.3%) and chopped grass (51%). Whole pods contributed over half (1.52%) of total dry matter intake (DMI) of lactating goats (2.8% BW) (NRC, 2007). Thus, supplementation using whole *Acacia tortilis* pods may decrease intake of the basal forage diet (Bii *et al*., 2010). The concomitant reduction in forage intake limits energy intake and animal performance. The lower intake of ground Acacia tortilis pods (seeds and husks) can be attributed to the meal form and slight dustiness of the diet supplement. During processing the seeds produced coarse particles, while empty pods formed fine particles. In the case of grass, the higher intake of chopped MGH was due to short length and good quality grass, while the low consumption of long MSG (40.4%) can be ascribed to the long length, high fibre and low CP contents. In this study, it was observed that spreading the grass diets allowed selectivity thereby enhancing intake.

Table 1. Mean intake (g d^{-1}) of supplement diets by lactating SEAG expressed as % of body weights (BW) and % consumption in 60 minutes

Treatment Group	Body Weight (kg)	SEM	Intake (g/d)	SEM	DMI, % of BW	SEM	% Consumed in one hour
Chopped MGH	28.2	1.8	309.5	37.2	1.12	0.15	51.0
Long MSG	29.0	1.5	165.4	18.5	0.58	0.08	40.4
Whole ATP	27.5	1.6	413.1	13.5	1.52	0.06	87.7
Milled ATP	28.4	1.2	186.4	6.3	0.66	0.03	67.3

MGH, Mixed grass hay; MSG, Mixed standing grass; ATP, Acacia tortilis pods; DMI, Dry matter intake

The result of high intake of chopped grass was supported by the findings of Castillo *et al*. (1982) who found that buffaloes consumed more chopped rice straw than long straw and Omokanye *et al*. (2001), who stated that chopping of browse species enhanced intake by 60%. In contrasts, animals offered long lengths of food had lower intake (Castle *et al*., 1979; Deswysen *et al*., 1978).

Chemical composition of treatments diets

Table 2 shows the chemical components of chopped grass hay, long standing grass, milled and whole *Acacia tortilis* pods. With the exception of ether extract, the DM, ash, CF, CP, NDF, ADF and ADL contents varied ($P<0.05$) among the diets. As expected, the DM content was higher ($P<0.05$) in long standing grass, while it was lower and similar ($P>0.05$) in chopped grass hay, milled and whole *Acacia tortilis* pods (Table 2). The high DM content of long standing grass can be attributed to the stage of maturity and exposure to sunlight. The concentrations of ash was highest in chopped grass hay (10.2%) followed by standing grass (9.2%) and least was milled (5.7%) and whole *Acacia tortilis* pods (5.9%). The CF contents ranged between 35.5-43.1% in grassed based diets and 18.3-22.2% in *Acacia tortilis* based supplements. Of the diets, milled *Acacia tortilis* pods was the lowest in CF content, while long grass contained the highest level. The Cell wall polysaccharides (NDF and ADF) of milled and whole *Acacia tortilis* pods were similar ($P>0.05$), but differed ($P<0.05$) with chopped grass hay and long standing grass. Except for long grass with high lignin content, the levels were similar in other diet supplements (Table 2). The variation in CF, NDF and ADL contents among the diets could be related to plant species and stage of maturity. Mckell (1980) reported that mature pasture plants in the tropics contained high CF contents that ranged between 30 to 40%. The CP content of chopped grass hay (7.4%) was slightly above the critical level of 7% necessary for optimum rumen function. Mero and Uden (1998), Aganga and Autlwetse (2000) reported lower CP contents of 5.1 and 4.88% in *Cenchrus ciliaris* grass, respectively. Mixed grass species appear to be richer in CP content than single

grass species. Milled and whole *Acacia tortilis* pods with CP contents ranging from 12.2-12.5% were adequate to meet the minimum (12%) recommended requirement for lactating does (NRC, 2007). However, Bii *et al*. (2010) and Abdulrazak *et al*. (1999) reported higher contents of CP, but comparable concentrations of NDF, ADF and ADL in *Acacia tortilis* pods.

In the case of macro (P, Mg, K, Na) and micro (Fe, Zn, Mn) minerals the contents were variable (P<0.05), while Ca was similar (P>0.05) among the supplements. Compared to long standing grass, chopped grass hay, milled and whole *Acacia tortilis* pods were higher (P<0.05) in P, Mg and K contents. Of the diets, chopped grass hay was richer in macro (Mg, K and Na) and micro (Fe, Zn and Mn) minerals. The high Na content in chopped grass hay may be attributed to *Dactyloctenium aegyptium*, which is a salty grass species. Milled *Acacia tortilis* pod diet was higher (P<0.05) in micro-minerals, while whole *Acacia tortilis* pod supplement was rich in K. The higher concentration of micro-minerals in milled pods may be related to accumulation of these minerals in the seeds, which were more in the processed pods than whole pods (24% of seeds removed). The low mineral concentrations in long grass can be attributed to loss of leaves, seeds and translocation of minerals to the root system with plant maturity.

Table 2. Chemical composition (DM basis) of dietary supplements consumed by goats in Olturot area of northern Kenya

Chemical component	Ingredient		Whole ATP	Milled ATP	SEM	P
	Chopped MGH	Long MSG				
DM (%)	89.7^{a}	93.4^{b}	87.9^{a}	88.8^{a}	0.510	0.006
Ash (%)	10.4^{a}	9.2^{b}	5.9^{ab}	5.7^{ab}	0.196	<0.001
EE (%)	2.5^{a}	1.5^{a}	1.6^{a}	1.6^{a}	0.217	0.09
CF (%)	35.5^{a}	43.1^{b}	22.2^{ab}	18.3^{ac}	0.942	<0.001
CP (%)	7.4^{a}	3.6^{b}	12.2^{ab}	12.5^{ab}	0.149	<0.001
NDF (%)	62.7^{a}	65.4^{a}	35.8^{b}	33.0^{b}	1.165	<0.001
ADF (%)	31.1^{a}	41.7^{b}	19.8^{ab}	18.8^{ab}	0.658	<0.001
ADL (%)	3.8^{a}	5.1^{b}	4.3^{a}	4.3^{a}	0.169	0.025
Ca (g/kg)	4.0^{a}	3.8^{a}	3.4^{a}	3.4^{a}	0.132	0.074
P (g/kg)	3.3^{a}	1.2^{b}	3.4^{a}	3.8^{a}	0.168	<0.001
Mg (g/kg)	4.5^{a}	2.0^{b}	2.3^{b}	2.8^{ab}	0.158	<0.001
K (g/kg)	31.7^{a}	13.9^{b}	26.5^{ab}	24.9^{ac}	0.255	<0.001
Na (g/kg)	3.6^{a}	0.9^{b}	0.5^{b}	0.4^{b}	0.158	<0.001
Fe (mg/kg)	198^{a}	158^{b}	154^{b}	143.5^{ab}	1.032	<0.001
Zn (mg/kg)	20.7^{a}	12.3^{b}	16^{ab}	18.7^{ac}	0.25	<0.001
Mn (mg/kg)	87^{a}	80^{b}	19^{ab}	25.5^{ac}	0.577	<0.001

^{abc}Means along the same row followed by different superscript differ (P<0.05); MGH, Mixed grass hay; MSG, Mixed standing grass; ATP, Acacia tortilis pods

In sacco dry matter degradability of supplementary feeds

The *in sacco* dry matter degradability (DMD %) of the diets consumed by goats are shown in Table 3. In the five prescribed incubation periods, the diets showed marked differences (P<0.05) in dry matter degradability. The extent of degradation improved with incubation period implying that the longer the resident time the better the degradation. This was in agreement with the report by Ondiek *et al*. (2010) who showed that degradation of *Acacia* browse leaves improved with incubation period (24-48 hrs). Milled ATP and whole ATP were degraded faster, followed by chopped grass hay, while long grass was the least degraded. Except at 32 hrs, where the DMD of milled pods was higher, the extent of dry matter disappearance of milled pods was similar (P>0.05) to whole ATP (Table 3). However, the level of degradation was lower than the average reported by Shayo (1992) in empty *Acacia tortilis* pod (60.4%) and seeds (58.5%).

The higher dry matter degradability of milled pods (32 hrs) may be attributed to the low crude fiber content and reduced particle size. Feeds with small particle size pass through the retriculoomasal orifice faster thereby stimulating intake and animal performance. Milled ATP and whole pods provide a rich source of nitrogen (N) for microbial growth and dry matter disappearance. The dry matter degradation of chopped grass which was higher than (P<0.05)

long grass maybe related to low lignin, rich mineral and CP contents (Table 2). The *in sacco* results compare favourably with that of *Cenchrus ciliaris* hay (Shayo, 1992). On contrast, the low crude protein and high lignin contents of long grass depress rumen microbial digestion and dry matter degradability. Degradation rate *in sacco* is a reflection of how fast the particular fraction of the plant will degrade in the rumen after being eaten and can indicate the relative importance of the plant in the diet (Lebopa *et al.*, 2011).

Table 3. *In sacco* DMD % of dietary supplements fed by goats in Olturot area of northern Kenya

Ingredient						
Incubation hours(hrs)	Chopped MGH	Long MSG	Whole ATP	Milled ATP	SEM	P-value
24	43.6^{a}	30.0^{b}	42.7^{a}	44.5^{a}	1.106	0.02
32	45.8^{a}	33.7^{b}	43.3^{ab}	51.9^{ac}	0.589	<0.001
48	48.6^{a}	34.52^{b}	55.3^{ab}	53.7^{ab}	1.037	<0.001
72	59.4^{a}	51.0^{b}	70.0^{ab}	67.4^{ab}	1.803	0.006
96	59.9^{a}	55.9^{b}	69.3^{ab}	68.1^{ab}	0.744	<0.001

^{abc}*Means in the same row followed by different superscript differ (P<0.05)*

Milk yield of lactating goats

The milk production of does and percent increases in milk yield are presented in Table 4. Diet treatment significantly (P<0.05) influenced the milk yield of goats. Supplementation increased milk production in the range of 6.3-45.3%. The daily milk yield was highest in goats receiving milled ATP followed by chopped grass, third whole ATP, fourth long MSG and least was control with no supplement (Table 4). The results are in agreement with previous studies in northern Kenya than indicated that milk yield of SEAG was a function of nutrient status than stage of lactation. Thus, supplementation modified the nutrition status and therefore milk production of goats. Similar findings was reported by Pamo *et al*. (2006) who observed increase in milk production in West African dwarf goats receiving browse leave supplements. The higher milk yield of goats supplemented with milled ATP was related to increased degradability and rate of passage of the ground ATP at 32 hrs (Table 3). Alteration of the physical form of Acacia seeds increased protein utilization and the dry matter digestibility (Aganga *et al*., 1998). Milled *Acacia* pods with seeds provided a supplement of similar value to maize bran (Gohl, 1981). The increased milk yield with processing of roughage are consistent with the report by Church and Kellems (1998) who showed that milled ration with roughages increased milk yield of lactating dairy cows. Conversely, as expected whole *Acacia tortilis* pods were bulky, limiting intake of forage and milk production of goats. The mean daily yield was in agreement with the value of 264 g d^{-1} reported by Mbui (1992) and 385 g d^{-1} by Ruvuna *et al.* (1984) for Small East African goats. Cooper *et al*. (1992) also reported a similar yield (270± 99 g/day) for SEAG supplemented with 250 g of maize bran and 259± 99 g/day for control group.

Table 4. Milk yield of supplemented and none supplemented lactating SEAG at Olturot area of northern Kenya

Treatment Group	Milk yield (g d^{-1})	SEM	% increase in milk yield
Long MSG	255.2^{a}	12.6	6.3
Chopped MGH	307.8^{ab}	15.0	28.3
Whole ATP	300.5^{ab}	16.5	25.2
Milled ATP	348.6^{b}	17.8	45.3
Control	240.0^{a}	14.0	

^{ab}Means along the same column with different superscript differ (P <0.05) , $_{LSD0.05}$ =39.9

Daily weight gain of suckling kids

The average daily weight gain (ADG) of kids suckling supplemented and none supplemented does are given in Table 5. ADG of kids were similar (P>0.05) among the treatment groups. It appears that at early and mid lactation, the milk output of supplemented and none supplemented SEAG does was sufficient to support the observed kid growth rates (Table 5). The findings concur with the report by Nga'mbi *et al.* (2008) who found that kid growth rate was not correlated with milk yield during the first two months after birth. Traditionally, kids in early lactation were allowed to stay with their mothers during the night and only separated during the day. The kids of dams producing low milk may be suckling more frequently and therefore consuming equivalent amount of milk suckled by kids of

supplemented does. Feeding of kids with browse leaves in the second month may contribute to improve the growth rate of suckling kids. The moderate growth rates observed can be attributed to young age of kids (2-9 weeks) and adequate consumption of milk in early lactation. The mean ADG obtained were within the range of 59-83.9 g/day reported by Harry (1999) for SEAG kids between the ages of 0-16 weeks and Nga'mbi *et al*. (2008) in Angora goat kids at eight weeks.

Table 5. Body weights and average daily weight gain (g d^{-1}) of kids suckling supplemented and control does

Long MSG		Chopped MGH	Whole ATP	Milled ATP	Control	SEM	P
Initial weight(kg)	2.9	3.0	2.6	2.8	2.7	0.190	0.634
Weight gain (kg)	4.9	5.4	5.5	5.9	5.3	0.345	0.350
Final weight (kg)	7.8	8.4	8.1	8.7	8.0	0.297	0.295
ADG (g)	71 .7	79.8	82.0	86.8	77.6	5.07	0.350

Conclusions

This study has confirmed that processing by milling of *Acacia tortilis pods* improved digestibility, while chopping of grass hay (mixed) increased intake. Milled *Acacia tortilis* pod with low CF content was better utilized than whole pods. Inclusion in the diet of good quality supplements such as mixed grass hay, milled and whole *Acacia tortilis* pods increased milk yield of goats. However, at early ages, supplementation had no benefit on kid growth. Thus, processing of feed supplements such as *Acacia tortilis* pods and grasses would enhance the productivity of goats during the dry season in northern Kenya. Further studies are warranted to assess the benefit of feeding a combination of processed feeds to lactating goats and on-station experiment to validate the findings.

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Productivity measures and challenges facing smallholder livestock farmers in humid north central Nigeria

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Abstract

This study was conducted in three states of north central Nigeria (Nasarawa, Benue and Plateau) with the objective of evaluating the productivity of small holder subsistent livestock production system and to identify major challenges confronting this system of production in this region. A total of 111 smallholder farmers from 34 villages were interviewed using structured questionnaire and also physically verified to determine the herd distribution, productivity and farmers constraints. Major livestock reared by smallholder are bunaji cattle, West African dwarf sheep and goat and indigenous pigs. Three farming systems were identified nomads, crop-livestock farmers and those keeping only livestock, and varied between the three states in the zone. The farmers were keeping on an average 13.19 cattle, 6.61 sheep, 8.58 goat and 11.58 pigs per household. About 78% of the farmers were keeping at least a goat as against 38% of the entire farmers keeping at least one cow. Cattle was the only dairy animal others for meat purpose. Major challenges of the smallholders in the zone were disease, communal conflicts and seasonality of feed. With the poor production environment it was observed that overall performance of the smallholder production system was encouraging, and if adequate strategic planning for livestock development is adopted in this area there will be hope for improvement.

Introduction

Livestock are living assets contributing to nutrition, food security and building wealth. The increasing consumption of meat in some developing countries, related to rising household income and rapid urbanisation, has been well documented (Delgado, 2003). Among all the livestock that makes up the farm animals in Nigeria, ruminants, comprising sheep, goats and cattle, constitute the farm animals largely reared by farm families in the country's agricultural system. Nigeria has population of 34.5million goats, 22.1million sheep and 13.9million cattle (Lawal-Adebowale, 2012). Though the population may have well gone far more than this currently. The larger proportion of these animals' population are however largely concentrated in the northern region of the country than the southern region. Specifically about 90 percent of the country's cattle population and 70 percent of the sheep and goat populations are concentrated in northern region of the country, likely to have been influenced by the ecological condition of the region which is characterised by low rainfall duration, lighter sandy soils and longer dry season.

Characterization of small holder's subsistence livestock production system in Nigeria have not received adequate attention in term of evaluation of the productivity performance of the livestock and some major challenges and remedies that could improve their performance, this study was aimed at evaluating the productivity of smallholder livestock in north central Nigeria and to identify challenges confronting the smallholder farmers in this region

Materials and Methods

The study was conducted in rural areas of three states in Nigeria. The states were Benue and Nasarawa and Plateau State. These States lies within the north central zone of Nigeria, extending from approximately 8º to 12º N and 4 to 7.3º E. Annual rainfall of this zone is about 800-1100mm. The zone has about 4.5 million inhabitants. Thirty four villages distributed in the three states were selected. The study was carried between February to December, 2013. A total of 111 small holder livestock farmers distributed in the three states were considered for the study.

Data were obtained from direct interview and or/observations and also use of structured questionnaires. The structured questions were asked to each farmer in order to examine the farming system (nomad, crop-livestock or only livestock keeping), herd size and distribution and average production and reproduction of each animal species kept and major challenges confronting the activity. Physical verification were carried out in some cases

to supplement the responses. Visit were normally in the morning and evening when farmers and the animals are available at home. The data analyses was performed using the SPSS 16.

Results

The distribution of livestock population by species within a state in the zone is presented in Table 1. A total of 34 villages were visited. The number of farmers interviewed were 111 with Nasarawa state having the highest number in all cases and Benue the least. The animal population in this zone were bunaji, West African dwarf sheep and goat and indigenous pigs mainly.

Figure 1 outlined the distribution of production system and percentage distribution of the farming system among the smallholders. Three production system were identified, nomadic, crop-livestock farming and those keeping only livestock. Majority of the smallholders are practice crop-livestock farming 59 to 73 percent with Benue farmer having the highest concentration of crop-livestock farmers.

The percentage relative frequency of herd size by animal type is presented in Table 2. For cattle majority of those keeping them have herd size between 11 and 30 cattle, for sheep and goat major herd sizes were found between 6 to 10 animals. While in pigs 52 percent have animals between 11 to 15.

The average number of animals per household is presented in Table 3. It was observed that sheep and goat are the animals most farmers keep in this zone. Majority of farmers (79%) were keeping at least one goat, about 65% of the farmer were maintaining at least one sheep, while 38% keep at one cow. The average number of cattle and pigs per household were higher compared to sheep and goat 13.19, 11.58 and 6.61, 8.58 respectively.

Table 4 present the average production and reproduction performance of the various animal species studied in the zone. Age at first birth were 48, 11.2, 11.8 and 13.2 months for cattle, sheep, goat and pigs, respectively. Calving or farrowing interval, litter size, mortality, number of birth per year, survival index and rate of offtake are outlines for each animal species in the zone.

Challenges confronting smallholder livestock owners (Table 5) were disease, intra ethnic conflict, lack of reliable market, theft, poor water supply and seasonal feed availability in that order. There were variation in the ranking of the various challenges with states, diseases and seasonal as most important challenges rank high in Nasarawa and Plateau while conflict in the case of Benue, this could be due to the fact that the two state share boarder and have tendency of shearing some similarities in the socio-cultural attributes.

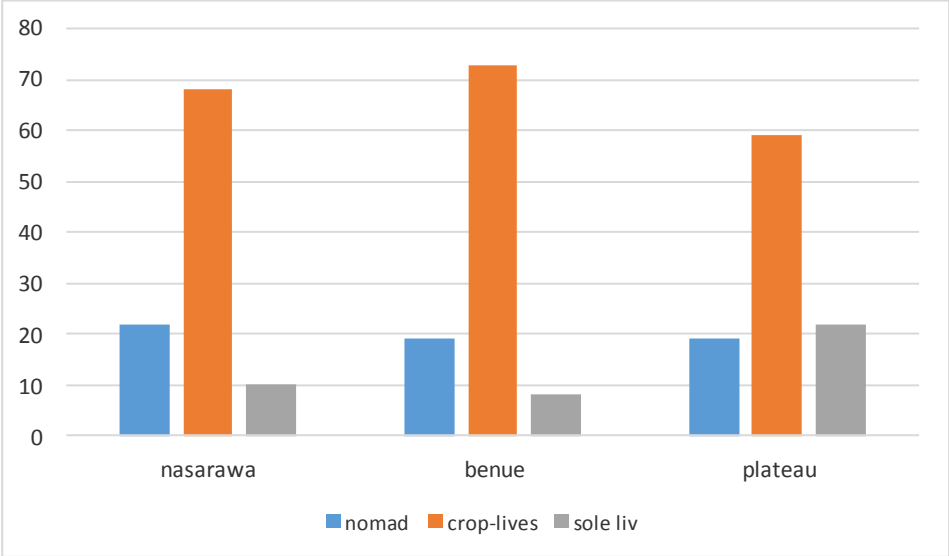

Figure 1. Percentage distribution of livestock farming system in the zone

Table1. Distribution of livestock population by states and species in north central Nigeria

State	Villages	Contact farmers	Cattle	Sheep	Goat	Pig
Nasarawa	15	53	262	182	342	128
Bunue	8	26	124	142	172	169
Plateau	11	32	168	152	241	111
Total	34	111	554	476	755	408

Table 2. Percentage relative frequencies of herd size by animal type in the zone

Herd size Category	Cattle%	Goats %	Sheep%	Pigs%
0-5	5	24	44	11
6_10	2	62	38	15
11_15	15	12	15	52
16-20	32	2	3	14
21-30	40	-	2	5
>30	6	-		3

Table 3. Average number of animal per household in the zone

Species	Number of household keeping at least one animal of the species	Total number of animal	Average number of animals per household
Cattle	42 (38%)	554	13.19±2.68
Sheep	72 (65%)	476	6.61±1.34
Goat	88 (79%)	755	8.58±0.62
Pig	62 (56%)	408	11.58±1.52

Table 4. Average production and reproduction performance of the various animal species in the zone.

Parameter	Cattle	Sheep	Goat	Pig
Daily milk yield	1.52±0.21	NA	NA	NA
Age at first birth (m)	48	11.2	11.8	13.2
Calving Interval (d)	452	310	260	148

Litter size	1.00±0.01	1.23±0.20	1.63±0.03	9.87±0.71
Litter mortality	0.01±0.00	0.11±0.02	0.23±0.01	1.52±0.04
Number of birth per year	NA	1.6±0.01	2.1±0.01	2.0±0.03
Survival Index up to 90 days	0.92	0.75	0.86	0.88
Offtake rate%	9	32	29	38

Table 5. Challenges facing smallholder farmers in the zone by rank

	States		
Challenges	Nasarawa (n=58)	Benue (n=26)	Plateau (n=32)
Disease	1 (1.21)	2 (2.44)	1 (1.18)
Conflict	5(5.00)	1 (1.37)	4 (4.11)
Lack of amrket	3 (3.42)	4 (4.41)	3 (3.00)
Theft	4 (4.12)	3 (3.00)	6 (5.96)
poor water supply	6 (6.10)	5 (4.98)	5 (5.21)
Seasonal feed	2 (2.41)	6 (5.99	2 (1.87)

Discussion

There was variation in the distribution of the animals by state due to several factors, which may include, proximity, responsiveness, and cooperation of the farmers and availability of livestock. Among the animals investigated goat was observed to be the highest animal maintained by the farmers in the zone compared to cattle sheep and pig. On a state wise bases, Benue state had higher concentration of pig amongst its farmers compare to the two other states, the reason could be due to religious factors, as the state have higher concentration of Christians compared to a mixture of Muslim in the other two states.

Farming system among the population studied suggest greater number of individuals in this zone are crop-livestock farmers. This has earlier been outlined, that Smallholder livestock keepers dominate crop–livestock systems, with livestock playing an essential role in highly diversified livelihood strategies that typically combine crops and livestock with off-farm activities (Ellis and Freeman, 2004; Deshingkar *et al.*, 2008). Of all the production system observed the nomadic farmers were least, this could be due to the fact that they are not permanently in one place and normally not indigenous people but are seasonal visitors to the zone, similarly, Benue State had the least number of nomads though it's the state that lies around the river bank, the incessant crises between farmers and nomads is common here and must informed the low concentration of this group.

The number of animals maintained per household observed here varies with other works, for instance, average number of cattle per house hold here varies significantly from reports of Akpa *et al.* (2011) to 45 , the reason being that most of the nomads around this zones keep few cattle because of the incessant crises between nomads and farmers. Variation in number of animals maintained per household here with other studies agrees with submission of Belay (2003), who reported that number of livestock per unit area of cultivated land increased significantly with density of rural population. Bunaji cattle is the main cattle breed in this zone and the only animal responsible for milk production, thus, the value for daily milk yield recorded here agrees with According to Wilson (1989) concern is often expressed at the poor reproductive performance of African indigenous livestock.

Litter size seemed to be the most useful selection criterion for genetic improvement of meat production. The litter size for goat in this study of 1.63 this is comparable to 1.7 as reported by (Akpa *et al*., 2011) and to the litter size ranged of 1 to 4 with a mean of 1.847 earlier reported by (Amoah *et al*., 1996) but higher than the litter size of 1 to 3 reported by Amoah and Gelaye (1990). The result of litter size, litter mortality and number of birth of all the animals under consideration, were similar to what many scholars reported for smallholders in various part of the country.

The offtake of the four animals under consideration in this zone indicate that pig has the highest offtake rate with cattle having the least. The low offtake from the cattle herds is in agreement with the result of Musemwa *et al*. (2010), 9% that showed that cattle in communal areas are usually retained for their input into crop production as draft power and manure rather than their terminal benefit of cash and meat.

Disease ranked high as challenges to these livestock production in this zone, this might be due to lack of vaccination against common disease. Constraints to livestock production like feed problems as reported in present study is consistent with the findings of (Rekhis *et al.,* 2007**)** who reported unbalanced nutrition as a major constraint in smallholder system.

Conclusion

The productivity of livestock in the studied smallholder herds were suboptimal, with the major problems being disease, seasonal feed availability and communal conflict. The variation in performance of the various herds indicates that an opportunity exists to raise productivity in the studied herds with improve input and managements.

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Carbon sequestration in a semi-arid pastoral ecosystem of northern Kenya

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Abstract

Data on carbon stocks in pastoral ecosystems is important for assessing their contribution for offsetting emissions of greenhouse gases through carbon storage. Available data is often based on limited carbon assessment in specified sites, which fails to capture spatial and temporal heterogeneity that characterize pastoral ecosystems. In this study we considered heterogeneity of a semi-arid pastoral ecosystem of northern Kenya by aggregating sample results taken during wet and dry seasons and from various landscape types. We found a mean carbon sequestration of 93.01 ± 15.72 tons ha^{-1} across landscape types and seasons. The amount of sequestered carbon had important contribution in climate change mitigation and has potential to improving pastoralists' livelihood through carbon credit trade.

Key words: Arid lands, Grazing, Landscape types, Seasons,

Introduction

Carbon dioxide (CO_2) is considered one of the greenhouse gases (GHGs) that has been associated with global climate change. Since pre-industrial times, global CO_2 has increased by 40% (IPCC, 2013). Although empirical evidence on the contribution of GHGs in causing atmospheric warming is not certain (Kobash *et al*., 2011; Mangini *et al*., 2005), land uses that offset atmospheric CO_2 emissions through carbon storage in plants and soils are commonly considered environmentally friendly (Lal, 2001). Nevertheless, in pastoral ecosystems characterized by communal grazing, carbon storage potential is poorly understood. Continuous grazing is often thought to reduce primary productivity or species composition; therefore, no substantial carbon stocks are assumed (Pineiro *et al*., 2010). This assumption is not supported by accurately collected carbon data. Carbon stocks are often measured in a single-assessment of a certain range site, despite spatial and temporal heterogeneous of rangelands (Qi *et al*., 2000). The spatial heterogeneity results from the variations in micro-climate, physical landforms and precipitation, and creates a skewed distribution of soil moisture and nutrients that influence carbon storage (Aguiar and Sala,1999). Temporal heterogeneity arises from seasonal difference in net primary productivity influenced by rainfall patterns and the variation in the grazing condition. More often than not, attempts to estimate carbon stocks in pastoral ecosystems seldom consider the challenges emanating from rangeland heterogeneity and therefore assume uniformity. As Kratli and Schareika (2010) observed, an average of measurements taken from different sampling points to represent rather heterogeneous environments is misleading since asymmetric distribution of carbon that characterizes pastoral ecosystems is not captured. Studies that use this methodological approach result in incomplete accounting of carbon stock estimates in rangelands. This poses challenges for promoting or managing pastoralism as environmentally friendly livelihood. Consequently, there has been a general development of replacing pastoralism with other land uses without looking at associated environmental implications (Behnke and Kerven, 2013). This study seeks to assess carbon stocks in semi-arid pastoral ecosystems, commonly perceived to have been degraded by livestock grazing. We purposively selected a site in northern Kenya with adequate heterogeneity in spatial characteristics and we sampled across wet and dry seasons to capture temporal variability. We asked the following two research questions: a) what is the amount of carbon stocks in semi-arid pastoral ecosystems of northern Kenya? b) How does the spatial and temporal heterogeneity of the environment influence the amount of carbon stocks in pastoral ecosystems?

Materials and Methods

Study area

This study was conducted in Marsabit central grazing land, located along the topographical gradient of Marsabit Mountain of northern Kenya. The topographical gradient stretches from the upper side of Marsabit Mountain through the transitional zone to the foot-slope. Diverse vegetation that consists of grassland, shrubland and woodland are found along the topographical gradient. The area is a semi-arid with annual rainfall ranging from 400 mm to 750 mm distributed over a long-rainy season (March - May) and short-rainy season (October - December). The prevailing livelihood option is pastoralism where cattle, sheep, goats and camels are kept in communal grazing lands.

Data collection

Samples of grassland, woodland and shrubland vegetation were identified and selected as landscape type. The landscape types were replicated three times (n = 3). Within each landscape type, a permanent plot of 400 m x 400 m, was geo-referenced using a Global Positioning System (GPS) and marked future reference. From the centre of permanent plots, transects of 200m in east, west, north and south directions were laid out. At intervals of 30m, nested sub-plots (of 10 x 10 m for trees, 4x4 m for shrub and 1 x 1 m for herbaceous) were established. Woody carbon (n = 72), herbaceous carbon (n = 72) and soil carbon (n = 72) were assessed for each landscape type within its nested sub-plots. The assessments were done for two consecutive seasons of wet and dry in the year 2013.

Woody carbon assessment

Using a flexible tape, the diameter at chest height (DCH) (1.3m above the ground) of all the trees within 10 x 10m plots and basal diameters (BD) of all shrubs within the 4 x 4m plots were taken. Carbon estimates were done using allometric equations as described by (Henry *et al*., 2011). Trees: Y = 0.1975xDCH1.1859, Shrubs: Y = 0.1936 (x1.1654)**,** Where Y = Fresh weight of trees/shrubs biomass (Kg), x = DCH/BD in cm**.** The results of allometric equation were multiplied by 60% to get dry biomass weight and the carbon content taken as 50% of the dry biomass weight (Brown *et al*., 1999). Root carbon estimates were 20% of above ground carbon (Cairns *et al*., 1997). Both above-ground and below-ground carbon estimates within nested plots were converted to carbon in tonnes per hectare (1 tonne = 1000 kilograms, 1 hectare = 10,000 m^2)

Herbaceous carbon assessment

A prepared quadrant of $1m^2$ was placed in each of 0.5 x 0.5m sub-plot. Herbaceous materials within $1m^2$ were then clipped at 1cm stubble height. Herbaceous root materials were also excavated and fresh weight recorded. Both the above-ground and root materials of herbaceous plants were oven-dried at 80°C for 48 hours. Herbaceous carbon contents were calculated as 50% of oven-dried herbaceous biomass. Results were then converted into carbon tonne per hectare (1 tonne = 1,000,000gm).

Assessment of soil carbon

Soil sampling was done in each 0.5 x 0.5m sub-plot at a 30cm depth using a soil auger whose volume-head had been pre-determined using the formula below;

$V = \pi r^2 h$, Where: V = Volume head, π =3.14 cm, r = head radius (cm), h = head height (cm).

Soil samples were oven-dried at 80°c for 48 hours. The oven-dried samples were then sieved by passing through 2-mm sieve. Bulk density of each soil sample was then calculated using the following formula;

$BD_{sample} = ODW_{sample}/VAD$, Where: BD_{sample} is the bulk density of soil sample (gcm^{-3}), ODW_{sample} is the weight of oven dried sample (g), VAD is the volume of soil auger head (cm^3)

An estimated 10g sample of sieved soil was taken for carbon content analysis. Soil carbon (C) was determined through oxidation as described by Anderson and Ingram (1993). The carbon concentrations were read on the spectrophotometer at 600nm. The concentrations (%) obtained from the laboratory were used to calculate carbon mass per unit area. Carbon contents in the samples were calculated using the indicated formula below:

C (gram cm^{-3}) = (BD_{sample} * C%), Where: BD*sample* is the bulk density of soil sample (gcm^{-3}), C% is the percentage carbon concentration of the sample, sample carbon content was multiplied by soil sampling depth (30cm) to carbon content per unit surface area using the formulae:

CSA (gram cm^{-2}) = C (gram cm^{-3}) * SD (cm), Where; CSA =Carbon per unit of surface area (gram cm^{-2}), C = carbon content in the sample (gram cm^{-3}), SD = soil sampling depth (cm), taken as 30 cm. The results were converted into carbon ton per hectare using the ratio of hectare to cm^{-2} (1: 1, 000, 000)

Data analysis

Aggregations of carbon from various carbon pools (above-ground herbaceous, below-ground herbaceous, above-ground woody, below-ground woody, soil carbon) were done and averages calculated for each landscape type. General Linear Model (GLM) was used to evaluate the effect of landscape type and season on the carbon level of various carbon pools

and significance difference accepted at 5% level of probability error. Model: $y_{ijk} = \mu + \rho_i + \alpha_j + \varepsilon_{ijk}$, Where: y_{ijk} is the observation from the ij combination of factors; landscape type, and season, μ is the overall mean of carbon content, ρ_i is the effect of i factor of landscape type on carbon content, α_j is the effect of j factor of season on the carbon content, ε_{ijk} is the error term

Results

Results of carbon stocks in various landscape types are presented in Table 1. Calculations of the total carbon stocks across all landscape types showed an average carbon level of 93.01 ± 15.72 ton ha^{-}

Table 1. Carbon stocks in the grazed landscapes of Marsabit central

Landscape type	Carbon level (tonne ha^{-1}) Above-ground herbaceous carbon	Below-ground herbaceous carbon	Above-ground woody carbon	Below-ground woody carbon	Soil carbon (at 0-30cm depth)	Total carbon
Grassland (n=3)	0.28 ± 0.04	0.44 ± 0.03	2.21 ± 0.825	0.44 ± 0.16	92.86 ± 14.62	96.23 ±14.78
Shrubland (n=3)	0.53 ± 0.04	0.17 ± 0.03	6.48 ± 0.83	1.3 ± 0.16	107.22 ± 14.84	115.7 ± 15.00
Woodland (n=3)	0.32 ± 0.04	0.17 ± 0.03	4.63 ± 0.83	0.93 ± 0.16	78.93 ± 15.63	85.15 ± 15.28

Landscape types were found to influence ($P < 0.05$) carbon stocks for all carbon pools of the landscapes (Table 2).

Table 2. Effects of landscape types on carbon stocks of Marsabit Central grazing lands

Carbon pool	Degree of Freedom (DF)	P-value	R square
Above ground herbaceous carbon	2	0.0001	0.050251
Below ground herbaceous carbon	2	0.0001	0.213012
Above ground woody carbon	2	0.0001	0.062989
Below ground woody carbon	2	0.0048	0.025326
Soil carbon (at 0 - 30 cm)	2	0.0001	0.241363
Total carbon	2	0.0001	0.170183

Unlike the landscape types above there were no seasonal effects ($P>0.05$) on the carbon stocks. Season only influenced the above-ground herbaceous carbon pool. Table 3

Table 3. Seasonal variations of carbon stocks of Marsabit Central grazing lands

Landscape carbon pool	Seasonal variation Wet	Dry	P value
Above ground herbaceous carbon	0.49 ± 0.02	0.39 ± 0.02	0.0027
Below ground herbaceous carbon	0.27 ± 0.01	0.24 ± 0.01	0.1208
Above ground woody carbon	4.43 ± 0.47	4.4 ± 0.47	0.9833
Below ground woody carbon	0.88 ± 0.0957	0.89 ± 0.0957	0.9844
Soil carbon	93.32 ± 9.06	87.5 ± 9.06	0.0926
Total carbon	99.39 ± 9.1576	93.42 ± 9.1576	0.0942

Discussion and Conclusion

The results are consistent with carbon stocks for grazing areas of sub-Saharan Africa (Matieu, 2010). The effects of landscape types on rangeland carbon stocks demonstrated rangeland ecological variability in terms of differences in the spatial distribution of plant communities. Rangelands are generally considered mosaics of diverse ecological conditions

created by spatial variation in soils, topography and micro-climate (Scoones, 1999). The ecological variations result in asymmetric distribution of carbon stocks. Assessment of carbon content or biomass productivity should therefore consider the heterogeneous nature of the environment to avoid errors arising from asymmetric resource distribution (Kratli and Schareika, 2010). The measured amount of stored carbon exists under communal grazing management in semi-arid pastoral ecosystems. Carbon stocks have been possibly maintained by pastoralists' grazing practices, which are characterized by herd mobility over diverse grazing landscapes to utilize patchiness of range resources. Upholding these grazing practices will reinforce the contribution of pastoral ecosystems in protecting the atmospheric environment. Furthermore, the largest proportions of carbon stocks were found in the soils, meaning that any alternative land use to pastoralism that exposes soil carbon would have substantial adverse environmental effects.

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Strengthening livestock health and pastoral nutrition and livelihoods in Tanzania

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Abstract

Pastoralists in semi-arid environments—whose livelihoods depend crucially on livestock—are threatened by climate change impacts on water, pasture, and disease dynamics. In the biologically diverse and economically important Ruaha landscape, pastoralists relying on livestock for food, economic security, and cultural preservation have felt the devastating effects of disease on animal survival and productivity. Research by the Health for Animals and Livelihood Improvement (HALI) project, a long-term partnership between Sokoine University of Agriculture and University of California, Davis, has identified diverse zoonotic diseases in livestock in this water-limited environment. During earlier livestock health capacity interviews, pastoralists repeatedly called for household-level education and better trained and equipped livestock extension officers to increase herd resilience to disease threats in their changing environment. Extension officer interviews echoed this need for livestock health training and diagnostic capacity. The interdisciplinary HALI team is working with local communities to identify key livestock diseases of concern and to develop and deliver livestock health and human nutrition education to pastoralists and extension officers. In partnership with local stakeholders, we intensively monitor and evaluate impacts on animal health and maternal and child nutrition and pastoralist livelihoods. The collaboratively developed education intervention will provide locally relevant knowledge and practices promoting adaptability and resilience of livestock systems, human nutrition, and pastoralist livelihoods.

Introduction

Livestock populations in semi-arid grassland regions are extremely vulnerable to climate change. These impacts may be particularly severe in Tanzania where productivity is extremely low, accounting for only 4% of sub-Saharan Africa (SSA) meat production despite harboring Africa's third largest national herd. Per capita calories from animal products are 18% lower in Tanzania than other SSA nations and 73% lower than the rest of the world (WRI, 2003). Animal numbers indicate that there is significant development opportunity for livestock keepers, but because of recent changes in livestock systems, vulnerability to climate change, disease, and other perturbations is similarly high.

In the economically and biologically important Ruaha ecosystem, water scarcity currently limits the sustainability of livestock production and livelihoods. The economy of the region is closely tied to the Great Ruaha River, a critical freshwater resource for people, livestock, and wildlife, which also generates over 50% of the nation's electricity through hydropower. In recent decades, large-scale hydrologic disruption, caused by river diversion for agriculture and intensive livestock grazing, has limited the delivery of freshwater ecosystem services, threatening the ecological integrity of the Ruaha region and the viability of pastoralist households. Pastoralists are particularly vulnerable to climate change due to their reliance on their herds for nutrition and income, as well as higher risk of exposure to zoonotic diseases (Ellis and Swift, 1988).

Climate change-driven alterations in variability and intensity of rainfall will likely have direct impacts on livestock productivity, but also indirect impacts through alteration of disease dynamics and incidence (Ostfeld, 2009). Models of livestock systems in northern Tanzania suggest that disease risk can be more limiting to livestock populations than forage availability (Boone *et al.*, 2002). In addition to increasing animal morbidity and mortality (especially during drought years), disease reduces livestock producer income due to quarantines and loss of public trust in meat products (Barrett *et al.*, 2003).

Response of disease vectors, animal hosts, and pathogens to climate change may increase outbreaks of diseases like Rift Valley fever, which can cause severe symptoms and even death in livestock and people (Gould and Higgs, 2009). Known diseases in the Ruaha region that have the potential to or have seriously impacted livestock production and could be exacerbated by climate change include zoonotic tuberculosis (*Mycobacterium bovis)*, contagious bovine and caprine pleuropneumonia, East Coast Fever, trypanosomiasis, brucellosis, water-borne protozoal diseases, and Rift Valley fever (Clifford *et al*., 2008). Expected severe weather patterns and intermittent, extensive periods of drought, as well as human influences on local resources, are likely to increase disease impacts on already burdened livestock populations in the Ruaha landscape.

In sub-Saharan Africa, semi-arid grassland systems face significant pressure from increasing human populations. Above average population growth in rural communities especially surrounding protected wildlife areas (Wittemyer *et al*., 2008) and consequent land conversion pressures from logging and agriculture can increase disease transmission among overlapping human and animal populations (Patz *et al*., 2004). Climate change may also increase risk of disease spillover among pastoralists, livestock, and wildlife by increasing contact around already dwindling water sources (Mazet *et al*., 2009) with direct consequences on pastoralist livelihoods.

The wellbeing of pastoralists in Tanzania is inseparable from the health of their livestock. Livestock provide nutrition, fertilizer, draft power, income, cultural status, and wealth (Scoones and Wolmer, 2006). As a living, mobile bank, livestock herds offer an economic safety net, allowing pastoralists to sell animals when money is needed. However, the multifunctional role of livestock can strongly influence pastoralists' decisions about when they should sell their animals. Osterloh *et al*. (2003) examined a number of hypotheses for the death of livestock sales by pastoralists in Kenya and Ethiopia. Rejecting cost-based explanations e.g., lack of information, costs of transporting animals to market, complex property rights they found that choosing to sell livestock appeared to be largely preference-based and occurred when cash was needed for household expenses or emergencies (Osterloh *et al*., 2003). Pastoralists' ability to sell animals for emergency funds is highly dependent on the health, condition, and size of their herds.

There are also important differences in male and female roles in pastoralist households that are intertwined with herd health and management. Because so much of household nutrition is derived from animal products either directly, e.g. milk, or indirectly, e.g. the sale of a goat to purchase other food stuffs such as cereal grains, the health of family members depends heavily on the health and productivity of their animals. Men, in general, manage sale of livestock, including money earned from livestock sales, and wages or salaries earned, while women manage production and income from other animal products and non-farm trade (Nguvava *et al*., 2009). In addition, many studies conducted in developing countries have found evidence that increases in women's status, income, and control of resources correlate with increases in childhood health and nutrition outcomes, as well as expenditures on health and human capital (Quisumbing, 2003).

Research on the nutritional status of women and children in pastoralist communities in Tanzania indicates widespread malnutrition. Sellen (2000) found that approximately 50% of women studied were chronically energy deficient; additionally, half of children exhibited growth retardation due to insufficient nutrition. Despite livelihoods based on animal production, pastoralists' diets are often lacking in calories (Fratkin, 2001). Nyaruhucha *et al*. (2006) determined that approximately a third of pastoralist children in Simanjaro district were underweight and undernourished. They concluded that nutritional and hygiene education, environmental sanitation, and zoonotic disease prevention practices needed to be taught at household and village levels.

Multiple pathways may yield improved pastoralist livelihoods. For one, global demand for livestock products is increasing rapidly, leading some to label the trend a "livestock revolution" (Rosegrant *et al*., 2001). Even with favorable conditions for improved pastoralist livelihoods, increases in climatic severity (e.g. extended periods of drought or sudden floods) can stress livestock and decrease forage availability, enabling disease outbreaks (Galvin *et al*., 2004). Therefore, building mechanisms to adapt to changing conditions is important. Increasing capacity of veterinarians, livestock extension officers, and pastoralists themselves to meet the requirements of local trade channels promoting food safety and preventing seriously damaging outbreaks of livestock disease can increase pastoralists' wealth, nutritional status, and access to education (Scoones and Wolmer, 2006). Evidence exists that this type of strategy can significantly improve the productivity of these livestock systems. Pastoralists with access to a community animal health project in northern Tanzania experienced reductions in calf mortality between 59 and 93% (Nalilotela *et al*., 2001). Providing access to health services by training animal health specialists also proved to be quite effective in disease recognition and surveillance; training workers on disease reporting in three districts of the Arusha region increased reported disease cases by 49% to the highest levels in the country (Allport *et al*., 2005).

Project Description

The Health for Animals and Livelihood Improvement project is working collaboratively with pastoralist communities, university researchers, government veterinary officials, and stakeholders at the local and regional levels to provide and evaluate the impact of community-requested education on livestock health and human nutrition in rural Tanzania. During a previous research phase, we found that pastoralist households were experiencing heavy disease burdens (production-limiting infections and deaths) in their livestock herds (Gustafson *et al*., 2014). Additionally, both pastoralists and livestock extension officers felt that very little communication occurred between these groups. Both groups believed that they needed education on key livestock diseases and disease prevention, and district and regional government veterinarians also recommended education for pastoralists and extension officers as a tool to increase herd health and resilience. Through a series of stakeholder meetings, community focus groups, and surveys with pastoralist households and livestock extension officers, we identified the main local livestock diseases of concern, the types of education desired, and the delivery methods preferred for the education. The primary purpose of the project is to evaluate the impact of livestock and human nutrition education on herd health and productivity, maternal and child nutritional status, and pastoralist household livelihoods with the broader goal of increasing pastoralist household and herd resilience to environmental change. We use a variety of research methods to analyze the effect of education and training, including collecting longitudinal household-level data through surveys on livestock number and health, sales of animals and animal products, and disease prevention and management practices; anthropometric measurement of household members (height, weight, arm circumference, and hemoglobin level); and testing to examine the effect of training on extension officers' and pastoralists' understanding of livestock health and human nutrition topics.

Accomplishments

We have completed livestock health training and field practical workshops with all of the livestock and agricultural extension officers working in the Ruaha landscape study area. Veterinarians and representatives from governmental organizations and institutions of higher education, including the Tanzania Veterinary Laboratory Agency, Sokoine University of Agriculture, and the Iringa Rural District Veterinary Office, contributed to the trainings. Eighteen extension officers (six livestock extension officers and twelve agricultural extension officers) received training to enhance understanding of diverse aspects of animal health and disease, and to prepare them to participate in village-level education workshops for pastoralists. Extension officers received in-depth education and training on key local diseases of livestock (cattle, sheep, and goats) and other domestic animals (dogs and chickens); diagnostic sample collection, storage, and testing; disease reporting; meat inspection; post-mortem examination of carcasses; control of external parasites, such as ticks; and potential effects of climate change on disease. These workshops were extremely well received by local veterinary stakeholders. District level governmental representatives identified livestock health training as a critical need for all extension officers, and asked that the trainings be extended to other areas if possible.

We also completed pastoralist educational workshops in 21 study villages, which reached a total of 459 participants, including 369 pastoralists and 90 health clinic officers, extension officers, and government officials. The education was developed to include pastoralists' livestock health priorities identified in surveys and village-level focus groups, as well as findings from baseline nutrition work and livestock health interviews conducted with pastoralist households in Pawaga and Idodi divisions enrolled in the study. The 21 villages were split into four different groups, each of which received one of four types of education: 1) livestock health education and baseline zoonotic disease prevention and climate change education, 2) human nutrition (with special emphasis on women and children) and food preservation education, as well as baseline zoonotic disease prevention and climate change education, 3) livestock health, human nutrition, and baseline zoonotic disease prevention and climate change education, and 4) baseline zoonotic disease prevention and climate change education (comparison group). We included livestock and agricultural extension officers, who had previously attended a practical training and instruction course on livestock health that we led, to provide an opportunity for them to network with and provide education to pastoralist households. One of the aims of our work is to increase communication and trust between pastoralists and the village extension officers who provide livestock health services. Pastoralists' lack of trust of extension officers' abilities has been a major barrier to the local livestock health service system. We also included local human health center representatives to promote greater local health care utilization; in particular, to encourage pastoralist families to take their young children to the clinic for regular check-ups to assess health and nutrition.

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Devolution of customary rangeland governance institutions: impacts on pastoral livelihoods and rangeland management in Borana plateau, southern Ethiopia

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Abstract

For centuries, the Gadaa customary resource governance institutions have been the backbone of the successful traditional pastoralism in Borana plateau of Southern Ethiopia. However, today these customary institutions are weakening due to internal and external stressors. This study was carried out on 120 households in four districts of the Borana zone to investigate the impact of the institutional change on pastoral livelihoods and rangeland management. Analysis of the household survey showed that the devolution and replacement of the customary Gadaa institutions has diminished pastoralists' access to communal rangelands, livestock mobility, conflict management and mutual support. As a result pastoral households' income and livestock holding is significantly declining along with the institutional change. The study suggests that the Borana Gadaa system has still some effective rangeland governance institutions that could play vital role in improving the pastoral production systems and livelihoods if rightly integrated with the emerging state governance systems.

Keywords: Borana, Customary institutions, Livelihood assets, Rangeland management, Pastoralism

Introduction

Pastoralism in Borana plateau of Southern Ethiopia is founded on extensive livestock keeping, seasonal herd mobility and flexible resource use arrangements, which until recently have been governed by strong customary institutions collectively known as the 'Gadaa System' (Homann, 2004). The Borana Gadaa system is an elaborate and all-embracing socio-political governance system that has survived for centuries independent of the formal administration (Legesse, 1973; Tache and Irwin, 2003). Under the Gadaa system, access to communal rangelands and water, conflict management, social assistance and many other aspects of the pastoralist life are managed by indigenous rules and regulations. The organizational structure of the Gadaa system is intricate with strong kinships and hierarchical ties. The *Gumi Gaayo (*assembly of Gadaa council) led by Aba Gadaa (the father) form the highest decision making body. Both Aba Gadaa and the Gumi Gaayo are elected every eight years (Legesse, 1973).

In Borana pastoral production system, virtually all rangeland resources are communal and are governed by the Gadaa indigenous customs and bylaws (Ada and Sera) established by the (Gumi Gaayo) Gadaa and effected by appointed managers. For example, access to water is managed by the water manager (*abba herrega*). The use of pasture across clans is negotiated by special elders committees (*jarsa madda*) and sharing of seasonal grazing lands is managed by *jarsa dheeda*. With these elaborated and flexible institutional arrangements, the Boranas have been able to freely move and match their livestock to the available rangelands even during times of severe drought. In essence, the customary institutions and the core rules and regulations have been the backbone of the communal resource management codes and collective actions of the pastoralists (Homann, 2004). Thus, any threat to the customary rangelands governance system could also threaten the livelihood of local pastoralists and the pastoralist system.

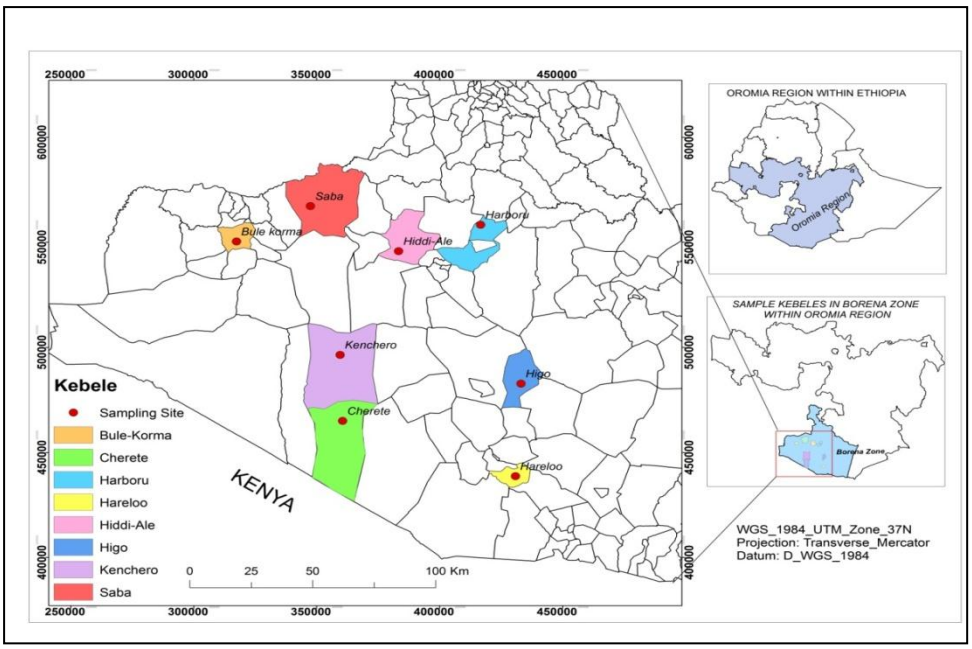
However today, both the Borana traditional livestock production systems and core customary institutions are under pressure from multiple internal and external factors. One of the most pressing stresses to the Borana pastoral production system today are changes in the communal rangeland governance systems and ownership arrangements. In particular, influences from recent pastoral development policies of the government including; privatization of rangelands, agricultural expansion, sedentarization of pastoral associations (PAs) and introduction of formal administration structures are weakening the role of the customary system (Homann *et al*., 2005).

With increasing human and livestock populations under unclear formal institutions to regulate the use of rangelands, the weakening of the customary institutions could lead to the rebuttal of individual herder behaviors to the collective bylaws. This in practice results in unregulated use of rangeland resources, more competition and frequent conflicts with increased degradation of rangelands, a classic example of the tragedy of the commons (Hardin, 1968). However closer examination of the problem and evidences from previous studies (Angassa and Beyene , 2003) reveal that the key challenge for the sustainable utilization of Borana rangelands lies more on how the commons are governed and managed to adapt to the changing socio- economic and institutional arrangements than population pressures. This suggests that, part of the solution could be integrating some of the effective customary institutions into the emerging state administration; which entails comprehensive understanding of the institutional change, and its influences of vis-a-vis designing mechanisms for integrating the Gadaa institutions with the emerging state administration. This paper reports finding of a study on the impacts of the institutional changes on the livelihoods and communal resources use systems of the Borana pastoral communities.

Materials and methods

Description of the Study Area

The Borana zone is one of the 13 administrative zones in the Oromia regional state of Ethiopia. It is located in the Southern tip of the country (fig. 1.1) between 3°36'– 6°38'N and 3°43'- 39°30' E. Yabello, the capital of the zone, lies 570 km south of Addis Ababa. The zone is made up of thirteen districts or '*woreda'*, divided between two agro-ecological zones – the semi-arid lowlands to the south and the more humid lands at higher altitudes to the north (Tache and Irwin, 2003). The climate of the area is arid and semi-arid. Rainfall is bimodal, with the long rainy season in March–May and the short rains in September–November, followed by long dry season. Rainfall is variable with strong effects on range productivity. Average annual rainfall varies from 353 to 873 mm (McCarthy *et al*., 2002). Droughts occur once every 5–10 years (Coppock, 2007). The population of the zone is about 1.1 million; 84 % living in rural areas and 16 % living in urban areas (CSA, 2003).The major ethnic groups are Borana Oromos and Guji Oromos, the former living in the lowlands and the latter in the highlands. Livestock mobility is the main strategy used by the pastoral communities for climate-related risk management and efficient utilization of communal range resources.



Map of the Study area and location of Sample PAs (Source: Ashenafi, 2013)

Sampling Design

A multi-stage sampling design was used to select sample households and collect the primary data for the study. In the first phase four representative districts (Yabello, Dire, Dillo and Teltele) were identified, covering over 30% of the Borana zone. The selection of the districts was made on the accounts that two of the districts contain pastoral communities who

still practice traditional mobile pastoralism largely governed by the customary institutions; while others on the other hand comprise agro/pastoralists chiefly governed by the emerging hybrid and formal state administration (PAs). In the second stage a total of eight pastoral associations (PAs), two from each of the districts representing the existing scenarios of resource governance structures were selected on the basis of information obtained from preliminary survey and district level pastoral development offices. Households in each of the selected PAs were then categorized into three socio-economic classes i.e. rich, medium and poor (locally determined by livestock holding and other capital assets). Taking 5 % of the households (out of 2,368) for the survey (Meant, 1999), the total number of sample households for the study was determined to be 120. Finally, random sampling (lottery) was used to select the sample households from each socio-economic class accounting a total of 120 sample households for the detailed survey. In order to ensure the adequate representation of women households, women-headed households were systematically included when all the randomly selected households turned out to be solely male-headed.

Data Collection Methods

A Household Survey Method was used to collect the primary data for the study. Accordingly, a semi-structured questionnaire was prepared and translated into local language (Afan Oromo). The questionnaire was then pre-tested onto 3 households from each PA amounting to a total of 24 pre- tests. The survey was finally administered through face-to-face interview by trained enumerators in two seasons: i.e. from April 15 - May 15 (wet season) and Sept 8 - 29 (beginning of the dry season). A cognitive recalling technique of maximum ten years (based on the local calendar) was used to elicit relevant information from respondents.

Four focus group discussions were made in the four districts; two were in agro-pastoralist (Harallo and Hid-Ale) and two were in relatively pure pastoralists (Higo and Kenchero). For that purpose, a total of 10-12 participants representing all socio-economic classes, gender and the local Gadaa system (Rabaa Gadaas = local leaders from the customary institution) were included.

Review of relevant literatures, government policy documents and reports from national and international organizations including the Borana Pastoral Development Office, Yabello Pastoral and Dryland Agriculture Research Center, the International Livestock Research Institute, the Borana Raba Gadaas, and CARE-Ethiopia were made and important additional information was collected.

Data Analysis and Interpretation

The robust qualitative and quantitative data collected from the four districts was analyzed using relevant descriptive and inferential analysis tools. A frequency index value analysis, correlation tests and mean livelihood asset value comparisons were carried out to examine the influence of the institutional change on: pastoralists' income, livestock holding and a number of physical and social capitals of the pastoralist.

Results and Discussion

Household Livestock Holding and Species Composition Dynamics

Table 1. Mean Household Livestock Holding in Agro-pastoral and Pastoral PAs

	Cattle		Goats		Sheep		Camel	
Year	Agro-past	Pasto	Agro-past	Pasto	Agro-past	Pasto	Agro-past	Pasto
2009	8.8	41.8	9.9	5.1	6.0	7.2	9.5	7.8
2010	7.5	37.9	10.6	6.6	5.8	5.1	6.2	8.0
2011	6.6	30.3	10.8	8.7	6.1	5.8	5.0	11.6
2012	7.0	20.7	9.3	9.1	6.8	5.1	6.3	10.0
2013	7.6	22.6	11.4	9.7	7.3	4.9	5.6	13.3

The above result shows that in pastoral areas household cattle holding are highest followed by camels, goats and sheep; while in agro-pastoral areas goats are highest followed by cattle, sheep and camels. Consistent with previous studies by Desta and Coppock, (2002), the general trend in household livestock holding, particularly of cattle, is declining in pastoral communities, whilst the total livestock population is steadily increasing. The findings were in line with a recent study by Boru *et al*. (2014) who noted that the number of cattle per household has declined by more than 25% between 2000 and

2011. Among the main reasons for the sharp decline in household cattle population over the years in pastoral areas was the growing shortage of grazing land as a result of bush encroachment and frequent drought shocks. The falling number of cattle in both communities is strongly attributed to the weakening of the customary communal resource governance that has led to the loss of access to productive grazing lands and frequent resource conflicts. The consequence is confinement of livestock production to marginal areas. This was also demonstrated in a previous study by Angassa and Oba (2008). Already stressed by frequent drought and bush encroachment, loss of scarce grazing lands is forcing pastoralists to reduce cattle holdings, thus diminishing the physical capital of mainstream pastoralists. In contrast, holding of camels and goats is on the rise in pastoral and agro-pastoral areas respectively. This has come from two reasons. The first is the relative ecological fitness (browsers) of both species in an increasingly bush encroached rangeland with limited grass to support the cattle population, especially in dry seasons. The other is the growing commercialization of camels and goats for national and international markets encouraging pastoralists and agro-pastoralists to keep more and more camels and goats than before.

Impact on Access to and Management of Communal Rangelands

One of the most profound influences of the institutional change in Borana range governance system was the loss or restriction of mainstream pastoralists' access to productive communal rangelands. As shown on table 2, the transition of the Borana rangeland governance system from customary to the PA over the years was negatively correlated with pastoralists' access to communal grazing lands with correlation coefficient r = - 0.947. This has come from two processes. Primarily, the designation of increasing number of private enclosures by the few rich and elite pastoralists/ agro-pastoralists is depriving the customary communal ownership and use rights of mainstream pastoralists to communal rangelands. Secondly, the growing individualized crop cultivation on communal rangelands is fragmenting and shrinking the size and utility of productive rangelands.

Table 2. Correlation Coefficients of the relationship between institutional change and pastoral livelihood assets (rangeland utilization and social capitals)

	Variables	Institutional Change	Access to Rangelands	Access to water	Mobility and cooperation	Resource conflicts
1	Institutional Change (customary to PA)	-				
2	Access to Communal Rangelands	-0.947	-			
3	Access to Communal water resources	0.776	-0.939	-		
4	Livestock mobility and mutual cooperation	-0.875	0.816	-0.856	-	
5	Resource conflicts	0.905	-0.863	0.872	-0.722	-

In both cases, the privatization of rangelands is part of the government's development policy towards increased crop cultivation and private commercialization of livestock production. However, the current scenario in Borana shows the limited success and massive trade-offs of the cropping expansion to the pastoral production system. With limited social ground and unclear regulations of the Coree and PA systems; the weakening of the customary institutions has led to over exploitation of the communal lands by the economically able agro/pastoralists. The result is declining livestock productivity and dwindling income leading to increased vulnerability of the mainstream pastoralist noted by Gemtessa *et al*. (2005). The current inequity in communal resources use has led to the loss of social cooperation and willingness of pastoral households to take part in rangeland management and maintenance of ponds. In effect, the erosion of the customary social cooperation creates a more individualized way of life fueling the degradation and mismanagement of rangelands by private land holders (Wario *et al*., 2013).

Impact on Livestock Mobility, Conflict Management and Mutual Support Systems

Traditionally, the Borana clan leaders coordinate and negotiate the movement of livestock during Fora (seasonal her mobility) and Godantu (long distance movement in search of grazing land and water during severe droughts). This was possible because of the strategic negotiations for communal range utilization among different pastoral communities within and outside the plateau. Similarly, the Boranas were able to cope with risks of drought due to their strong culture of mutual assistance where the rich supports the poor and women. However, these invaluable social systems are fading today along with the weakening of the customary system shown by the strong negative correlation coefficient of - 0.875 on table 2. In the same fashion, the frequency of resource conflicts is increasing with the transition of the customary institutions

into formal PA administration with correlation coefficient of r= 0.905. The result has led to constrained livestock production and increased conflicts in a rangeland that virtually remains dry for over 9 months in a year. The deterioration of the mutual support systems has weakened the cooperation among pastoralists increasing the vulnerability of the poor and women-headed households to risks associated with climate variability and poverty.

Impact on Livestock Holding and Income from Livestock Production

Table 3. shows that mean livestock holdings are remarkably different among households in the three resource governance systems. Mean livestock holdings are higher (44.3) for pastoral households in the traditional Gadaa system compared to in the Coree (16.38) and in the formal PA administration (6.66). The significant decline in livestock holding along the institutional transition implies the strong influence of the range governance and use arrangements on the livestock production system.

Table 3. Comparison of mean livestock holdings and annual income from livestock production among households in different rangeland resources governance systems.

N	Rangeland governance	Mean Livestock holding	Std. Error	Mean Income from Livestock (Birr)	Std. Error
1	Customary/Gadaa	44.30	6.095	14,603.60	2009.41
2	Coree/Committee	16.38	2.276	4,431.00	1425.47
3	PA/Formal	6.66	1.770	3,262.00	1021.38

Among other factors, the decreasing number of livestock holdings in the Coree and PA, has come from the loss of access to productive rangelands due to the establishment of competing land-uses such as crop farming and private Kallos (enclosures) often fragmenting and shrinking the communal rangeland ecosystems. This in turn confines livestock to marginal lands with poor forage productivity as was early noted by Spencer (1974). The result reaffirms findings of a previous study by Agassa and Oba (2008) who concluded that the management and productivity of rangelands in Borana was more effective under the traditional system than the formal state management. They argued that the degradation and replacement of some of the most effective customary range management and use arrangements has led to critical shortage of productive grazing lands thus forcing pastoralists to reduce livestock holding. Similarly, analysis of the mean annual income of households from livestock production showed sharp decline from 14, 603 in customary to 4,431 in Coree and 3,262 under formal government administration as presented on table 3. In a society where income from livestock production is the main stay of household economy, declining income from livestock production along with institutional transitions indicate the dependency of pastoralism as an economic activity on the compatibility and effectiveness of the rangeland management and use institutions enforced. In fact, one could argue that the reduced income from livestock production in the Coree and PA systems might be attributed to the diversification of livelihood strategies and unaccounted incomes from other sources. However, findings of both the household survey and observational studies revealed that traditional pastoral production system is still the main source of income for the overwhelming majority of households in Borana plateau.

Conclusions

The study has revealed that the weakening of the customary resources governance institutions has deteriorated the livestock production and livelihoods of mainstream pastoralists in the plateau. Yet there are also encouraging improvements in the development of essential infrastructures, resource bases and market networks as a result of institutionalization of state governance systems. This suggests that the Gadaa customary system has still some effective institutions that could play vital role in improving the pastoralist livelihoods and rangeland management if appropriately integrated with the emerging state governance structures.

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Crop-Livestock integration systems in arable areas of Marsabit County, Northern kenya

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Abstract
There are arable areas of arid northern Kenya which has potential both for livestock and crop production. These areas include mountain, footslopes and oasis areas. This arable zone is inhabited by resource-poor agropastoralists with limited capacity to access modern inputs for crop and livestock production. While the comunities living in arable areas of northern Kenya pursue both livestock and crop production, it is not clear whether livestock and crop components are interdependent. Sociological survey method and key informants were used to study farmers with both crop and livestock components. The study revealled that 93% of farm labour is provided by people but not oxen, camel or donkey as expected in ideal intergrated systems. 77% of interviewed farmers throw away most of produced manure instead of using it for field fertilization. Crop residues are not stored and used in times of feed scarciy, but 71% of interviewed farmers release livestock to feed on crop residues directly from farm which in most cases livestock tample and destroy residues. The study concluded that farmers in arable areas of northern kenya diversified sources of livelihhods to crops and livestock production. However, crop and livestock components are not intergrated. The study further recommend for disemination on sustinable crop-livestock integration systems by agricultural extension officers and other development agents.

Introduction

Crop-livestock integration system involves interdependency among crop and livestock components. This system can be viable, both ecologically and economically. However, it is knowledge intensive and sometimes, farmers are not realizing its benefits. Crop-livestock integration has been beneficial for fragile arid and semi-arid environments. Similarly, resource-poor farmers with low financial ability to access external inputs, has option of benefitting from integration system (Williams *et al*., 1995; Powell *et al*., 1996). In arable areas of northern Kenya, the interactions between crop and livestock enterprise is blurry both at farm and regional level.

Mountain, footslopes and oasis areas of northern kenya have potential for both livestock and crop production systems. However, the human population living in these zones mainly depend on famine relief food due to food shortage. Low nutrient contents and acidic propoerties have been noted in the soils within Mountain areas of northern kenya (Muya *et al.*, 2010). Climate variability coupled with unsustainable farming practices have negatively impacted on production capacity of these important arable zones. While farmers in arable areas of northern kenya, are known to pursue both crop and livestock production. The relationships between crops and livestock at farm or regional level is not clearly understood. This study seeks to understand crop – livestock integration systems in key potential areas of northern kenya.

Methodology

Structured questionnaires were used to collect data from farmers with crop farms and livestcok. Purposive sampling method were applied to identify the respondents. The data was analysed using SPSS computer software.

Results and Discussions

Sources of power in the farm

Farm operations for crop farmers of northern kenya is mainly provided by people. 93% of the respodents are providing farm power for themselves (Fig. 1). 40% of the resepondents are using animal power, including oxen and donkey. Donkeys provide power for watering livestock, especially calves, while oxen provides power during planting and also weeding (Table 1). In northern Kenya, the power provided by people is the most important and commom than power provided by the animals. However, animal power is very important among farmers in sub-saharan Africa (FAO, 2011). In northern Kenya, even farmers owning livestock (cattles, camel, donkey) still use human power which is more common in the area. The common use of human-power by farmers in northern kenya, reduces interdependency among crop and livestock components. Animal power has shown to improve tillage and allows water infiltration within the arable zones of northern Kenya (Obanyi *et al*., 2011). However, when animal power is less used, there is chance of soil compaction and reduced crop yield.

Table 1. Sources of power in the farm

Sources of labour	Number of farmers using (n=55)	Percentage
People	51	93
Animal/Livestock	22	40
Machineries/Tractor	4	7

Use of crop residues

The agropastoralists communities in Marsabit County feed 71% of their crop residues with their livestock (Figure 2). Communities in this region are historically pure pastoralists, hence livestock play important role in their lives. The community in the region makes tradeoffs when it comes to use of crop residues. Fertilization of crop field using residues is less important to the communitity in question when it comes to use of residues. Furthermore, crop residues are not fed to all livestock but fed to cattle calves and few home-based livestock. Jaleta *et al*. (2012) also showed competing uses of crop residues among farmers of Kenya. Contrary to the case in northern Kenya, in Nigeria the full use for crop residues for soil fertilization has been reported (Bagayoko *et al*., 1996). The findings of this study compares well with others, where the importance of crop-residues in feeding the livestock has been shown in arid and semi-arid environment. Further, it was reported that crop-residues are the only source of feed during drought and late dry peiods in arid and semi-arid environment (Valbuena *et al*., 2012). Howevwer, In Marsabit, county crop residues are not managed or stored, but animals are allowed to graze directly. This can result to damage and loss of crop residues, through trampling by livestock. Moreover, 100% of crop-residues are fed to livestock with no residues used for soil fertilization which can potentially result to nutrients imbalance.

Table 2. Proportion of farmers and their preffered use of crop residues

Use of crop residues	Number of interviewed farmers (n=55)	%
Plough back to farm for fertilization	10	18
Use it for mulching	7	13
Preserve for future use	3	5
Release livestock directly to feed on residues	39	71
Burn to clear farms	2	4
Just leave it on farms without planned use	3	5

Production and utilization of Manure

Farmers in Marsabit County produces approximately two wheelbarrows of manure per day (Figure 3). Manure are mainly produced from cattle (55%) and small stock (30%). Camel manure is not utilized since the farmers frequently change boma (night enclosures) for them. 77% of the respondents throw away Over 75% of collected manure. While 46% use some manure for field fertilization (Figure 4). This is an ineffeciency within the production system. Throwing away of manure is attributed to lack of knowklege on manure use and importance. Additionally, heaps of manure with no management lies in each and every village visited for the study. This can result to N losses through volatilization and contributing to greenhouse gas emissions.

Similar studies has reported on advantages of livestock manure for soil fertilization within the intergrated systems. For, example, Liu *et al*. (2010), reported that over 23% of nitrogen is provided by manure in crop-livestock integrated system. In northern kenya, manure is neither sustainably used nor managed.

Table 3. Quantity of manure produced per day

Livestock species	Indigenous cattle	Small stock	Others	Average quanity of manure produced by one farmer per day (wheelbarrows) (n=55)
Average manure per day (wheelbarrowa) in Saku	1.31	0.45	0.14	1.95
Average in Moyale	0.81	0.7	0.4	1.91
Average in the County	1.06 (55%)	0.58 (30%)	0.27 (15%)	
Average	1.91 wheelbarrows			

Cash flows in the integrated production systems

The potential benefits of integration, where cash from one component support the other componenet is non-existent in Marsabit County. Although, the farmers with both crop and livestock enterprise earns more annual income than farmers with only one componenet (Table 4), there is no cash flow from one component to another. This finding compare well with other finding, For example, Liyama *et al*. (2007), reported that households with intergrated crop-livestock earn higher income than those with single production systems. Contrary to the finding of this study, Homann *et al*. (2007) reported scenario in Zimbabwe where women farmers sell goats to develop crop component. This is a missing link in the crop and livestock production system of Marsabit County.

Table 4. Comparison of annual incomes among livelihood systems

Livelihood systems	Average annual income (KES)
Crop production alone	20,000
Livestock production alone	35,000
Both crop and livestock production	55,000

Conclusion

There is diversity within production systems of northern kenya, i.e. crop production and livestock keeping. Diverse production systems are not necessary integrated. There is no clear-cut conectivity between livestock production and crop farming in northeren kenya. There is therefore need to build the capacity of farmers on crop-livestock intergrated systems. Agricultural officers also need to be trained on intergrated system so that they can pass this knowledge to farmers. This findings provide entry point to more indepth research on the crop-livestock production in Marsabit County, Northern Kenya. Further research is recommened on management of crop residues and animal manure, conservation agriculture in crop-livestock systems, and study on nutrient flows and balances.

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Chemical composition of Cactus species and *Prosopis juliflora* as Drought-resilient Feed resources in Kenya

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Abstract

Two plant species; cactus (Opuntia spp) and Prosopis juliflora were sampled in Baringo, Laikipia, Naivasha and Machakos counties for evaluation of nutritional quality. Different plant parts were sampled for chemical analysis; old and young leaves, ripe and unripe fruits of different cactus species, mature and young barks, green and dry leaves and pods and seeds of P. juliflora. Dry matter ranged from 158 to 180 g/kg DM for young and mature cladodes of spineless Opuntia respectively and 153 to 172 g/kg DM for young and mature cladodes of spiny Opuntia respectively. Crude fibre (CF) ranged from 134 to 305 g/kg DM for spiny young and old Opuntia respectively and 254 to 323 g/kg DM for spineless Opuntia species (young and mature cladodes). CF content of Opuntia species increased with increase in maturity. High content of starch was observed in all the Opuntia species. Higher starch content was reported in the mature cladodes than the young ones. Spiny Opuntia had higher reported starch content ranging from 243 to 61g/kg DM (mature and young cladodes respectively) as compared to spineless Opuntia which ranged from 95 to 61 g/kg DM. High contents of starch was also recorded in both ripe and unripe fruits of spiny Opuntia, ranging from 146 and 136 g/kg DM (ripe and unripe spiny Opuntia fruits respectively). Mature cladodes of spiny Opuntia had higher recorded ash contents than young shoots, ranging from 54 to 39 g/kg DM. Old barks of P. juliflora had the highest ash content (144 g/kg DM) as compared to other parts, with 124 g/kg DM reported for the young barks. Prosopis seed had the highest CP content (400 g/kg DM), and starch contents (129 g/kg DM). High CP content (150 g/kg DM and 200 g/kg DM) was reported for dry and green leaf meals respectively. The study revealed high contents of starch in Opuntia spp, high CP content in Prosopis pods, seed and leaf meals. The high energy and CP pools available in Opuntia species and Prosopis juliflora can be exploited as livestock feed supplements in rangelands experiencing energy and protein imbalances due to feed quality variability and frequent droughts posed by climate change

Keywords: Resilience, Climate change, Livestock, Feeds

Introduction

The problem of animal feed supply and quality is aggravated in arid and semi-arid regions by scarce and erratic rainfall that limits the growth of herbaceous species and biomass in rangelands. Thus, livestock in such regions have to survive on recurrent shortage of feed resources of insufficient nutritional value for most of the year (Robles *et al.*, 2008). These drought conditions, exacerbated by climate change will force pastoral communities to look for alternative plants species as forages. Cactus species and *Prosopis juliflora* are such lesser- known and under-utilized feed resources in Kenya.

Although Prosopis species has been reported to improve livestock production in the Kenya's rangelands, pastoral communities have perceived it as a noxious plant responsible for decay of animals' teeth, with subsequent death due to starvation. The problem of *Prosopis species* has elicited mixed reactions by the community members in Baringo County (Syomiti, Unpublished data). In the absence of concrete information about the nutritional significance of Prosopis species in addition to negative community perceptions about its forage value there are many that have expressed the need for an external support to manage the spread or eliminate it altogether and replace it with desirable plant species. However, *prosopis spp* can provide many of the needs of populations living in dry lands of the world, and have the potential to provide much more if knowledge on their utilization is expanded. For instance, a feeding trial in India on livestock using rations containing up to 45% of *Prosopis spp* components yielded a 1 .5% of cattle body weight with acceptable live weight gains (Tewari *et al.*, 2000). On the other hand, cactus (Opuntia ficus-indica) is drought tolerant and makes use of little moisture in the rainy season to produce large quantities of forage and has high carrying capacity than any other drought tolerant fodder in arid and semi-arid areas (Tegegne, 2001). It remains green and succulent during drought thus supplying the much needed energy, water and vitamins to livestock in dry periods. Opuntia ficus-indica withstands severe defoliation and has good regeneration ability. This plant material can be easily and inexpensively established and is quite promising because of its low maintenance costs. Due to its anatomic and physiological constitution, Cactus withstands a wide range of soil types as well as harsh climatic conditions.

Therefore, plausible pastoral systems should incorporate Cactus establishment as a suitable soil conservation plant material. It is also a promising plant for arresting desertification (De kock, 1980; Nefzaoui and Ben salem, 2001). The fact that Cacti combines drought tolerance and water use efficiency, it produces a large quantity of forage that remain green and succulent in dry periods and makes it the best fodder option in the changing climatic situations (Nefzaoui and Ben-salem, 2001). The purpose of the current study was to establish the feed value of cactus species and *P. juliflora* as potential, alternative drought- resilience feed resources in Kenya's rangelands.

Materials and methods

Location of the Study

The study was carried out in four pilot administrative counties of Baringo, Laikipia, Naivasha and Machakos, Kenya. Purposive sampling of these study sites was used due to availability of large tracks of spiny and spineless cactus species and *P. juliflora.* These zones are located in agroecological zones IV and V, with annual rainfall between 500-1000 mm and 300-600 mm respectively.

Sampling of plant materials

Different parts of spiny and spineless cactus species and *P. juliflora* sampled for nutritional evaluation were; young and mature cladodes/shoots, ripe and unripe fruits, *P. juliflora* leaves (green and dry), pods (green and dry) and bark (from a mature and young tree stem). A duplicate sample weighing 500 g was collected and dried in an oven at 60ºC for 48 hours, ground to pass through a 1-mm sieve and stored in plastic bottles at room temperature for subsequent chemical analyses.

Data analysis

Statistical package for social sciences (SPSS) version 20 was used for data analysis for computation of nutrient means.

Results

The chemical composition of different parts of Cactus species and Prosopis juliflora are shown in Table 1. The results indicated that crude protein (CP) and ash content of different plant parts varied greatly between species

and maturity stage. The CP content of spineless Opuntia spp was higher than that of spiny Opuntia ranging from 115 to 145 g/kg DM (for mature and young cladodes respectively), and 120 to 135 g/kg DM (for mature and young cladodes) respectively. Variations were observed between CP content of young and mature cladodes of both spiny and spineless Opuntia species (Table 1). Low contents of dry matter (DM) and crude fibre (CF) were also reported in both spiny and spineless Opuntia species. Dry matter ranged from 158 to 180 g/kg DM (young and mature cladodes of spineless Opuntia respectively) and 153 to 172 g/kg DM (young and mature cladodes of spiny Opuntia species respectively). Crude fibre ranged from 134 to 305 g/kg DM for spiny Opuntia species (young and old Opuntia species) and 254 to 323 g/kg DM for spineless Opuntia species (young and mature cladodes).

Table 1. Chemical Composition of Different parts of Cactus and *Prosopis juliflora* species (g/kg DM)

Species	Part	Chemical composition				
		DM	CP	CF	Starch	Ash
Spineless cactus	Mature cladodes	180	115	323	95	44
	New cladodes	158	145	254	61	26
Spiny cactus	Mature cladodes	172	120	305	243	54
	New cladodes	153	135	134	61	39
	Ripe fruit	120	111	327	146	9
	Un-ripe fruit	133	122	294	136	32
Prosopis species	Young leaves	890	263	142	110	98
	Mature leaves	900	143	192	42	20
	Mature green leaves	627	200	186	-	110
	Mature dry leaves	833	150	230	-	59
	Dry Pods meal	926	218	322	107	79
	Green pods meal	780	109	275	25	88
	Ground Seed meal	920	400	-	129	-
	Mature bark	910	0	860	126	144
	Young bark	890	33	584	79	124

Variations in CF were also observed in young and old cladodes of both spiny and spineless Opuntia species, with increase of CF content with plant maturity. However, higher content of starch was observed in all the Opuntia species cladodes. Higher starch content was reported in the mature cladodes than the young ones (Table 1).

Table 2. Prosopis pods comparison with other sources of non-conventional animal feed ingredients

Feedstuff	ME	CP (%)	CF (%)	Cost (Kes/Kg)	Rank
	(MJ/kg DM)				(Weighted Index)
Prosopis seed meal	9.9	399	7.3	-	1
Sunflower seed cake	7.95	27	28	24	2
Prosopis pod meal	12.95	21.8	20.1	-	3
Maize germ	11.51	12.4	10.2	21	4
Wheat bran	8.37	15.5	15	18.4	5
Molasses	9.8	2.9	0	35	6
Rice polishing	10.04	8.2	31.9	18	7

Source: Kyuma, 2010

Spin y Opuntia had higher reported starch content ranging from 243 to 61 (for mature and young cladodes respectively) as compared to spineless Opuntia cladodes which ranged from 95 to 61 g/kg DM. High contents of starch was also

recorded in both ripe and unripe fruits of spiny Opuntia species ranging from 146 and 136 g/kg DM (ripe and unripe spiny Opuntia fruits respectively). Mature spiny Opuntia cladodes had higher recorded ash contents than young shoots, which ranged from 54 to 39 g/kg DM. Mature barks of *P. juliflora* had the highest ash content of 144 g/kg DM as compared to other parts, with ash content of 124 g/kg DM reported for the young barks (Table 1). Prosopis seed meal had highest reported CP content (399 g/kg DM) and starch contents of 129 g/kg DM (Table 2). Young Prosopis leaf meal had substantial CP content of 260 g/kg DM as compared to 146 g/kg DM for older shoots.

Discussion

Spineless Opuntia species had higher recorded levels of CP content which ranged from 115 to 145 g/kg DM (for mature and young cladodes respectively), than that of spiny Opuntia which ranged from 120 to 135 g/kg DM (for mature and young cladodes respectively). This can be attributed to the formation of the spines, which can be speculated that some of the plant protein is channeled to spine formation with subsequent lignifications of these spines. Variations observed between CP content of young and mature cladodes of both spiny and spineless Opuntia species (Table 1) is in agreement with Mustafa *et al (*2007) who reported higher CP content of soybean straws as the plant matured. Low contents of DM and CF reported in both spiny and spineless Opuntia species were expected. According to Ben Salem *et al*. (1996), Opuntia species is a succulent plant with approximately 90% water, which can sustain livestock without water for about 60 days in drylands which experiences water scarcity. The reported low CF contents of Opuntia is in agreement with findings by Firew *et al.* 2007, who reported average low CF content of 14.5% in Oputnia species. Strategic supplementation of Opuntia species with high DM content feeds such as cereal straws and hay is required to control bloat and oxalate poisoning in Opuntia (Nefzaoui and Ben Salem, 2001). Higher content of starch was observed in all the Opuntia species cladodes, with higher starch content reported in the mature cladodes than the young ones (Table 1). Opuntia being a succulent drought tolerant plant with high reported starch content can be effectively utilized as non-conventional feed ingredient in ration formulation in rangelands. Spiny Opuntia species had higher reported starch content (with higher reported levels for mature spiny cladodes than young spiny cladodes) as compared to spineless *Opuntia cladodes*. High contents of starch were also recorded in both ripe and unripe fruits of spiny Opuntia species.

These results reveal that starch content of Opuntia species increases as the plant matures. This would be useful information with respect to domestication and agronomic management of Opuntia as livestock feed. Higher starch content in spiny Opuntia can be attributed to the spines, which upon hydrolysis can be reduced to simple sugars. However, the spines pose a limitation as livestock feed. According to Kang'ara and Gitari (2010), the spines can be eliminated by passing the cladodes through a borne fire for livestock feeding. This is in agreement with reports by Syomiti (Unpublished data), where agro-pastoral communities in Nyeri North used cactus to feed their livestock during droughts and applied fire to remove the spines.

Highest ash contents reported in the mature barks of *P. juliflora* is an indicator of high mineral content. Prosopis seed meal was reported to have highest levels of CP content (400 g/kg DM), which is comparable to those of other conventional feed supplents such as sunflower seed cakes (Table 2). This indicates that *P. juliflora* can be a valuable non-conventional protein supplement for livestock in drylands. However, inclusion levels in feed rations is required due to the fact that livestock, mainly small ruminants were reported to lose teeth after consuming large quantities of *P. juliflora* (Choge *et al.*, 2002), with subsequent starvation to death. Reports by Kyuma (2013) indicated that pastoral communities perceived prosopis species as a noxious weed. Prosopis leaf meal had substantial CP content of 150 g/kg DM and 200 g/kg DM for dry and green leaf meals respectively. However, green leaf meal of Prosopis species is reported to have high anti-nutritional factors owing to mainly condensed tannins, thus slow drying in a shade reduces the tannins levels thereby increasing the feed intake (Koech *et al*., 2011).

Conclusions and recommendations

Cactus (Opuntia) species, Prosopis seed and pod meals are ideal non-conventional feedstuffs, and can be recommended as alternative feed resources for substituting scarce conventional protein and energy feed sources in Kenya's drylands. Promotion of cactus-Prosopis based feed rations in the rangelands is required to enhance resilience in pastoral communities for sustainable livestock production in the wake of climate change.

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Implications of constrained mobility on livestock production and pastoral livelihoods of Borana plateau, southern Ethiopia

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Abstract

In the Borana plateau of Southern Ethiopia, mobility has long served as a tool for pastoral adaptation to climate variability. However, this tool is increasingly constrained by different forms of rangeland fragmentation. The current study was conducted to assess the pattern and trend of mobility constraints and commensurate implications on pastoral livelihoods using focus group discussions, semi-structured questionnaires and personal observations. Different forms of rangeland fragmentation, such as expansion of cropping, bush encroachment, land appropriation and settlement, were reported as the major drivers of mobility constraints. Almost all respondents ranked the expansion of cropping as the leading factor constraining mobility. The average number of cattle and small ruminants per household showed a strong positive relationship with the distances in seasonal herd mobility (R^2= 0.769 and 0.748), respectively. Consequently, the gap between the rich and poor economic classes, in terms of cattle holding per household, has widened by 83.6% and 93.7% in agro-pastoral and pastoral systems, respectively. Rangeland fragmentation induced mobility constraints have

reshaped the status of livelihood assets and widened the gap between the rich and poor pastoralists, which could increase the vulnerability of the poor. Thus, investigation on the sustainability of both systems, equitable utilization of private enclosures and the trade-offs between area of crop expansion and livestock holding is recommended.

Keywords: Borana, Land fragmentations, Pastoral livelihood

Introduction

In the horn of Africa, pastoralism remains a dominant form of land use that supports the livelihood of 15 to 20 million people (FAO, 2010). The Borana plateau of southern Ethiopia supports more than one million of these people (Kamara *et al*., 2003; CSA, 2008). Pastoralism is predominantly practiced in arid or semi-arid ecosystems like the Borana, where climate is a limiting factor for vegetative structure, function, and dynamics available for grazing or internal ecological processes (Behnke *et al*., 1993; Hiernaux, 1996). In such an ecosystem, availability of resources required for livestock, such as forage and water, are variable both spatially and temporally and to large extent unpredictable (Niamir-Fuller, 2000). The Borana plateau is no exception; it is characterized by recurrent droughts where rainfall variation creates a vicious cycle of massive cattle losses every 5 to 6 years (Desta and Coppock, 2002). There is insufficient rainfall to sustain agriculture. Therefore, pastoralism has long existed as the single most important and viable means of sustainable livelihood strategies of Borana pastoralists (Tache and Irwin, 2003).

The existence of such an entrenched system is due to the fact that the people that live there have developed strategies over time that solved a number of problems related to making a living on the dry lands. Livestock mobility is one of the most important ways that African pastoralists have historically managed uncertainty and risk (Bassett, 1986; Scoones, 1994). It creates an opportunity for pastoralists and their livestock to respond to gradients in forage quality by matching their distribution to spatially variable peaks and valleys (Coppock *et al*., 1986; Scoones, 1995; Fryxell *et al*., 2004). Hence, mobility enables pastoralists to take advantage of pasture resources that are only seasonally accessible and spatially variable (Coughenour, 2008).

Despite the importance of mobility as a management tool in the Borana, expanding crop cultivation in pastoral areas is inducing land fragmentation by removing the most productive lands from the grazing herds (Coppock, 1994; Angassa and Oba, 2008). Moreover, fragmentation of rangelands in Borana has been aggravated by bush encroachment, sedentarization and in excess fencing of private grazing lands (kalos) (Angassa and Oba, 2008). Increasing land fragmentation has restricted the area available to pastoralists (Hobbs *et al*. 2008), resulting in less grazing land and water (Boone *et al.*, 2005 and Thornton *et al*., 2007). Consequently, the total area and overall diversity and condition of the remaining rangelands have also declined, further threatening traditional pastoralism (Freudenberger, 1993) and accelerating the declining rate of livestock ownership per capita and production per livestock unit (Oba, 2001; Ehui *et al*., 2002).

Although different studies have been conducted in Borana, the issue of rangeland-fragmentation induced mobility constraints, and its implication on livestock population dynamics and pastoral livelihood assets, has received little attention. Thus, there is little information available about how land fragmentation has been influencing mobility, or on the consequences of constrained mobility on livestock population, herd composition and income. Therefore, the objectives of this study are: (1) asses the pattern and trend of mobility constraints and their drivers, and (2) evaluate implications of constrained mobility on livestock population and pastoral livelihood assets in the Borana plateau of southern Ethiopia.

Study area

The Borana zone is located in the Southern tip of Ethiopia between 3°36'– 6°38'N and 3°43'- 39°30' E. The climate of the area is arid and semi-arid. Rainfall is bimodal, with the long rainy season in March–May and the short rains in September–November, followed by the long dry season. Average annual rainfall varies from 353 - 873 mm (McCarthy *et al*., 2002). The total population of the Borana zone is approximately 1.1 million; 84% live in rural areas and 16 % live in urban areas (CSA, 2007). Pastoralism is the major economic activity of the Borana people. Mobility of livestock is the main strategy used by the pastoral communities for climate-related risk management and efficient utilization of communal range resources. The mobility takes two forms: the first is the movement of the satellite herds and locally called "Godaanssa Foorraa" , takes place during rainy season to lowland areas where there are no permanent sources of water while the second type is moving the herds to other regions, further away from the homestead locally called as "GodaanssaWarraguda". It is takes place during acute drought or conflict.

Methodology

Sampling design

A multi-stage sampling method was employed to select sample households. Accordingly, eight pastoral associations (PAs) were selected from four districts. From each PA, 15 households were sampled, the 15 sample households were distributed to the three socio-economic classes in each PA based on the proportion of households in each socio-economic class. Finally, random sampling was used to select the sample households from each socio-economic class in each of the eight PAs accounting a total of 120 sample households.

Data collection methods

The interviews were held with each household head and took up to 3 hours to complete. Respondents were asked to recall herd histories and mobility routes from 2008 to 2013. They were also asked to recall introductions of cropping and pastoral associations, banning of fire, occurrence of bush encroachment and fencing for kalos from 1974 to 2013 in a stepwise fashion. The years 1974 and 1991 represent regime change in Ethiopia through the fall of the Feudal system and Durg, respectively. To collect the required information, a semi-structured questionnaire was prepared and the initial version of was pre-tested. The survey was administered through face-to-face interviews. In addition to household survey, focus group discussions were also held in four pastoral associations (PAs), two were in agro-pastoral (Harallo and Hid-Ale) and the rest were in pure pastoral regions (Higo and Kenchero). In each group discussion a total of 10-12 participants representing all socio-economic classes, gender and the local Gadda administration (Rabaa Gaddas) were included.

Secondary data was also collected to better understand the factors that have caused mobility constraints and to determine if they confirm farmer perceptions. Data collected includes pastoral development issues (implemented rangeland improvement activities), accessibility of infrastructure and agricultural extension activities implemented for the last four decades.

Statistical analysis

The collected data were analysed using the Statistical Package for Social Sciences (SPSS) version 20. Repeated measure analysis was employed to plot the relationship the relationship between mobility constraining factors, rank and farming system. The relationship between distance in mobility, livestock holding and number of watering points were examined using Pearson correlation analysis. The sources of mobility constraints on pastoral livelihoods were ranked using index values (Table 1). Index values were computed using the formula: Index = $(4*n_{rank\ 1} + 3*n_{rank\ 2} + 2*n_{rank\ 3} + n_{rank\ 4}$ of constraint i)/(sum $4*n_{rank\ 1} + 3*n_{rank\ 2} + 2*n_{rank\ 3} + n_{rank\ 4}$ for all constraints i-I), where n is the frequency that respondents ranked each constraint i-I (Teklu *et al*., 2011). Qualitative data is also compiled, summarized and used to support discussion under respective sections.

Results

Factors constraining pastoral mobility in Borana plateau

Borana pastoralists of southern Ethiopia had well-planned herd mobility routes for their livestock across heterogeneous landscapes. During focus group discussion with representatives of pastoralists and key informants, they explained that communal owned rangelands have been the basis for mapping such routes in a way to detect resources available in a spatially and temporally variable landscape. However, since 1970 the effectiveness of such well-planned herd mobility has been deteriorating rapidly due to fragmentation of communal rangelands. In this regard, establishment of pastoral associations, bush encroachment, private enclosures, agricultural expansion and settlement were listed as the major mobility constraints from rangeland fragmentation in both agro-pastoral and pastoral systems (Figure.1). Accordingly almost all respondents in agro-pastoral systems (APS) pointed to expansion of cropping as the major cause of mobility constraints, followed by private enclosures (kalo). In pastoral systems (PS) more respondents indicated bush encroachment as the major mobility constrains, followed by private enclosures (Fig. 1).

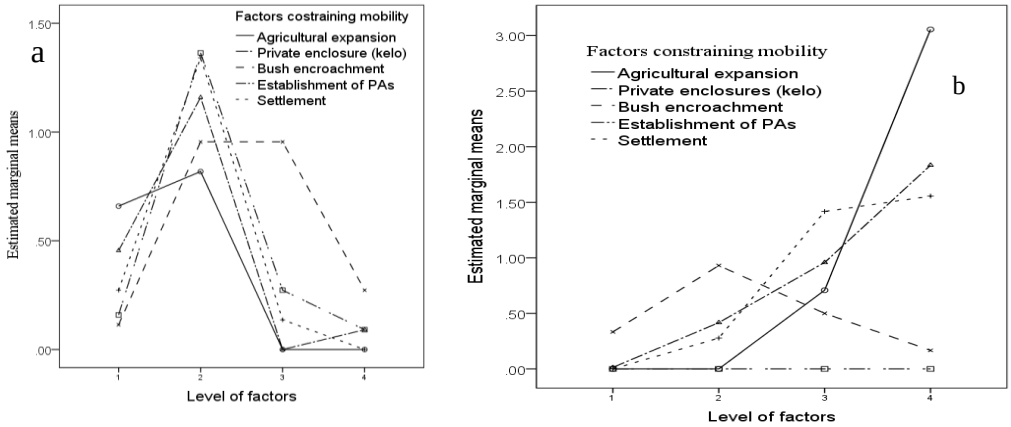

Figure 1. Mobility constraining factors ranked by agro-pastoral (a) and pure pastorals (b) respondents (1= highest; 2= medium; 3= low and 4= very low)

Settlement and expansion of private enclosures further exacerbates the disruption of the Borana pastoral system by constraining mobility. Another newly emerging mobility constraint in Borana is private enclosures (kalos). Following agricultural expansion, private enclosure was the second most ranked mobility constraining facts in agro pastoral system. This indicated that land appropriation is becoming increasingly apparent in agro-pastoral systems compared to pastoral systems.

Consequences of constrained mobility for livestock production and income

Cattle, sheep, goats and camels were the dominant livestock types reared by the local community of both farming systems in Borana. The average number of cattle and small ruminants per household showed a strong positive relationship with the distances in herd mobility, with an R^2 value of 0.769 and 0.748, repetively (Fig. 2). For example, agro-pastoralists with 5 head of cattle travelled approximately 10 kilometres per trip compared to pastoralists with 40 head travalling about 40. Causality is impossible to identify at this time. In arid and semi-arid ecosystem like Borana, the continuation of herd mobility and existence of communal rangeland is necessary to maintain large numbers of livestock holding per household and let pastoral systems function.

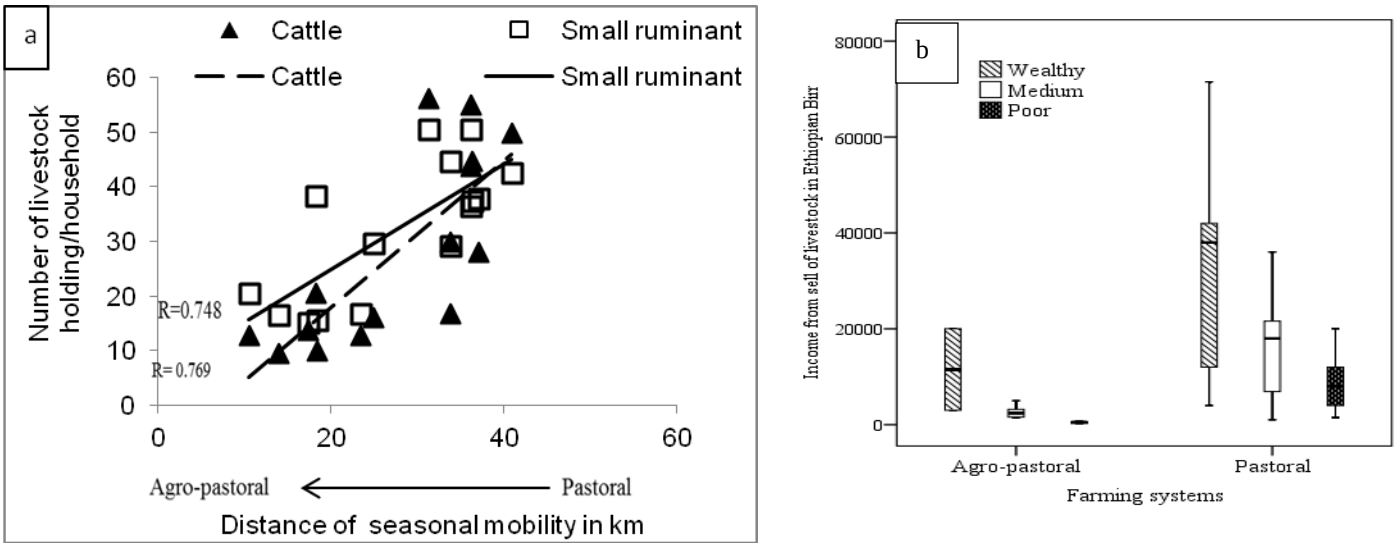

Figure 2. The relationship between seasonal mobility and cattle, small ruminant holding per household (a) and box and whisker plots of income from sale of livestock distributed for wealthy, medium and poor economic class of agro-pastoral and pastoral systems (b) of Borana zone (Agro-pastoral=44; pastoral=73) in Borana zones of southern Ethiopia

Figure 4b shows the disparity among different socio-economic classes in terms of income from livestock has widened in the last half a decade. Almost all respondents in the agro-pastoral system earned less than twenty thousand Ethiopian birr

from selling of livestock, while up to seventy thousand Ethiopian birr per annum was earned in the pastoral system (Fig. 2b). Respondents categorized in the poor economic class of the pastoral system earned income from livestock almost equivalent to the respondents categorized under wealthy economic class of agro-pastoral system (Fig. 2b). Causality is again illusive, but it is clear that the poor in both systems are not earning enough from livestock to more than barely sustain themselves

Implications of constrained mobility on pastoral livelihood outcomes

Reducing vulnerability is the primary livelihood outcome for pastoralists to survive and thrive in arid and semi-arid ecosystems. Livestock mobility is a means of managing uncertainty and risk in prevailing harsh and erratic conditions in those regions. Therefore, mobility constraints could influence the livelihood activities by which pastoralists struggle to attain their livelihood. As shown in table 1, respondents of both agro-pastoral and pastoral systems ranked eight livelihood outcomes that has been significantly influenced by mobility constraints over the last half a decade. Limited access to grazing land was ranked 1st ,with an index value of 0.228 and 0.283 in agro-pastoral and pastoral systems, respectively, as consequences of mobility constrain on pastoral livelihood outcomes. Reduction in herd size was ranked 2nd , with the index value of 0.179 in the agro-pastoral system, while limited access to watering points had an index value of 0.185 in the pastoral system (Table 1).

Compared to pastoralists, higher numbers of agro-pastoralists ranked the occurrence of trespassing conflict and shift in diet from milk to crop as consequences of mobility constraints. In addition, a higher number of agro-pastoralists ranked moving out to towns (abandoning livestock keeping and cropping) with the index value of 0.075 as a livelihood strategy compared to the pastoral system. This indicated a decline of agro-pastoral systems' carrying capacity to be able to accommodate the increasing population pressure.

Table 1. Value index for consequences of mobility constraints on pastoral livelihood outcome in agro-pastoral and pastoral systems of Borana zone

Variables	Agro-pastoral system (Sample size, n=44)				
	1st rank	2nd rank	3rd rank	4th rank	Index[a]
Reduction in herd size	8	19	0	0	0.179
Shift from cattle to sheep and goat	4	3	1	5	0.065
Limited access to grazing land	26	3	0	0	0.228
Limited access to watering points	12	3	1	5	0.129
Loss of communal rangeland	7	10	2	1	0.127
Trans passing conflict	9	7	4	1	0.133
Moving out to towns	1	9	0	6	0.075
Shift in diet from milk to crop	0	6	6	2	0.065
Pastoral system (Sample size, n =73)					
Reduction in herd size	7	11	7	0	0.114
Shift from cattle to sheep and goat	10	2	1	4	0.079
Limited access to grazing land	35	13	3	2	0.283
Limited access to watering points	3	23	15	11	0.185
Loss of communal rangeland	11	9	10	12	0.156
Trans passing conflict	10	5	7	9	0.118
Moving out to towns	1	2	6	7	0.044
Shift in diet from milk to crop	1	1	2	3	0.021

[a]Index = $(4*n_{rank\ 1} + 3*n_{rank\ 2} + 2*n_{rank\ 3} + n_{rank\ 4}$ in row$)/($ sum $4*n_{rank\ 1} + 3*n_{rank\ 2} + 2*n_{rank\ 3} + n_{rank\ 4}$ for all rows$)$

Conclusions

In Borena zones of southern Ethiopia the different types of development intervention options that have been implemented since 1970 have caused rangeland fragmentation, which reduced mobility. Consequently, the accessibility of resources required for livestock rearing has declined. The decline in the accessibility of such resources (water and pasture) has resulted in a shift from pastoral to agro-pastoral systems. This system shift has caused a decline of livestock holding per

household, a change in livestock species composition and socio-economic inequality among pastoralists. In the newly evolving systems, agro-pastoral, although cropping, has been considered an alternative livelihood strategy. However, its coexistence with livestock in arid and semi-arid ecosystems of Borana has not been thoroughly investigated. Therefore, evaluating the sustainability of a newly evolving system could enable policy leaders and decision makers to design different alternatives options that would enhance the resilience, adaptability, reliability and productivity of newly evolving system in a way to coexist with pastoral system which has been practiced since time immemorial.

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Changing pattern of local rainfall: Analyses of 50-year record in Marsabit central, northern Kenya

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Abstract

Understanding rainfall patterns in the face of increased climate variability and change is crucial in determining management strategies of the associated risks. Analysis was done for 50-year rainfall data (1961-2010) collected on daily basis from a meteorological station in Marsabit central area of northern Kenya. The data was computed for yearly and seasonal rainfall pattern. The results showed reduction in yearly rainfall totals by 521.85 mm, long-season rain totals by 262.836 mm, and short-season rain totals by 109.76 mm. The pattern will adversely affect crop and livestock production unless adaptation measures are identified and supported.

Keywords: Climate variability and change, Dry lands, Rainfall trend

Introduction

In sub-Saharan Africa greater proportion of agriculture is rainfall dependent. Change in rainfall pattern associated with climate change would therefore impact on agriculture and food security in the region (Gornall *et al.,* 2010). The importance of understanding rainfall patterns in the context of changing climate cannot therefore over-emphasized (Omondi *et al.,* 2014). Understanding rainfall patterns helps in developing climate change adaptation strategies for rural communities dependent on rainfall agriculture. Yet, it is actually unclear how rainfall pattern evolve particularly in the tropical regions of Eastern African both in terms of magnitude and direction. The common view has been that present tropical areas with already high rainfall will have even enhanced rainfall –"wet-get-wetter"- (Chou *et al.,* 2009). This concept was based the assumption that increased air circulation in the Inter-Tropical Convergence Zone (ITCZ) will trigger more precipitation. Based on this concept, Intergovernmental Panel on Climate Change (IPCC) (2014), in their Firth Assessment Report (AR5), projected a modest increase in rainfall in eastern Africa. However, the concept of "wet-get-wetter" have been criticised for failing to acknowledges key other processes that affect rainfall pattern. Chadwick *et al.* (2009), suggested that the tropical convergence can be distorted by complex pressure patterns created by topography or distribution of water bodies which might create shifts in atmospheric air circulations.

Implication of anthropogenic or climate-induced changes on vegetation cover is also another key process that influence rainfall pattern and seldom emphasized in the IPCC projections. Increase atmospheric carbon dioxide concentration associated with climate change is assumed to trigger increase in vegetation cover and consequently result into increased rainfall scenario through feedback process between oceans, atmosphere and land surface (Melillo *et al.,* 1993). But areas

with more anthropogenic activities which are destructive to vegetation may actually counteracts any gains in rainfall associate carbon dioxide increase (Brooks, 2006). IPCC projections on rainfall patterns had therefore certain limitations that make them unreliable for particularly for locational-specific rainfall scenarios. Despite these limitations, policies on climate change adaptation strategies for local communities are continuously shaped by IPCC projections. There is need to understand locational-specific implication of climate change on rainfall pattern, not only for climate preparedness and early warning but also for developing context-specific adaptation strategies (Omondi *et al.,* 2014). This study was generally aimed at evaluating long-term pattern of rainfall in Marsabit central, northern Kenya. Northern Kenya is arid and semi-arid region, epitomised by frequent occurrences of normal and below-normal rainfall. Although climate variability is an inherent phenomena in the dry lands, increased climate variability and change present additional challenge for pastoralists in northern Kenya, manifested in the frequent occurrence of dry and drought conditions. Nonetheless, rainfall pattern is seldom understood, yet it is of crucial importance in pastoral risk management.

Materials and Methods

Study area

Marsabit central is situated on the slope of Mount Marsabit which is cold and sub-humid area in the midst of arid surroundings. The area has an annual rainfall of 400 – 800 mm, distributed bio-modally long-rains season (March to May) and short-rains season (October to December). The area historically serves as dry season grazing reserves for lowland pastoralists, but it has now attracted farming and human settlements. Significant proportions of lowland pastoralists have now settled and engage in agro-pastoralism as key livelihood option. Farming is rain-fed where crops including maize and beans are grown on small scale for subsistence. Livestock species including cattle, goats, and donkeys are kept in semi-sedentary system. In the recent past, crop and livestock production have negatively been impacted by frequent reoccurrences of seasonal failures causing continuous shift to camel keeping and *Miraa* (Khat) farming (Dabasso, 2012). Camels keeping and *Miraa* farming are usually thought to be resilient livelihood systems.

Data collection and analysis

Long-term daily rainfall data (1961–2010) were sought from Marsabit metrological station from which yearly rainfall totals, seasonal rainfall totals, and yearly number of dry-days and rainy-days were calculated. Daily rainfall were aggregated into monthly and yearly totals. Monthly rainfall were aggregated for long-rain season (March-May) and for short-rain season (October – December). Rainy-day was adopted as any day with equal to or more than 1 mm of rainfall while dry-day was taken as any day with less than 1 mm of rainfall. Both rainy and dry-days were then counted for each year from daily data by inserting “count if” function in the Microsoft excel. The yearly rainfall totals, seasonal rainfall totals, yearly number of rainy-days and dry-days were analysed for linear patterns. Descriptive statistics on averages, maximum, minimum, standard deviation and total change over time were calculated and tabulated for each of the rainfall variable.

Results

Trend in yearly and seasonal rainfall totals

A declining trend of yearly and seasonal rainfall totals were observed over 50-year period (Figure 1. and 2.) Yearly rainfall has reduced by more than 500 mm from 1961 to 2010 (Table 1.).

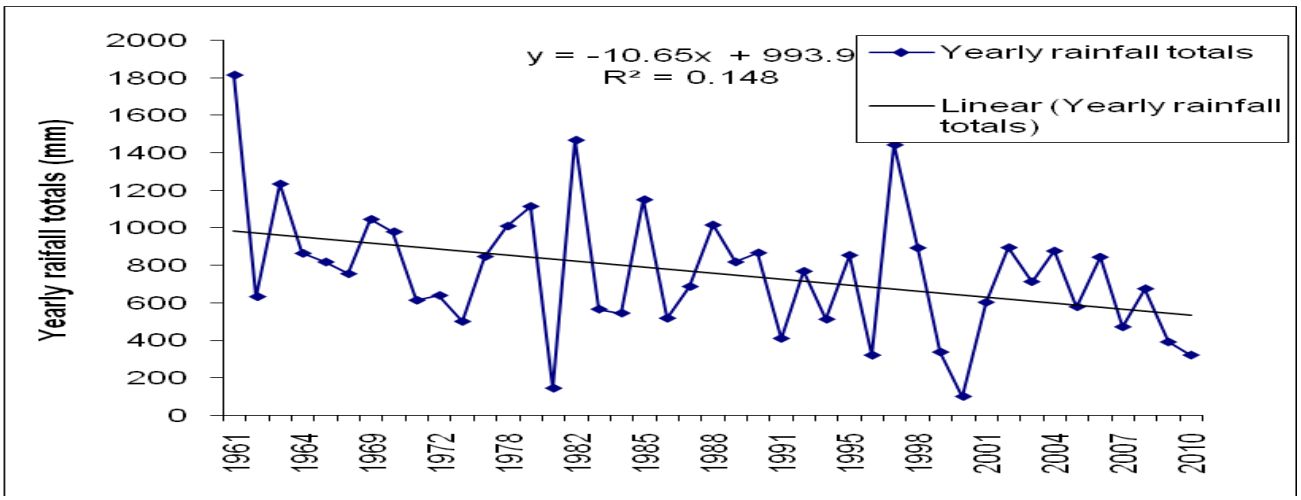

Figure 1. Annual rainfall totals in Marsabit central from 1961 to 2010

Table 1. Analysis of yearly rainfall totals from 1961 to 2010

Rainfall attribute	Value
Mean (mm)	759.495
Standard deviation (mm)	347.487
Maximum (mm)	1816.8
Minimum (mm)	73.5
Total change calculated from trend line (mm/50 years	521.85

Seasonal rainfall trend

Table 2. Analysis of seasonal rainfall data from 1961 to 2010

Rainfall attribute	Long season rainfall	Short season rainfall
Mean (mm)	386.4326	294.0884
Standard deviation (mm)	197.343	201.5881
Maximum (mm)	864.5	1042
Minimum (mm)	13.2	60.0
Total change calculated from trend line (mm/50 years	-262.836	-109.76

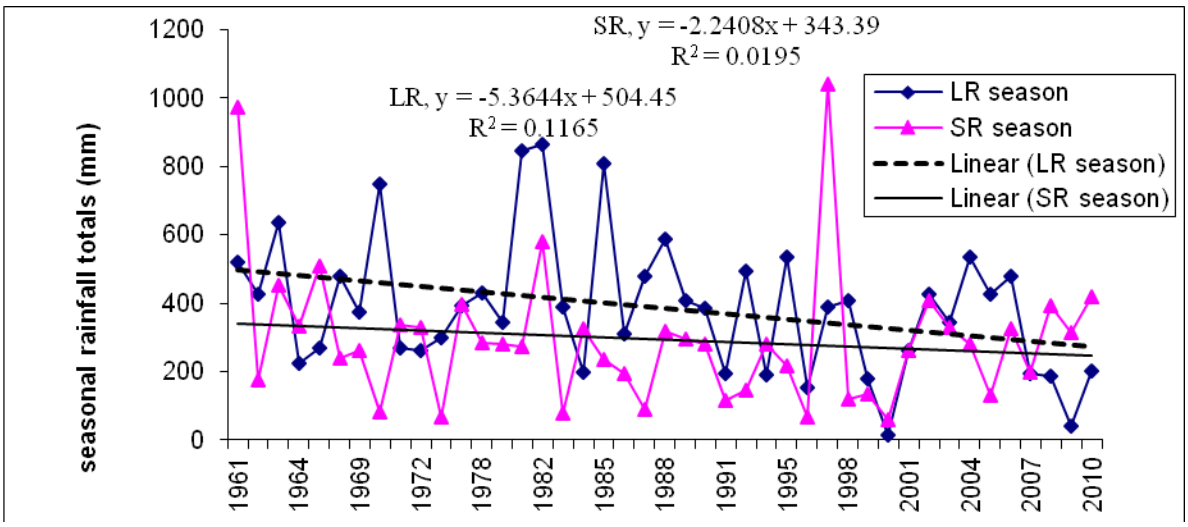

Figure 2. Trend of seasonal rainfall totals in Marsabit central, 1961-2010

Trend in the number of rainy and dry days

Yearly number of rainy days have decreased by more than 10 days while dry days increased by more 19 days (Figure 3 and Table 3).

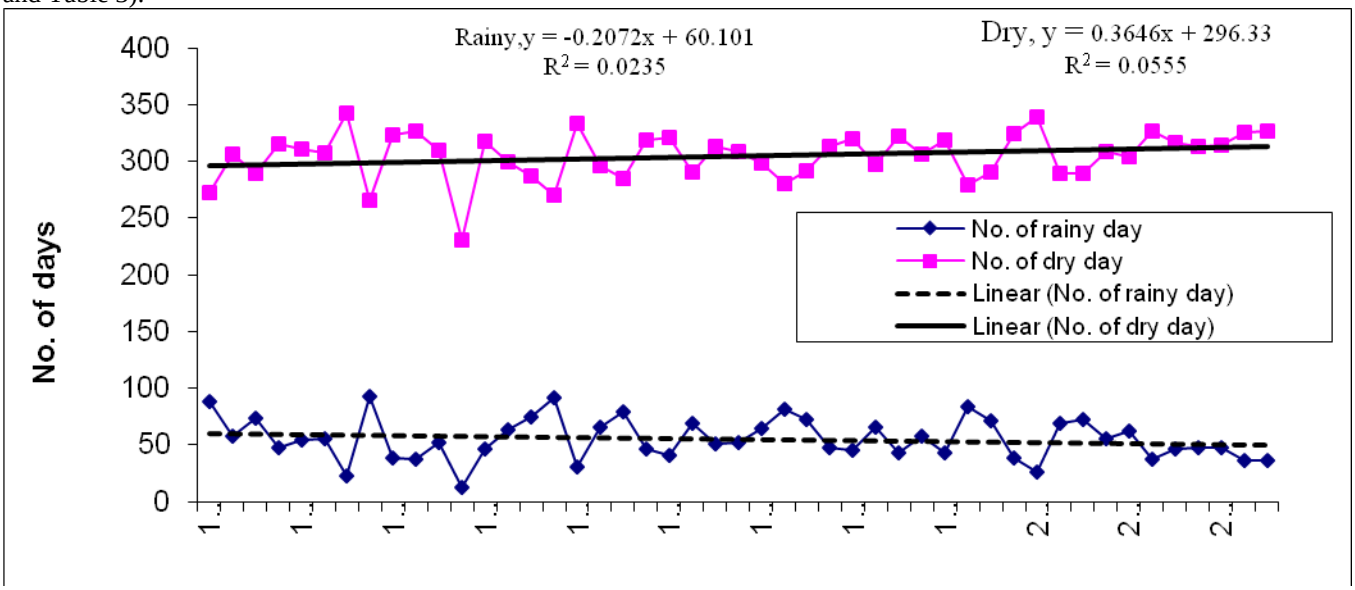

Figure 3. Trend in the yearly number of rainy and dry-days in Marsabit from 1961 to 2010

Table 3. Analysis of annual rainy and dry days in Marsabit from 1961 to 2010

Rainfall attribute	Rainy day	Dry day
Mean	55.127	305.08
% of yearly total	15.3	84.7
Standard deviation	18.52	21.21
Maximum	93	342
Minimum	12	231
Total change calculated from trend line (no./50 years	-10.143	19.656

Discussion and Conclusion

Our analysis of the 50-year rainfall record (1961 -2010) had demonstrated decreasing trend of yearly rainfall totals, seasonal rainfall totals and yearly number of rainy days. However, a trend of rainfall recovery was observed from 1980 but only lasted up to 1991. Although, the rainfall recovery trend from 1980s was comparable to what had been suggested for African Sahel as result of changing climate (Daie *et al.*, 2004; Maynard *et al.*, 2002), our findings indicate continuing aridity in the study area. Whilst we could not directly attribute the observed pattern of aridity to global climate change, but it is imperative to note that change in rainfall had occurred. The observed rainfall changes are opposite scenario to the projections of Intergovernmental Panel on Climate Change (IPCC, 2014) on rainfall pattern in eastern Africa. Using a case study from northern Kenya, our study provide evidence for oppose rainfall trend in eastern Africa. Two different thoughts can be advanced to explain our findings. First, the study area might had experienced anthropogenic activities which are destructive to vegetation cover and therefore possibly resulted into human induced-climate change. Second, complex pressure created by east African highlands causing atmospheric air divergence in the Inter-Tropical Convergence Zone (ITCZ). Our findings are consistence with results from similar rainfall analysis of 1960 to 2009 for central parts of Kenya (Funk, 2010). Similar trend of aridity had also been observed in some parts of African including East Africa (Lyon and Dewitt, 2012), West Africa (Nicholson *et al.*, 2000) and southern Ethiopia region (Viste *et al.*, 2012). The observed rainfall tendency is also in line with common perceptions among farmers in Kenya (Ovuka and Lindqrist, 2000). Recent shifting of agro-pastoralists to camel keeping and *Miraa* (Khat) farming in Marsabit central might have been prompted by numerous experiences of seasonal failures. Camels are well adapted to harsh climatic conditions while the *Miraa* shrub can grow even with minimal moisture content. Identifying and supporting farmers' adaptation strategies is important to cushion livelihoods against the adverse consequences of decreasing trend of rainfall.

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Client satisfaction with livestock improvement technologies in Marsabit, Turkana and Garissa counties, northern Kenya

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Abstract
A study was conducted in Marsabit, Turkana and Garissa counties of arid northern Kenya to capture client satisfaction on livestock improvement technologies. Data was collected using a structured questionnaire randomly administered to different clients in various exhibitions where the technologies were disseminated in Marsabit (n=56), Garissa (n=47) and Lodwar (n=107). The data was analysed using descriptive statistics. Results show that 2,580 clients were reached with the technologies during the exhibitions, 32% being adult males, 21% adult females, 30% youth males and 17% youth females. Out of these, 210 filled the client satisfaction questionnaire, 70% being males and 30% females. Majority of the clients in Lodwar (93.2%) and Garissa (69.6%) were satisfied with the technologies, as opposed to only 19.6% in Marsabit. The same trend was observed in the rating of service delivery in terms of quality, cost and usefulness. The main reason is that people in Marsabit also practice agro-pastoralism and would have preferred more crop-based technologies. Clients mostly liked milk processing technologies and the fact that the exhibitions were elaborate, well-organised and relevant to their livelihood systems. However, 10% of the clients disliked selling of brochures and literature of exhibition materials being in English. Clients in all the exhibitions agreed that technology dissemination at grassroots needed to be improved and the exhibitions organised more regularly. In conclusion, this study shows that clients were generally satisfied with the livestock technologies. Future studies should investigate the extent to which agricultural technologies disseminated through shows and exhibitions in pastoral areas impact on the clients.

Keywords: Agricultural technologies, Dissemination, Pastoralism

Introduction

Satisfaction is a subjective concept and varies from individual to individual. It can be loosely viewed as the utility an individual obtains from consumption of a certain good or service (Allen and Wilburn, 2002). However, just like utility, it is hard to quantify. It can, therefore, be viewed in ordinal terms, where an individual is asked to rank or score the level of satisfaction obtained from using a certain service or commodity.

Kenya Agricultural Research Institute (KARI) is the premier national agricultural research organisation in Kenya, with the legal mandate to carry out research in agriculture and veterinary sciences. The Institute has 22 main research centres mandated to undertake strategic, applied and/or adapted research as well as outreach and partnerships. KARI-Marsabit is one of the KARI centres located in the northern part of the country and conducts research on livestock (camels, cattle,

sheep, goats), crops (cereals and pulses) and cross-cutting issues (climate change, gender, etc.). KARI-Marsabit provides technologies, products and services to various clients' who have varied requirements. Their level of satisfaction, therefore, largely depends on how the technologies, products and services benefit them at their environment. In order to improve on service delivery to its clients, KARI-Marsabit should ensure that there is continuous improvement on technologies, products and services it offers to its clients to suit their needs. However, the extent to which clients are satisfied with the livestock technologies and services is not clearly known. This study, therefore, aimed to capture client feedback on their level of satisfaction with different aspects of livestock technologies, products and services offered to them through shows and exhibitions, and suggest ways for improvement.

Methodology

Study sites

The survey was conducted in Marsabit, Garissa and Turkana counties of arid Northern Kenya. These areas are arid and fall in agro-ecological zones V and VI. The prevailing agricultural system is livestock keeping (pastoralism) and agro-pastoralism in a few pockets in the arid rangelands. The main livestock kept are camels, sheep, goats and cattle. The sites were purposively selected following the shows and exhibitions held in the areas, and the high potential for commercialising livestock production.

Data collection

Data was collected using a structured questionnaire randomly administered to different clients in various shows and exhibitions. These included the Agricultural Sector Development Support Programme (ASDSP) launch in Marsabit (n=56), the Garissa Agricultural Society of Kenya (ASK) show (n=47) and the Kenya Pastoralist Week (KPW) in Lodwar (n=107). Several technologies were exhibited during the shows and exhibitions, including the following:

Livestock technologies: Different grass species for drylands, Baled hay, management of diarrhoea in camel calves, management of ticks in camel calves, management of worms in small ruminants, mobile house for kids and lambs and mineral supplements.

Value addition and postharvest technologies: Technologies for milk quality testing (CMT, lactometer, resazurin), milk cream separator and ghee making, processed milk products (cultured fermented milk, yoghurt, ghee), wet salting technology for hides and skins and tanned leather

Practical demonstrations on the application of the various technologies and information were held during the shows and exhibitions.

The clients were asked about the positive and negative aspects in the KARI-Marsabit stand in each show /exhibition, their level of satisfaction with the technologies, overall rating of KARI-Marsabit service delivery in terms of quality, cost and usefulness, and areas of improvement. The clients were given the questionnaire at the exit point of the KARI stand after they had seen the various technologies; they filled the questionnaire and left it at the customer desk. Data was analysed in SPSS Statistics Version 20 (SPSS, 2011) and presented using descriptive statistics (totals, frequencies, percentages and measures of dispersion).

Results and Discussion

Clients reached

A total of 2,580 clients were reached with the technologies and information, 32% being adult males, 21% adult females, 30% youth males and 17% youth females. Out of these, 210 filled the client feedback questionnaire, 70% being males and 30% females (Table 1).

Table 1. Number of clients reached and questionnaires administered

	Marsabit launch	ASDSP	Lodwar KPW	Garissa show	ASK	Total
Adult males	40		588	195		823 (32)*
Adult females	28		398	120		546 (21)

Youth males	16	485	276	777 (30)
Youth females	13	260	161	434 (17)
Total number of clients reached	97	1,731	752	2,580
Total questionnaires administered	56	107	47	210
Male	39	71	36	146 (70)
Female	17	36	11	64 (30)

*values in parentheses are percentages

Positive aspects (likes) in the KARI-Marsabit stand in each show /exhibition

The customers indicated different positive aspects in each show/exhibition (Table 2). Technologies on milk processing (milk testing, cultured fermented milk, ghee making) were the most liked in all the three sites. This could be because this resonates directly with household food security in the study sites in which livestock keeping (pastoralism) is the main livelihood activity. Clients secondly liked the fact that KARI-Marsabit stand was very elaborate, well organised and relevant to their livestock-based livelihood systems.

Table 2. The positive aspects (likes) in the KARI stand in each show /exhibition

	Marsabit ASDSP launch		Lodwar KPW		Garissa ASK show	
Likes	N*	%	N	%	N	%
Milk processing technologies (cultured fermented milk, yoghurt, ghee, milk testing)	19	34.5	41	38.3	13	27.7
KARI staff are knowledgeable and professional	3	5.5			1	2.1
KARI staff are welcoming and approach people well	3	5.5	2	1.9		
Nerica rice	2	3.6			2	4.3
Bee keeping and honey processing	2	3.6			1	2.1
Pasture seeds	2	3.6			5	10.6
Tea manure	2	3.6				
Well organised and educative / relevant stand	18	32.7	17	15.9	9	19.1
Mineral supplement	2	3.6	2	1.9	1	2.1
Livestock drugs and disease treatment	1	1.8	26	24.3	6	12.7
Camel plough	1	1.8	-	-	7	14.9
Mastitis in camels			1	0.9		
Camel feeds and camel production			2	1.9		
Burdizzo castration for goats and camels			8	7.5		
Hides and skins value addition			7	6.5		
Mobile house for kids and lambs			1	0.9		
Dairy goats					2	4.3
Total	56	100.0	107	100.0	47	100.0

*n indicates number of clients who responded

Negative aspects (dislikes) in the KARI-Marsabit stand in each show /exhibition

Ten percent of the interviewed clients (n=210) were not happy with some of the aspects in KARI-Marsabit's stand. These aspects were different in each show (Table 3). In Marsabit, for example, the three aspects that customers (n=8) disliked most about KARI-Marsabit's stand were selling of brochures and ghee, lack of demonstration farms and brochures, posters and labels being in English. The KARI-Marsabit stand at the KPW in Lodwar attracted a lot of clients who overcrowded the stand, and this was a cause of dissatisfaction to some clients (n=3).

Table 3. Percent of customers indicating negative aspects (dislikes) in the KARI-Marsabit stand in each show/exhibition

Dislikes	Marsabit ASDSP launch (n=8)	Lodwar KPW (n=9)	Garissa ASK show (n=3)
Literature being in English	12.5 (1)*		

Lack of milk products (yoghurt, ghee) for show goers to taste	12.5 (1)	11.1 (1)	
Selling of brochures	25.0 (2)		
Lack of demonstration farms	25.0 (2)		
Selling of ghee	25.0 (2)		
Tent too small leading to overcrowding, hence facilitators cannot give recommended information		33.3 (3)	
Improper translation of English words to local language		33.3 (3)	
Items on display not locally available		22.2 (2)	
Prices not put on products on display			33.3 (1)
Cream separator not working			66.7 (2)
Total	100.0 (8)	100.0 (9)	100.0 (3)

*values in parentheses indicate number of clients who responded

Level of satisfaction with KARI-Marsabit technologies

Majority of the clients in Lodwar and Garissa were satisfied with the KARI-Marsabit technologies. However, some of the clients in Marsabit were somewhat dissatisfied or indifferent about the KARI-Marsabit technologies (Table 4). This is mainly because most of the technologies were livestock-based, whereas a significant population within Marsabit Mountain practice a mixture of livestock and crop farming because of the micro-climate provided by Marsabit Mountain.

Table 4. Level of satisfaction with KARI-Marsabit technologies in each show/exhibition

Level of satisfaction	Marsabit ASDSP launch		Lodwar KPW		Garissa ASK show	
	n*	%	n	%	n	%
Satisfied	11	19.6	96	93.2	32	69.6
Somewhat satisfied	23	41.1	4	3.9	11	23.9
Neutral	20	35.7	2	1.9	1	2.2
Somewhat dissatisfied	2	3.6	-	-	2	4.3
Dissatisfied	-	-	1	0.9	-	-
Total	56	100.0%	103	100.0%	46	100.0%

*n indicates number of clients who responded

Overall rating of KARI-Marsabit's service delivery in terms of quality, cost and benefits criteria

Results in Table 5 show that most of the clients in Lodwar and Garissa were satisfied with KARI-Marsabit's service delivery in terms of quality, whereas 52.7% of the clients in Marsabit were somewhat dissatisfied and 27.3% were indifferent.

Table 5. Overall rating of KARI-Marsabit's service delivery in terms of quality criteria

	Marsabit ASDSP launch		Lodwar KPW		Garissa ASK show	
Level of satisfaction	n*	%	n	%	n	%
Satisfied	5	9.1	89	90.8	28	63.6
Somewhat satisfied	29	52.7	5	5.1	12	27.3
Neutral	15	27.3	3	3.1	3	6.8
Somewhat dissatisfied	6	10.9	-	-	1	2.3
Dissatisfied	-	-	1	1.0	-	-
Total	55	100.0	98	100.0	44	100.0

*n indicates number of clients who responded

There seems to be no problem with costs because most of the customers in Lodwar and Garissa were satisfied, except in Marsabit where about 60% were somewhat dissatisfied or indifferent (Table 6). The main reason for the low satisfaction with clients in Marsabit was that most of the displayed technologies were livestock-based whereas the community in Marsabit practices agro-pastoralism and would have preferred more crop-based technologies.

Table 6. Overall rating of KARI-Marsabit's service delivery in terms of cost criteria

	Marsabit ASDSP launch		Lodwar KPW		Garissa ASK show	
Level of satisfaction	n*	%	n	%	n	%
Satisfied	2	4.8	75	78.1	16	44.4
Somewhat satisfied	13	31.0	11	11.5	6	16.7
Neutral	10	23.8	7	7.3	5	13.9
Somewhat dissatisfied	16	38.1	2	2.1	2	5.6
Dissatisfied	1	2.4	1	1.0	7	19.4
Total	42	100.0	96	100.0	36	100.0

*n indicates number of clients who responded

Most of the clients were satisfied with the benefits (usefulness) of KARI-Marsabit's service delivery, even though this varied within the shows/exhibitions (Table 7).

Table 7. Overall rating of KARI-Marsabit's service delivery in terms of benefits criteria

	Marsabit ASDSP launch		Lodwar KPW		Garissa ASK show	
Level of satisfaction	n*	%	n	%	n	%
Satisfied	24	48.0	90	94.7	32	78.0
Somewhat satisfied	12	24.0	1	1.1	7	17.1
Neutral	9	18.0	1	1.1	2	4.9
Somewhat dissatisfied	5	10.0	1	1.1		
Dissatisfied			2	2.1		
Total	50	100.0	95	100.0	41	100.0

*n indicates number of clients who responded

Areas of improvement on the technologies, products and services

Customers who visited KARI-Marsabit stand in all the shows and exhibitions were in agreement that information dissemination and feedback at grassroots needed to be improved, and the shows/exhibitions to be organised more regularly and for longer duration. Clients in all the shows also agreed on the need to increase dissemination of livestock products value addition technologies (milk, hides and skins). This should be encouraged, as the study by Kuria *et al*. (2013) showed that farmers are more likely to adopt technologies if these are availed to them, and this could improve livestock productivity in the arid northern Kenya.

Conclusions and recommendation

The study shows that clients were generally satisfied with KARI-Marsabit technologies, products and services. Shows and exhibitions provide an expensive and rapid way of disseminating agricultural technologies to a large population in a relatively short time and capturing their feedback on the same, especially in the hard to reach pastoral areas. To increase attendance, deliberate efforts should be made to sensitise the clients on the importance and benefits of attending such events, and especially to encourage women to attend. Future studies should investigate the effectiveness of exhibitions as a means of disseminating agricultural technologies in pastoral areas, and the extent to which the disseminated technologies impact on the clients.

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Pastoralism in Kenya and Tanzania: Challenges and opportunities in animal health and food security

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Abstract

Pastoralism is used to describe a society that derives majority of their food and income from livestock. This form of farming system is largely practiced in the arid and semi arid land (ASAL). It is estimated that 70% of the landmass in the horn of Africa is dry land; in Kenya 80% of the landmass is classified as ASAL, while approximately half of Tanzania consists of dry land. These dry lands support wild resource harvesting, tourism but most importantly livestock rearing. It is estimated that over 75% of cattle herds in Kenya and 90% in Tanzania are kept by pastoralists who supply the bulk of meat consumed in the countries. In this paper we present current animal health challenges and opportunities being faced by pastoral farmers in Tanzania and Kenya based on primary data collected in Kajiado county, Kenya and Tanga and Morogoro regions in Tanzania. In the midst of many challenges and opportunities, food safety and food security are never assured amongst the pastoralists. We highlight pastoral community high livestock dependency for food and income, market access to livestock products, access to animal and human health services, livestock-wildlife interaction, factors that hinder increase of livestock assets and explore the knowledge of disease and exposure to zoonosis within the pastoral community.

Introduction

Livestock are an important food security source to the pastoral community and will remain to be so in the many years to come (Hesee and MacGregor, 2006). Amongst this community, livestock is a form of savings as well as financial capital for cash and socially it is the basis of wealth description (Aklilu and Catle, 2010). Animals are a source food (e.g. meat, milk) does provide high quality protein with essential amino acids that are highly bio-available in these food products compared to those from plant sources and is highly liked and valued among the pastoral communities (FAO, 2011).
Opportunities for pastoral farmers immensely depend on the livestock assets that they own. However, they do also face social, economic and environmental challenges that hinder their capacity to harnessing these opportunities. Animal diseases, inaccessible animal health services, erratic weather patterns and high number of dependents are among the major constraints to pastoralist. Endemic diseases that affect production are one of the major challenges faced by pastoralists and they hinder the growth of livestock assets thus reducing the animal product harvested for both domestic consumption and commercial use, and limit the safe utilization of animal products.
The objective of this paper is to describe the challenges currently being faced by pastoralist and to discuss opportunities available for these farmers in Kenya and Tanzania.

Material and methods

This was a cross-sectional study among pastoralist communities in Kajiado County (Kenya), and Tanga and Morogoro regions (Tanzania). A structured questionnaire was administered to 177 pastoral cattle farmers with a focus on animal management practices, knowledge on animal health and zoonosis and access to animal and human health services. In addition, the study did also investigate the socioeconomic status of the farmers, including the farmers' level of dependency on livestock vis-a-vis other economic activities.

Results

Pastoralist in both countries depend largely on livestock for survival as a regular source of income and source of food, with 37% (n=65) of the interviewed herd owners declaring total dependency on cattle rearing for livelihoods. In spite of the high dependency on livestock assets, animal diseases remain one of the major constraints in pastoral areas; tick borne infections and trypanosomiasis were listed as leading endemic diseases in Kenya and Tanzania respectively. Pneumonic condition, mastitis and abortions were also among conditions highly mentioned that impede growth of livestock assets. Tick control in the herd is primarily the farmers' responsibility in both countries (i.e. government does not conduct tick control campaigns) and 99.4% (n=176) of farmers declared practicing tick control on their cattle herds, with hand spray being the most commonly method used (67.3% of all respondents). Despite 45.2% (n=80) of the pastoral farmers confirming that they apply acaricide once a week on their cattle, tick borne infections were listed as the most common disease conditions affecting the herd.

Access to quality veterinary services is a challenge in pastoral areas; most government veterinarians (i.e. local veterinary services) whom the pastoralists look up to for help and advice are not easily accessible, and this gap is not filled by private animal health practitioners, who are unavailable in pastoralist areas, as a result, 91.53 % (n=162) of the respondent declared they do administer veterinary drugs by themselves. The relatively frequent presence of veterinary drug stores (Agrovets) has enhanced accessibility of veterinary drugs among pastoral farmers, but professional advice on drug administration was largely lacking. Inconsistent vaccination regimes to the common livestock diseases, inaccessibility of professional advice from extension workers and constant interaction between livestock and wildlife animals are some of the other factors that seem to have enhanced the prevalence of livestock diseases.

Practices that promote transmission of zoonotic disease from animal to human were found to be common among pastoral communities in the study. 77.97 % (n=138) reported to consume raw milk and milk products, while 25.42 % (n=45) indicated to consume milk from cows that are sick and under medication. Forty nine percent (n=88) of pastoralist will consume an animal that dies in the farm, while 22% will call in the local butcher to buy the animal/carcass who will eventually sell the meat to other members of the community, potentially enhancing transmission of zoonotic infections and the risk of consumption of meat with veterinary drug residues.

The availability of weekly animal market days within major Townships in pastoral areas offers constant marketing avenues for live animal from pastoral farmers; these markets are also the main source of replacement stocks and breeding animals. Despite having almost constant milk production amongst pastoral dairy herds with its peak during rainy season, marketing opportunities and channels for this produce are not well defined. Less than 1% of the pastoral farmers stated selling their milk to milk processors and only 15% sell to milk vendors who eventually sell it to neighboring township as raw milk. The majority of pastoralists consume in the family all the milk produced by their animals either as raw milk or processed as fermented milk or ghee. Milking and milk marketing activities remain majorly a task of women among pastoralists.

With high numbers of mixed animal species in the livestock herds of pastoralists, the quantity of manure available in most cattle bomas is immense. However, only 5% of the pastoral farmers (primarily those living close to crop farmers) did indicate to sale the manure, while 28.5% who practice agro pastoralism use this animal product in their own farms.

Discussion and conclusion

The findings of this study do indicate that pastoralists in Kenya and Tanzania are facing serious challenges in managing their livestock assets. With the observed increase in human population within the region, the demand for animal protein source is also on the rise and pastoral areas are looked upon to continue supplying the ever increasing demand for animal products especially the red meat. The enormous challenges in the pastoral areas requires multifaceted approaches from

relevant stakeholders and more so encouraging public-private partnership investments in the animal health sector within the pastoral areas to build capacity and enhance animal management skills.

Diversification on economic activities, with more focus on marketing of other livestock products like manure and milk will significantly reduce over dependency on sale of live livestock to meet basic family needs. Social transformation of the pastoralists, especially by capitalizing on women through capacity building on clean and consistent milk production, marketing and processing will create more interest from milk processors and upscale milk collection, hence improved returns from milk sales. To ensure sustainable food safety and security, functional extensional services in ASAL areas must be enhanced.

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ABSTRACTS

Poultry's Potential for Livelihood Improvement in Pastoral Households: Evidence from Tanzania

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Poultry production has the potential to provide an important nutritional and financial resource for households throughout the world. Flocks of chickens can be raised simply and inexpensively, providing access to animal-source protein in eggs and meat and a source of income through the sale of eggs, meat, or birds. Importantly, women, who in many societies allocate more resources to pro-household ends such as health and education, tend to control the production and use of poultry products and revenue. Recognizing this, many governmental bodies and NGOs are promoting the production of local poultry as a way to combat poverty for villagers. While there are many similarities between village and pastoral households, there are also some important differences. We investigate the production of chicken and chicken products in pastoralist households in rural Tanzania. We examine differences in characteristics and outcomes for households that do and do not raise poultry, including such important development-relevant results as nutrition status of women and infants, school attendance, and dietary diversity. We also study constraints to poultry production among households that do raise chickens, including disease burden and predation. Low investments in vaccination for high-risk chicken diseases hint at the complexity of the choice environment, indicating a need for human capital development and training. Evidence from our on-going work with pastoralist communities in Tanzania suggests that poultry can play an important role in improving lives, provided that the proper combinations of human capital and health infrastructure exists.

The effects of climate variability on *Prosopis juliflora* spread, vegetation trends and livestock dynamics in the drylands of Kenya

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The effects of climate variability and *Prosopis juliflora* invasion on pastoral livestock production and pastoral livelihoods have not been assessed. A study was conducted to determine the effect of climate variability and *Prosopis juliflora* spread on other vegetation trends and livestock population dynamics in Kajiado County, Kenya. The effects of climate variability on the spread of *Prosopis,* vegetation dynamics and livestock populations were analysed. Monthly mean temperatures and total monthly rainfall amounts over the last 20 years varied widely, with mean temperatures ranging between 28^0C to 40^0C and total monthly rainfall amounts ranging from 0mm to 213mm, respectively. Cattle population decreased from 7,200 to 2,100 between 1990 and 2013and sheep and goats' population increased from 14,000 to 20,000 in the same period. Climate, vegetation, and livestock population trends are analysed over the study period. Dry season vegetation and *Prosopis* NDVI trends, derived from MODIS 250m satellite imagery (2000-2014) were developed. Prosopis clusters, participatory mapped with the help of the local informants were used to isolate the Prosopis NDVI from the other vegetation. There was association between climate variability, *Prosopis* invasion and livestock population dynamics. Correlation coefficients for *Prosopis* spread against shoats are 0.2 and 0.3 and coefficients for *Prosopis* spread against rainfall were 0.4 and 0.2 in Olkiramatian and Ngurumani respectively. The rate of spread of *P. juliflora* was highest when

rainfall was most erratic. Changes in land cover types and soil types were directly associated with the spread of *Prosopis* while specific areas likely to attract next spread of *Prosopis* were identified. Overall rainfall was highly variable in amounts, with declining trends; and the mean temperatures increased over the years of the study period while vegetation cover declined, especially during the long dry seasons. At the same time, *Prosopis* cover, sheep and goats populations increased while cattle populations declined.

MARKET ACCESS: OPPORTUNITIES FOR ENHANCED ACCESS TO LOCAL, REGIONAL AND GLOBAL MARKETS

Opportunities for enhanced access to local, regional and global markets

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Abstract

Almost 33% of GDP of sub-Saharan African (SSA) countries come from Agriculture. Transforming agriculture from subsistence to market oriented and consequently realization of industrialization is direction of African development. In addition to crop farming, Livestock production and marketing in SSA countries is becoming among critical area of attention in African development. Africa imports livestock products mainly from developed countries with less than 5 % import from countries within Africa. The comprehensive African Agricultural Development Program (CAADP) developed by the will of African leaders gave high emphasis toward improving market access for SSA agricultural Products. The tariff and non tariff barriers (NTB) (Sanitary and Phytosanitary requirements for animal products, subsidies, etc) from developed countries together with the poor infrastructure and agro-processing industries in SSA countries hamper competitiveness of SSA animal origin products in the international markets. The huge opportunity for SSA countries is to focus on Intra regional trade in Africa until the SPS requirements of developed countries could be fulfilled. However, with the commitment of African politicians second phase of CAADP showed determination to move from rhetoric to action, where countries are requested to abide with Maputo declaration of investing at least 10 % of GDP on Agriculture, allocate at least 1% of GDP on research, maintaining at least 6% annual agricultural growth and strengthen the regional development communities (SADC, EAC, ECOWAS, COMESA, IGAD, etc).

Importance of markets in the livelihood strategy of most rural households in SSA

Most of rural households have diverse livelihood strategies, encompassing a range of activities that enables households seek to ensure their food requirements and to generate the income. Establishment of efficient and well-functioning markets and trade systems that keeps transaction costs low, minimize risk and extend information to all players is vital. Rural income would substantially increase if there is market oriented production with intensification of agricultural production systems, increased commercialization and specialization in higher-value products.

There are cases where market glut happens and discourage farmer's decision to produce in the following year. For instance, effect of Sasakawa global increased maize productivity and absence of market together with climatic variability led to hunger in the following year in Ethiopia. Similarly, there is excess maize production in Tanzania that needs to be converted into animal feed to value add and provide market for maize. The excess supply of milk during rainy season and scarcity of the same during dry season in Kenya and Tanzania is another area of market problem. Such variability in supply of animal origin products demands for agro-processing industries. Hence, efforts in enhancing productivity alone are not sufficient to bring sustainable economic growth unless the surplus produce get market at the right time, price and place.

Market access difficulty as livelihood challenge for rural households

Limited all weather roads and communication services characterizes rural settings of most SSA countries. The issue of market access may usefully be considered according to three dimensions: physical access to markets; structure of the markets; and producers' lack of skills, information and organization. Farmers in the rural areas have difficulty to access markets because of remoteness of their location that limits market oriented production, reduced farm gate prices and increase input cost; and restricts opportunities for income-generation. In addition lack of effective cooperative organization subjects the farmers to be exploited by those brokers and traders.

Difficulty in accessing developed countries market and intra-regional trade barriers

Quantifiable tariff barriers aren't the only hurdle for developing country exports. The presence of NTBs can undermine the gains from trade liberalization (decline in tariff) for new entrants and constrain diversification efforts, across products as well as markets. The SSA least developed countries are the most exposed to non-tariff barriers such as animal health standards, food safety standards, environmental certification and other such export quality standards.

Some NTBs are an unnecessarily restrictive non-tariff measure (NTM) which affects trade in goods. While other NTMs may reflect legitimate public health concerns, others more strategic regional or national developmental objectives. The SSA countries except Namibia and Botswana fail to comply with NTB in EU markets.

Among the regional community development's the NTBs measurement for South Africa shows SADC member countries couldn't comply with stringent compliance of NTB. Though measuring impact of NTBs is difficult; based on the available data, the quantitative analysis reveals that NTBs applied by South Africa have a more significant negative impact on imports from SADC than Botswana and Namibia (non-SADC). Botswana agriculture contributes less than 2% of GDP, yet they give emphasis to livestock export. Potentially problematic barrier for importers and exporters in SSA are NTB that fall within the following categories: price controls; quantity restrictions; sanitary and phytosanitory (SPS) and miscellaneous, such as other charges intended to protect local industry and/or encourage local processing and Sanitary and Phyto-sanitary (SPS) measures (for plant and animal imports) require countries to base their regulations on international standards.

A number of areas are mentioned as requiring closer regional cooperation and harmonization of rules and regulations including: competition policy; protection of domestic industries; SPS/TBT; rules of origin; and customs procedures. Despite room for (policy-induced) improvements in market access, the (economic) remoteness of many SSA countries remains an important burden on their economic development prospects. Alleviating this burden by investments in (cross-border) infrastructure or improving international cooperation among SSA countries, is an important way to stimulate economic development across the continent.

Africa remains a net importer of livestock and livestock commodities, spending USD 3.6 billion of scarce foreign exchange on imports of products that could well be sourced from within the continent. SSA exports to the ROW are dominated by natural resources (for more than 75%). The fact reveals that market access to the ROW for SSA manufacturing products is not significant. It can also be taken as an indication that, to date, most SSA manufactures are not yet finding their way to markets outside the (sub) continent.

Trade distorting subsidies and protection of domestic markets in OECD countries

Developing countries generally have low levels of domestic support and export subsidies, reflecting both budget constraints and a more neutral policy stance in terms of supporting this sector of the economy. Moving forward on decoupling of domestic support from production and eliminating export subsidies is very important. Reductions in production subsidies and elimination of export subsidies in OECD countries are necessary, although not sufficient, for developing countries to reap significant gains from the current WTO negotiations on agriculture.
The weighted average tariff imposed by developed countries on LDCs export, notably agricultural goods increased from 5.4 % in 1990 to 8.9 % in 2002, mainly an increase in agriculture tariff from 3.3% to 6.6 %. On the other hand EU export of agriculture goods from other developed nation declined from 7.9 % in 1990 to 4.6% in 2002. Because of about 1.2 % of GDP agricultural support by EU, mainly through output payment or direct price support; OECD farmers receive price about 30 % higher prices than world price (Ingo and Nash, 2004)[4].

Inconsistency of supply of animal origin products constrain development of processing industries in the continent

[4] Ingco, M.D., Nash, J.D., 2004. Agriculture and the WTO. The World Bank, Washington, DC.

The existing medium scale processing plants, lack consistent supply of raw milk in the desired quality and operate well below the installed capacity (an average of 25%). There is little effort to integrate good practices in milk production and collection. Most processing facilities in SSA have not established modern food safety/quality management systems, unlike some similar establishments in the region, which have full-fledged HACCP based food safety/quality management systems and efforts are underway to introduce GAP in local food supply chains.
Smallholder dairy cooperatives are collecting milk from members, bulking and cooling it before selling it to the large scale dairy processor. Some cooperatives go even further and have established full scale dairy processing plant before delivering the milk to the retail market. Establishing linkages with centralized food processing units is crucial in production and marketing of livestock products. The alternative to setting up producer owned enterprises is to forge partnerships with the existing food companies. Central processing plants such as Inyange dairies in Rwanda are not formally linked to producers. Supply of raw materials is through informal channels and is often not in adequate quantities or quality. Such high operational costs usually force processors to squeeze producers to the lowest prices.

There is an opportunity for small scale producers to establish formal business relationships with private companies. The major constraint faced by medium scale processing establishments is the weak linkage between producers and processors. An example is drawn from the dairy sector, where milk production is largely by disorganized small scale producers, who have no formal relationship with the processors, resulting in unreliability of supply in terms of quantity and quality.

Current macro-trends and opportunities for African livestock sector

Accelerating national, regional, continental and global demand for red meat, where by 2020 livestock will produce about 30% of the value of global agricultural output. There is currently significant increased political will to improve livestock marketing as a strategy for poverty eradication, globally and in East Africa; compounded by recent increased government investments in market infrastructure. Utilize the untapped local/regional markets through comparative advantage and providing incentives to the markets. The key point is that these producers are undergoing a transition from producing animals to sell in time of need, to a desire to produce animals for best return. Thus production will increasingly be driven by market signals.

Commercialization of the smallholder livestock farming systems

Large scale commercial farming is at present only producing a minor share of the food for consumption in urban areas in most African countries. The landholding structure, dominated by many smallholder farmers (in millions) is simply the basis for production of domestic food supply and raw material for the industry. The landholding structure is not easy to change and the smallholder farming community will, at least in the immediate to medium term perspective, continue to be most important for supplying livestock products for domestic consumption – and eventually for regional export.

Development of the dairy sector in Kenya and Uganda over the last 40 years is excellent examples of such a process. Commercialization of the smallholder agriculture can create job opportunities along the value chain and many of them will be outside the farm and away from the primary agricultural production. The change in priority from household consumption to production for the market is a difficult transformation against the traditions of the rural population.

However, it is already happening at different regions (milk production in Kenya and Uganda are good examples) and this process of change can be enhanced by focused interventions; which demonstrate to the smallholders that livestock farming for the market is good business that will provide them with more income and security than the traditional production system. Investment in higher productivity has to be supported by intervention for a more effective value chain for the marketable products to: i) ensure market access/ availability; ii) ensure a fair share of product/ commodity value goes to farmers/producers; iii) ensure transparency in price and market through provision of market information.

Public support to ensure active inclusion of smallholders in economic growth

For smallholders to participate and benefit from market oriented production it is a must that they organize. Farmers' associations and cooperatives help to bulk (create volume) and can be involved in some kind of processing and adding value to get the maximum income before passing on the product to other stakeholders along the value chain. The rural population and the smallholder farming community are less educated and have low capacity for planning and making economic calculations/decisions necessary in commercial/market oriented farming. It is the responsibility of the public sector to ensure that the smallholder farming community is getting this capacity – preferably through the farmers own organizations with public support (training).

On the other hand, the following issues are important to consider

Commercialization and increased productivity will naturally, over time, increase land holdings (consolidation of land holding) – the most efficient smallholders will acquire more land and livestock and the less efficient will sell and leave agriculture for other employment. More productive agriculture will of course need fewer people to produce. Commercialization of the smallholder production system will create employment opportunities for those who will leave the primary agricultural production; he increased production and productivity will reduce transaction costs per unit through the value chain; and finally; the capacity building will provide the industry with raw material of better quality.

CAADP pillar 2 about commitment for mobilizing political will at continental and country

As a common framework for agricultural development and growth for African countries, CAADP is based on: the principle of agriculture-led growth as a main strategy to alleviate poverty; where investment in agriculture showed 11 times better in economic growth contribution over other sectors; the pursuit of a 6 % average annual sector growth rate at the national level; where only few countries implemented the Maputo declaration like Ghana, Ethiopia and Burkina Faso. In the allocation of 10 % of national budgets to the agricultural sector; only few countries allocated (e.g. Ethiopia allocated 15%).

The exploitation of regional complementarities and cooperation to boost growth; a lot is expected still in terms of infrastructure, intra regional trade, the principles of policy efficiency, dialogue, review, and accountability, shared by all New partnership for African Development (NEPAD) programs; the principles of partnerships and alliances to include farmers, agribusiness, and civil society communities; and implementation principles, which assign the roles and responsibilities of program implementation to individual countries, coordination to designated regional economic communities (RECs), and facilitation to the NEPAD Secretariat.

Key Pillar Strategic Areas :- Actual implementation of the agenda under Pillar II is to be carried out through the following main clusters of activities, or strategic areas, guided by the vision described: *Area A:* raising competitiveness and seizing opportunities in domestic, regional, and international markets; *Area B:* investing in commercial and trade infrastructure to lower the cost of supplying domestic, regional, and international markets.

Linking famers to high value livestock product markets in southern and eastern Africa: Opportunities and challenges

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Summary

Livestock is an important part of Africa's solutions in addressing its challenges related to food and nutritional insecurity, and poverty. Linking farmers to dynamic high value agricultural commodity markets through trade is viewed as important

for economic growth and poverty reduction in a global economy. Yet, many factors on both the supply and demand sides combined with protective trade policies and stringent traceability requirements in global value chains hinder broad-based participation of many smallholder farmers in Africa, which currently is estimated to account for barely 2% of global business in livestock trade annually. We highlight trends, challenges and opportunities and draw lessons using examples from two beef value chains in Southern Africa targeting extra-regional, mainly European markets, and emerging intra-regional trade in milk and milk products in East Africa.

Namibia and Botswana's beef exports to the European Union (EU) market present interesting cases of mixed success stories. As a small country, Namibia has consistently met high EU market quality and food safety requirements. With a smart marketing strategy Namibian beef exporters changed from selling a beef commodity product to selling key quality attributes in premium niche markets in the EU. On the other hand, Botswana's meat exports have suffered setbacks linked to traceability and animal disease threats that undermine its consistency as a meat supplier. Has their focus on the EU market undermined potential benefits from the growing regional markets?

Trade in milk and milk products in eastern Africa provide an example of emerging intra-regional trade in livestock products. Analysis of trends in dairy production and trade shows that currently, even though only less than 1% of total dairy production is traded, only 11% of the traded products originate from within the region. The underlying reasons for the low trade volumes include: dominant small-scale production; growing local/domestic demand; consumer preference for liquid raw milk over processed milk products, the high perishability of milk; and, the high cost of transforming milk to easily traded products such as powder. However, low production costs and business factors suggest the industry has strong export potential.

ORALLY PRESENTED

Sheep market integration in the pastoral and agro-pastoral communities of Ethiopia

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Abstract

This study examines the existence of the spatial market integration of the different pairs of sheep markets in the Central Rift Valley of Ethiopia. Using modern time series econometric techniques uncovered compelling pieces of evidence of strong steady state linkages of the various pair-wise combinations of the sampled CRV markets, with only an insignificant few segregated routes. The main conclusion of the study is that despite the geographic segregation of the sheep markets and the presence of fragmented and often inefficient distribution system, price signals and other market information are transmitted efficiently across the markets, thus negating the potential occurrences of unexploited arbitrage opportunities. Research on sheep price determinants in Central rift valley remained very limited. This study examined sheep price paid and offered price *visa vise* factors underlying price variations determinants. Based on their importance of sheep marketing sites, four markets from CRV were selected. The markets were surveyed on the main weekly market day for a period. Data were recorded on price, weight (kg), sex, age, color, body grade, buyers' purpose, buyer's type and sellers at the market spot transactions. A total of 550 observations were recorded. Econometric model and descriptive analytical methods were used for the analysis based on live weight price paid and offered. The results showed that there was a considerable factors variation throughout the sample markets in price paid determinants.

Keywords: Price integration, Spatial transmission, Granger causality

Introduction

Small ruminants are an integral part of livestock keeping in Sub-Saharan Africa (SSA), mainly kept for immediate cash sources, milk, meat, wool, manure, and saving or risk distribution (Kosgey, 2004). They are also sources of foreign currency (Asfaw, 1997; Berhanu *et al*., 2006). Moreover, due to their high fertility, short generation interval, adaptation to rain scanty environment and their ability to produce in limited feed resource they are considered as investment and insurance (Asfaw, 1997; Tsedeke, 2007).

Sheep contribute importantly to the GNP and welfare of individual animal owners. Sheep kept by small holders in Ethiopia are a major source of food consumption and cash income. In addition, to providing income from regular sales, sheep are ready saleable assets and can be traded for grains in time of shocks. Lambs can be sold at about one year of age if reasonably well managed and can provide quicker returns than obtained from the cattle (Wanger, 1986).

Measuring spatial price linkages of commodity market in developing countries of Africa has received much attention in the literature because of its implications for food and commercial markets. Competitive market equilibrium under well-known conditions in Pareto efficient and this extends to competitive market equilibrium when trade occurs between markets at fixed transport costs (Takayama and Judge, 1971). Property of competitive spatially equilibrium is characterized by the law of one price (LOP): if trade occurs between two markets, the price in the importing market equals that in the exporting market plus transport costs and the two markets are spatially integrated. However, existence of spatially integrated markets not necessarily implies the Pareto efficiency. Nevertheless as Ravallion, (1987) notes, 'one can be interested in testing empirically for spatial integration, without wishing to rest the case for or against Pareto optimality outcome. Measurement of integration can be viewed as basic data for an understanding of how specific markets work.' The objective of the current study was to evaluate sheep spatial market integration in Central Rift Valley of Ethiopia.

Methodology

Correlation coefficients
Correlation coefficients of real price changes of market pairs were estimated by

$$r_{ij}=\frac{\Sigma(\Delta P_{i,t}-\Delta\bar{p}_i)(\Delta P_{j,t}-\Delta\bar{p}_j)}{[\,[\Sigma(\Delta P_{i,t}-\Delta\bar{p}_i)^2][(\Delta P_{j,t}-\Delta\bar{p}_j)^{1/2}\,]\,]}$$

r_{ij} is the correlation coefficient of market price between the two markets, ($0 \leq r_{ij} \leq 1$).

Unit root tests
Augmented Dickey Fuller (ADF) test
The general form of this test's regression was:

$$\Delta P = \alpha + \beta_t + (\rho-1)\, P_{t-1} + \sum_{i-1}^{n} \gamma_i \Delta P_{t-i} + \varepsilon_i$$

Result and discussions

Correlation Coefficients
The ewe and ram was estimated using simple correlation coefficient. Six pair correlations were tested. Spatial sheep (ewe and ram) market pairs where identified by their levels of strength (i.e. strong, moderate, and weak), significant at real price exchanges (Table 1). In accordance with this analysis, Werer-Awash and Werer-Addis ketema markets were moderately integrated with 0.64 and 0.56 respectively in grade fat types while the rest indicates weakly integrated including the moderate grade. The least correlation coefficient was recorded at Awash-Adama with moderate grade recording (0.31) followed by the Addis ketema–Adama at (0.41) with the same grade (body condition) which is a weak correlation (r<0.6) but positively correlated.

Table 2. Correlation coefficient of ewe grades of body conditions

Markets Market exchange price	Ewes fat	Ewes moderate	Ewes thin
Werer- Awash	0.64**	0.50*	0.59**
Werer-Addis ketema	0.56**	0.42*	0.69**
Werer-Adama	0.54*	0.53*	0.13
Awash -Addis ketema	0.44*	0.31*	0.76**
Awash –Adam	0.46*	0.52*	0
Addis ketema-Adama	0.46*	0.41*	0

a: Correlation coefficients among different literature are strong (r>0.8), moderate ($0.6 \leq r \leq 0.8$) and weak (r<0.6).*: correlation is significant at 0.05 levels.**: correlation is significant at 0.01 levels. Source: price data computed, 2008-2012

Causal test OLS
H_0= all coefficient of lag of P_{ij} are equal to zero.
H_1= Coefficient of lag of P_{ij} are different from zero.
There is reasonable justification that Granger-cause of Werer ewe with grades of fat market on Adama market with significant cause effect to price at lag 4 with (1%) having the adjusted R squared value of 0.68 explaining the effect with the rejection of the null hypothesis, while the vice versa with lag two at the significant level of (5% and above) Adama cause effect on Werer with 4.30 F-value so the causation is a feedback from the two markets at (5%) with strong Granger cause from the former. Addis ketema market had weak influence (P<0.1) on the Adama market (Table 2).

Table 2. Granger causality test of ewe grades of fat OLS
*[2], *,** = causality is significant at P<0.25, 0.05, 0.01, respectively. Source: price data computed, 2008-2012

Market pairs	Lag length	Causality (F-value)	P>F	Adj R-squared	Market pairs
Adama- Werer	4	5.94**	0.00	0.68	Awash –Werer
Adama-Awash	1	2.43*	0.05	0.66	Awsh -Addis ketema
Adam-Addis ketema	1	1.62*[2]	0.12	0.66	Werer-Awash
Werer-Adama	2	4.30*	0.04	0.93	Addis ketema-Awash
Awash –Adama	1	4.40*	0.04	0.82	Addis ketema-Werer
Addisketema-Adama	1	4.78**	0.00	0.63	Werer-Addis ketema

Unit root test

Order of integration of price

The results of the unit root test show that prices are stationary at different differenced orders integration in Werer, Awash,Addisketema and Adama, which demonstrate that the order of integration in weekly prices is order one, that is I(1) for Awash and Adisketema while I (2) and I (4) for Werer and Adama since the analysis of ADF test statistics greater than the critical values of (1%), (5%) and (10%) of the interpolated Dickey-Fuller in absolute term and the Mackinnon P-value approximates to zero with these the null hypothesis of the unit root rejected in favor of stationarity alternative with the ewe at the grade of fat Table (3).

Table 3. Augmented Dickey-Fuller unit root test for ewe grades of fat

Sample Markets	Lag length	ADF τ -value	Mackinnon P-value	χ^2 @ 10 lags (P > χ^2)	τ -value @D(L)	P-value @D(L)	χ^2 @ 10 lags (P > χ^2)
Werer	2	- 4.26***	0.00	14.47 (0.15)	-3.39**	0.05	7.04 (0.72)
Awash	1	-4.56***	0.00	25.26 (0.01)	-4.17***	0.01	24.15 (0.01)
Addis ketema	1	-6.44***	0.00	22.20 (0.01)	-4.38***	0.00	8.66 (0.57)
Adama	4	-6.56***	0.00	28.90 (0.00)	-5.71***	0.00	14.99 (0.13)

Note: lag length was determined based on the significance level of the lag structure ***, ** and * indicate significance at 1 %, 5% and 10% respectively, τ -value in the parenthesis,

χ^2 = Durbin's alternative test for serial correlation, the values in the parenthesis show the significance level to reject the null hypothesis (Ho: No autocorrelation).

Source: price data computed, 2008-2012.

Co-integration test

Results of the Engle-Granger cointegration test (EG)

A linear combination and the left side will be stationary. ε_t will be the deviation from the long run equilibrium of the sheep price variable and is called "equilibrium error". Testing for cointegration is about finding this cointegration vector. By assumption for instance the price of Werer and Awash markets will have one cointegrating vector.

$\beta P_t = \varepsilon_t$Ó

As shown below (Table 4) the result of the ADF unit root tests of the residuals at test statistics with comparison to the critical values of (1%), (5%), (10%) respectively and considering the Macknnonian p-value to the test statistic after the OLS regression of the EG test involving the different market pairs. The table reveals that out of the 12 possible pairs, all routes produced stationary residuals at (1%) significant level for co integration.

Table 4. Engle-Granger co-integration two step OLS and unit root grade of fat

Sheep	Markets	Werer	Awash	Addis ketema	Adama

Ewe	Werer		-3.14**	-4.05***	-3.62***
	Awash	-4.26***		-4.23***	-4.53***
	Addis ketema	-6.15***	-5.43***		-6.15***
	Adama	-4.26***	-5.31***	-5.78***	
Ram	Werer		-4.48***	-6.07***	-5.29***
	Awash	-4.95***		-5.32***	-5.33***
	Addis ketema	-7.21***	-6.09***		-6.57***
	Adama	-7.17***	-6.81***	-7.25***	

***, ** and * indicate significance at 1 %, 5% and 10%, respectively.
Source: price data computed, 2008-2012.

The symbols exhibited in the (Table 5) are the causality directions of the market. For instance, a symbol => means that the information provided by the row market contribute in the price formation in the column market. A symbol <= on the other hand, suggests that the column market is the one providing the information for the formation of prices in the row market. When the symbol <=> is noted for the market pair, the conjecture is that there is some sort of feedback statistical causality between the paired market. Finally, the empty space implies market pair to be non-integrated or non-causation to each other's.

Table 5: Causality directions of linked markets based on results of Granger Causality Test

	Werer	Awash	Addis ketema	Adama
Werer		<=	<=>	<=
Awash			<=	<=>
Addis ketema				<=>

Note: => means the row Granger cause the column price formation..
<= means the column Granger cause the row price formation.
<=> price Granger cause feedback each other. Source: price data computed, 2008-2011.

Conclusion and recommendation

The primary result of the study is the empirically determined high level of spatial market integration of the inter-market sheep prices. Out of the twelve possible sample market pairs, using Granger-Causality Wald test using VAR model for cointegration showed statistically significant level of spatial integration except Werer-Awsh, Werer-Adama, and Awash Addisketema for ewes with grades of fat yet it is verified with other test the significant integration spatial market prices with results of the three empirical procedures confirming each other's results.

In the long run, substantial investment in transportation system is required to improve the integration of markets. Market integration will play a crucial role in improving the food security situation of the region, which account for the highest number of meat deficit district in the country. Price increases due to supply short falls in the region could be reduced by market integration which would therefore mitigate the negative effects on household food access.

In the case of the interregional market for sheep in the pastoral community of Ethiopia, the study uncovered the existence of a high level of spatial integration. Higher than 95% of all market pairs have long-run equilibrium price linkages, and that short-run deviations from equilibrium will readily be corrected through the efficient transmission of price setting information. The results shown in discussion part dictate the Law of One Price was found in operation in the inter-market sheep price for different body condition category for ewe and ram. For the sheep traders to take advantage of the high level of spatial market integration, the problem of the highly inefficient and fragmented distribution and transportation systems must be addressed with market information backup systems.

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Dairy ration formulation technology in Kenya: The voices of the stakeholders

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Abstract
An interview tool on dairy ration formulation technology was administered to dairy stakeholders in three prominent dairying districts Nairobi, Nakuru and Thika in Kenya. The objectives were to: analyse the challenges and opportunities in commercial feed manufacturing in Kenya; determine the current role of feed additives in dairy feeding; identify ration formulation computer packages currently in use; evaluate challenges and opportunities for up-scaling and commercialization of proven formulated dairy feed rations and explore the possibility of establishment of feed analysis centres. The challenges of commercialization of formulated feed rations included scarcity and high cost of ingredients. The opportunities included the large feed markets; well established ingredients supply chain and readily available technical support. Feed additives were available but few dairy farmers, rearing high producing dairy herds, benefited from this technology. There was no uniformity in approach and choice of computer software leading to their complexity. Stakeholders were enthusiastic on commercialization of formulated feed rations. They had capacity in training, essential capital and accumulated experience in financing the industry. Essential tools and equipment for field operations could efficiently and cost effectively be fabricated. Building capacity in feed analysis at the existing laboratories spread out in various dairying areas was the most viable approach. Simple ration formulation computer software should be developed, tested and users trained. Commercialization of feed rations is viable in Kenya as large feed markets, training capacity, financial credit; technical support and established ingredients supply chain exist.

Keywords: Computer packages, Commercialization, Dairy, Ration, Stakeholders

Introduction

There are many opportunities in the Kenyan feed industry. These include the potential large feed market, wide choice in ingredient sources and established ingredient supply chain. The feed industry is well established and there is readily available technical support in feed formulation and additives. Kenya's well established dairy industry requires manufactured feed to maintain its leadership in the East African Region in volume of milk produced annually. There is heavy investment in farmer education by private and public institutions to enable efficient and competitive dairy industry.

The current study involved administration of an interview guide to Stakeholders and Collaborators in Nairobi, Nakuru and Thika. The objectives of the study were to: analyse the challenges and opportunities in commercial feed manufacturing in Kenya; determine the current role of feed additives in dairy feeding; identify ration formulation computer packages currently in use; evaluate challenges and opportunities for up-scaling and commercialization of proven formulated dairy feed rations and explore the possibility of establishment of feed analysis centres.

Confidentiality in individual source of information was observed to the extent possible without making the study vague and the information was used only for research purposes. Privacy of individuals and institutions was maintained and the authors had no vested interests in this piece of research.

Materials and Methods

An interview guide in line with the study objectives was developed, tested and administered to dairy stakeholders in three prominent dairying districts, Nairobi, Nakuru and Thika in Kenya in order to obtain the necessary data according to Farming Interview Guide (htt://www.hcd.org). The interview guide was administered to stakeholders by scientists from Kenya Agricultural Research Institute (KARI). These stakeholders included: University of Nairobi (UoN), Egerton University (EU), Kenya Bureau of Standards (KEBS), Ministry of Livestock Development (MoLD), Headquarters, Feed Manufacturers, Feed Distributors and Agro-vet Stockists, Kenya Industrial Research and Development Institute (KIRDI), Milk Processors, Credit Providers and Groups (youth, women, church), Community Based Organizations (CBOs and entrepreneurs), Farmer Field Schools (FFS) and Cooperative Societies (Co-ops). Additionally, Kenya Bureau of Standards (KEBS), Nairobi and Nutrimix Ltd, Nairobi were involved in interviewed to establish the possibility of adding value to dairy rations through use of appropriate additives (enzymes, Yeasac) and on available ration formulation computer packages, respectively.

These interviews also explored the possibility of establishment of feed analysis centres (in Veterinary Investigation Laboratories (VIL), Agricultural Training Centres (ATC), college Laboratories) located in dairying regions across the country. Establishment of entry points for KARI scientists to work with various relevant groups (youth, women, church) on commercialization of formulated feed rations were also determined using the interview guide. The key results of the stakeholder interviews were extracted using Extracting Key Insights (htt://www.hcd.org) within the suit Tools and Tips that will Help You Master the HCD Process (htt://www.hcd.org/methods).

Results and Discussions

Commercial feed manufacturing in Kenya

Challenges: These include availability of ingredients in small quantities and the wide geographic spread. They cause high cost in bulking of raw materials and high transport costs of raw materials and feed distribution. These costs were aggravated by poor quality, high cost of ingredients with wide fluctuation in price and supply. Dishonesty was prevalent in declared quality of ingredients and finished products. Contracting in the cultivation of row materials such as maize, sorghum, cassava and soya bean was difficult due to high incidence of flouting of such contracts. Similarly row material supply contracts were flouted. The scarcity of local ingredients supply caused expensive importation from neighbouring countries including Tanzania and Uganda.

Other challenges included unhealthy competition among feed manufacturers caused by low feed demand compared to the high capacity of the 60 registered feed millers in Kenya. The inadequately informed consumers and service providers e.g. stockists have led to opportunistic investment in feed compounding. For example, although there were 60 registered feed manufacturers in Kenya more than 120 exist. These have caused the existence of unprofitable small operations and feed formulae poaching. Furthermore, the sources of utilities e.g. infrastructure, power source are inadequate and expensive.

*Opportunitie***s:** Numerous opportunities were enumerated by feed manufactures, stockists and service providers. These included the potential large feed market, wide choice in ingredient sources and established ingredient supply chain. There was a well established feed industry in Kenya and readily available technical support in feed formulation and additives. There was a pool of knowledgeable nutritionists in private practice, public institutions and Universities. Alternative feed ingredients were available including cassava, sorghum, lucaenea, Lucerne, maize and copra. The average milk yields of

less than 10 kg daily currently on most Kenya farms could be sustained by replacing preformed protein sources such as cotton seed cake and sunflower cake with use of non-protein nitrogen (NPN) including urea. The current Government policy on expanding irrigated land hectares may contribute to stabilization of ingredient supply, quality and price. The cost of feed manufacturing machinery may reduce as Kenya Industrial Research and Development Institute (KIRDI) was able to fabricate some of the feed manufacturing machinery.

Kenya's well established dairy industry required manufactured feed to maintain its leadership in the East African Region in volume of milk produced annually. There was heavy investment in farmer education by private and public institutions to enable efficient and competitive dairy industry. Such knowledgeable farmers will demand high quality feeds that are regularly supplied according to their production objectives. This will require customized feed formulae to supply the clients according to set standard by Kenya Bureau of Standards (KEBS). Good relationship and trust with dairy farmers will benefit the dairy industry through efficiency and farmer empowerment. Another opportunity to enable commercialization of formulated feed rations was the availability of tailor made credit by financial institutions.

Feed additives: Nutrimix Ltd, Nairobi had franchise for leading European and Israel feed additive manufacturers. Nutrimix Ltd, Nairobi supplied premixes, vitamins and feed additives to feed manufacturers. NOVAS which is another feed additive supplier worked closely with academic staff at Egerton University. They supplied organic acids, biflex minerals, mycotoxine binders and enzymes. While feed additives are available, only a select group of dairy farmers, rearing high producing dairy herds, benefited from this technology. Majority of dairy farmers in the country required to improve their dairy practice before feed additives gain prominence. The feed additives required to meet World Trade Organization (WTO) and FAO Codex and ISO Standards. The convincing benefits of feed additives were discussed using the American and Israel dairy experience and evidence collected during visits to these countries by some of the institutions visited.

Ration formulation software: Nutrimix Ltd, Nairobi routinely provided backup on formulae to the feed industry in Kenya using several softwares. Various softwares were available and in use among the researchers in the Institutions visited including Excel Spreadsheet, PC dairy and Feed Formulator MOF-Dairy Edition (2010). However, there was no unified approach and choice of software as each type met the unique need for which it was developed. Majority of these softwares were complex in operation and information needs for functioning hence not friendly to farm level use. Simpler software needs to be developed, tested and users trained before final commissioning for farm level application.

Up-scaling and commercialization of proven dairy ration options and funds

Youth Groups: The Youth Groups were enthusiastic on commercialization of formulated feed rations. It was felt that the demand was huge springing right from the individual households the youth came from, the existing groups, cooperatives and the community. The Youth were particularly happy on the prospect of use of computer software in ration formulation, its application in feed formulation and the opportunity to provide feed formulae at a commission.

Farmers' Cooperatives: Farmers' Cooperative Societies were already providing formulated feeds and ingredients to their clients and they were keen to join in commercialization of formulated feed. They were ready to formulate their dairy meal with the assistance of KARI as they knew the benefits neighbouring Cooperatives were reaping. They were capable of training their members on the technology and provide loans for its implementation.

Agro-vet shops and Private extension: Agro-vet shops provided formulated feeds and ingredients to their clients and they were keen to join in commercialization of formulated feed. They owned a subsidiaries business, Dairy Farms where they practiced use of formulated feeds in high yielding dairy herd. Agro-vet shops ran private Extension Services on dairy farming and were willing to incorporate feed formulation and its commercialization.

Private entrepreneurs: Entrepreneurs felt that the commercial manufacturers are out of touch will farmers' production situation. They were concentrating on their business profit hence over-pricing compounded feeds. As high yielding dairy herds require well balanced concentrates hence commercial dairying is receiving inadequate profit. The entrepreneurs felt that the Project should target cost effective and readily available formulated feeds. These will receive great success as the current milk price is fairly good and farmers target high milk yielding herds. The high cost of replacement stock has encouraged dairy farmers to feed their current cattle adequately and also rear their own replacements. They recommended the need to induce specialization in dairy production to create efficiency and to vertically integrate feed production, feed processing, dairy production and processing and eventual marketing. These entrepreneurs recommended demonstration of Project benefits with a few carefully selected dairy herds for at least 6 months and use the herds as springboard to reach

wider dairying community. The expansion could use individual dairy herds, existing groups particularly women groups who are well known in financial discipline and can be widely trusted.

Stakeholders: There was consensus among the stakeholders that the Project required to set a strict county and farmer selection criteria that may not be necessarily random in nature. At the onset a few counties and farmers or groups will be selected, intensively trained and supported on the technology and their success replicated later in the counties and among wider scope of farmers and Groups. This is borne out by the introduction of Model Farms in the Ministry of Livestock Development and Brookside Dairies, Ruiru. The model of intensive training spread out during the life of the technology and successful practitioners further trained as Training of Trainers was effectively used in a collaborative project among KARI-Egerton University-Catholic Dioceses of Nakuru.

Financial institutions: The Commercial Bank interviewed felt that the Project addressed real life dairying issues and was a good idea. They were keen to contribute to the success of the project and requested to be involved in the activities of the Project right from the beginning. This will enable the Bank to gauge the creditworthiness of participating farmers and groups early, train them during project events, with subsequent fast tracking of their credit with the Bank. Their experience when loaning in the dairy industry is that feeding the cattle was a big challenge that caused oscillation in milk production and loan repayment. They aimed at evening out loan repayment. Equity Bank ran loan packages to the dairy industry and had accumulated a wealth of experience in financing the industry. The Bank ran training programmes to build capacity of the borrower right from the onset including 8 weeks training on financial management, leadership, record keeping and group dynamics. They ran wide branch network at which preferably two officers had agriculture training and dedicated their time in handling agricultural credit and farmer capacity building. Equity Bank ran credit portfolio for individuals and groups.

Equipment for field operations: Discussions and a tour of facilities at Kenya Industrial Research and Development Institute (KIRDI) convinced us that essential tools and equipment for field operations in the Project can efficiently and cost effectively be fabricated at KIRDI, Nairobi.

Government Extension: The Extension Services emphasised the importance of involving the youth continuously. The technology requires tailor making to match the clients' needs and there was need to induce specialization in dairying. Entrepreneurs were to be encouraged to invest in feed production as commercial enterprise. Possibilities of forming private-public partnerships in livestock feed manufacturing was essential. There was need for efficiency in dairying particularly targeting reduction in feed costs. The Extension was keen to strengthen the use of commercial formulated feeds and search for alternative feeds in dairying. They had national coverage and would include commercial feed formulation in their extension messages to farmers. They were particularly enthusiastic to incorporate formulated feeds in the Model Dairy Farms extension approach currently in force at the ministry. Staff required training on feed formulation including Training of Trainers (TOT) for sustainability.

Feed analysis centres: A consensus was reached that, currently building capacity at the existing Veterinary Investigation Laboratories (VIL) spread out in various dairying areas was the most viable approach. However, additional capacity can be created at selected Agricultural Training Centres (ATC) and Brookside Dairies milk collection centres in the long run. Heavy investment was essential to train laboratory staff on use of modern equipment and computer software. The laboratories at Kenya Agricultural Research Institute (KARI), Kenya Bureau of Standards (KEBS), Nairobi, University of Nairobi (UoN), Egerton University (EU) will remain as reference laboratories. To strengthen this role the laboratory at the Centre of Excellence at Naivasha required additional modern state of the art equipment and staff training.

Conclusions

The Kenyan feed manufacturing industry enjoyed large well established feed market, wide ingredient choices and established ingredient supply chain. There was readily available technical and financial support. The available softwares are complex in operation and information needs. Building capacity in feed analysis at the existing Veterinary Investigation Laboratories (VIL) was the most viable approach. Feed additives were not widely used as majority of dairy herds recorded low milk yield. Stakeholders were enthusiastic on feed formulation and commercialization of formulated feed rations. Training and financing were available to individuals and groups and essential tools and equipment for field operations could efficiently and cost effectively be fabricated.

Recommendations

Simpler software needed to be developed, tested and users trained before final commissioning. Majority of dairy farmers should improve their dairy practice targeting high milk yield. Up-scaling and commercialization of proven dairy rations is an important strategic action for Kenya to maintain its leadership in the East African Region in volume of milk produced annually.

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Commercialization of palm weevil larvae at Mvog-Mbi market in Yaounde, Cameroon

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Abstract

Palm trees are important source of food and commodities in many African countries. However palm tree ecosystems are facing serious threats due to over exploitation of palm wood, wine and edible insects. The palm weevil (*Rhynchophorus phoenicis*) which is among the most consumed species of insects in Africa particularly in Western and Central Africa is a serious pest of palm trees *Raphia* sp and *Elais guineensis*. Both larvae and adults constitute an important source of protein to many communities and its consumption has been reported in more than 10 countries in the Sub-Saharan region. In Cameroon, the trade of *R. phoenicis* larvae is lucrative and is considered as woman business. In the Capital city Yaoundé, where this insect is considered as a delicacy, larvae are shipped from surrounding villages and delivered with raphia or palm fibers as food substrate to keep larvae alive up to 4days. A handful of 0.1L of palm weevil larvae costs 1000 francs (2 US dollars) which is quite a substantial income. Larvae pseudo reared on raphia palms using indigenous knowledge are much more preferred than those from palm oil tree. Although this commerce is still very informal, the value chain involves various actors who control the market between producers in numerous villages and the retailers in the city and since the demand of this insect is extremely high, this business could be associated to a serious threat to palm tree ecosystems in Cameroon. Therefore, in an attempt to conciliate both human interest and environment protection, we suggest a mitigating research programme between the consumption of this insect and the conservation of palm tree ecosystems in Africa.

Keywords: Cameroon, Edible insects, Palms, Trade, Weevils, Women

Introduction

Africa is the most susceptible continent in terms of food insecurity, with around one in four people estimated to be undernourished, and sub-Saharan Africa (SSA) has the highest prevalence of undernourishment at 24.8% (FAO, 2013). The region as a whole is extremely susceptible to frequent food crises and famines that are easily triggered by even the lightest of droughts, floods, pests, economic downturns or conflicts. However, a twin-track approach to reducing hunger and contributing to food security could be resolved by genuine usage of available resources in the sub Sahara humid belt. The rich biodiversity has huge potentials in term of non conventional food resources, mainly in the forest areas where Non forest timbers being exploited are numerous in Congo Basin (Hoare, 2007; Muafor *et al*., 2012).

Tropical palms provide a wide array of commodities in almost all African countries. The list of goods includes roofing, stools and other crafted items such as mats, hats and baskets. Also palm trees offer beverages such as palm wine which is widely consumed in Sub-Saharan Africa. Palm trees including raphia, palm oil trees host a variety of natural insect commensalisms or pests. Among them *Rhynchophorus phoenicis* which is considered as a delicacy for Cameroon rural and urban dwellers (Dounias, 2004; van-Huis, 2005; Muafor *et al*., 2014). This insect is among the top most consumed coleopteran in Africa (van-Huis, 2003; 2005).

Besides the various direct services and goods provided by cultivated or natural managed palms, socioeconomic importance of weevil larvae consumption evaluation could play a critical role for sustainable wide utilization of these resources. However, lack of relevant information for monitoring useful insects is persistently one of the challenges preventing to the take off of their possible domestication (Cicogna, 1992). It is also important to identify techniques of harvesting preservation for safety and sustainable use of this insect. Moreover, since Africa is one of the most susceptible continents to climate change and land degradation, it is of paramount important to find a resilient balance between ecosystem services provided by these palm trees and human use and their goods. The aim of our study was to assess the characteristics of *R. phoenicis* larvae trade in a large city like Yaoundé in Cameroon. We emphasized our focus on the key players involved in the business, the preservation methods and customer's preference.

Materials and Methods

The survey and marketing analysis was built on direct observations in one of the main Yaoundé food market reputed for NTFP products, semi-structured questionnaire and site visits were applied between February and August 2014. All identified palm weevil regular traders were interviewed. Inference environmental assessment on palms ecosystems was derived from our findings.

Results

The Business of palm weevil in Yaoundé

Actors: The main actors in the business of palm weevil include harvesters, secondary collectors, middle women, restaurateurs, ambulant retailers and consumers (Figure 1).

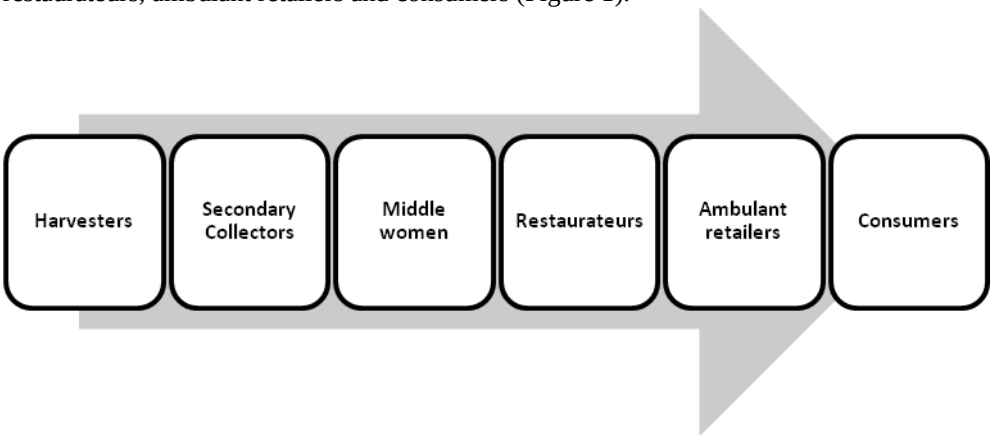

Figure 1. Palm weevil larvae market chain actors in Yaoundé (Mvog-Mbi)

While harvesters and secondary collectors (both men and women) are all based in the rural areas, middle women build their supply networks on 2-3 weekly trips. Alongside larvae, they also collect mainly live African cat fish that they sell in Yaoundé. Sales in the rural villages are made after bargaining and relationships. The freshness, colour, size and motility of larvae are the main price determinants. Origins are numerous, but all connected to Nyong river confluent small rivers or marshy areas where raffia palms grow. The distances vary from 40-120kms from Yaoundé.

Pricing and Preservation: Larvae are sold alive, in a conventional cup of around 0.1L at a flat price of USD 2. Larvae are maintained alive by regular water sprinkling and the sorting of dead or softened individuals. Vendors believe that larvae

will survive in the decaying palm fibres on which the feed for 5-7 days after harvesting. There is no particular arrangement for larvae maintenance.

Customers' preference: According to palm weevil vendors, consumers' preference was for larvae collected on raffia palms than those harvested on palm oil plants. Taste seems so different as well as final cooking aspects. Beside direct consumers buying for home consumption, palm weevil trade in Yaounde involves also professional restaurateurs who include some traditional recipes made up of this insect species in their proposed menu. Ambulant retailers buy palm weevil which they fry and sell in form of a brochette of 4 individual at USD 20 cents. Sales are made alongside the main urban avenues.

Harvesting methods: Weevil harvesting methods are related to palm wine (white starchy moderately alcoholic sap). Adult weevil lays eggs in the wounds made by palm wine collectors. The smell of decaying palm fibres and noise made by larvae (one should place his ear on the palm trunk) indicate the right state. Some haversters who have been doing this activity for long seem to have developed their own techniques to attract mature insect and facilitate egg laying in prepared raffia palm tree.

Conclusion and implications

Motives of larvae sales in Yaoundé Mvog-Mbi market are mainly for income generation. The trade is facilitated by already existing consumers' networks, making the palm weevil larvae a delicacy as shown by Dounias (2004). As for other food items or commodities, trade chain actors are many, with permanent and seasonal actors, more or less related to cultural background with entomophagy (Defoliart, 1995; Hoare, 2007). Traditional knowledge and new technologies may brigde to possible domestication based on well balanced scientific development (Cicogna, 1992; Defoliart, 1995).

However, taking into account the growing population in SSA and the exploitation of natural resources such as catfish based of wild harvesting, serious depletions are expected in a near future. Fosaranti (1993) already indicated that in a neighbouring country in Nigeria, palm trunks are deliberately cut to collect edible grubs. This practice is not sustainable. Sustainable diets are those diets with low environmental impacts that contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally accepted, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources. Sustainable diets can address the consumption of foods with lower water and carbon footprints; promote the use of food biodiversity, including traditional and local foods, with their many nutritionally rich species and varieties (FAO, 2010). Tropical palm tree contribute significantly in GHG reduction, hence there is a need to prevent massive destruction of raffia palm ecosystems which play variable roles for the communities.

The SSA is the only region of the world where hunger is projected to worsen over the next two decades unless some drastic measures are taken to reverse food insecurity. This implies that, while the population is rising, the number of adults available to produce food is disproportionately affected. Our study advocate for community mobilization through reforestation programmes but also capacity building in mass producing palm weevils. This will contribute strongly to increasing food security, which in turn helps promote economic diversification and growth. Since the business of palm weevil is lucrative, reforestation policies could serve as an incentive to generate higher incomes and creates income generating opportunities for populations in Cameroon and SSA.

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Field testing a conceptual framework for innovation platform impact assessment: the case of MilkIT dairy platforms in Tanga region, Tanzania

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Abstract

This article studies the impact of innovation platforms in Tanga Region, Tanzania, set up by the MilkIT dairy development project to intensify smallholder production through feeds enhancement and value chain approaches. The conceptual framework used builds up from three socio-economic theories. The Structure-Conduct-Performance model of markets contributes its elegant assumption linking the way markets are organized with how market actors behave, which has an influence on market performance. The framework is transposed to study innovation platforms, which can be envisaged as market-enhancing institutions, according to New Institutional Economics, the second theory also contributing notions of transaction costs to the framework. The final theoretical contribution comes from business relationship marketing with its field-tested constructs for supply chain performance. This new conceptual framework applied to innovation platforms posits that the structure of the platform (how it is organized) has an impact on its members' conduct (how they communicate and share information), which in turn influences platform performance targeted by members (feed availability and accessibility). Empirical data were collected from stakeholders involved in the MilkIT platforms through focus group discussions, key informant interviews and a survey of 121 farmers. Data were analysed using principal components factor analysis followed by regression analysis. This study finds positive links between frequency, quality and modes of communication by livestock keepers with their perception of satisfactory feed availability and accessibility. On the other hand, results for members and non-members of the platform are not statistically significantly different, probably due to the very early stage of platform development.

Keywords: Communication, Feeds, Livestock, Value chain.

Introduction

An innovation platform is "a group of individuals (who often represent organizations) with different backgrounds and interests: farmers, traders, food processors, researchers, government officials etc. The members come together to diagnose problems, identify opportunities and find ways to achieve their goals" (Victor *et al.*, 2013). These system-oriented approaches for stimulating technical, institutional and organizational innovations in agricultural value chains took shape in the 2000s (Nederlof and Pyburn, 2012). They have since been widely recognized by multiple programmes as a tool to establish connections and networks among value chain stakeholders. These enhanced interactions in turn encourage innovative changes via concerted collaboration in addressing common bottlenecks and co-creating solutions.

As innovation platforms are increasingly utilized, the importance of evaluating their impacts has also become a major concern of both researchers and development practitioners. Cadilhon (2013) developed a conceptual framework to address impact assessment of innovation platforms using quantitative research methods and proposed a field method for its empirical validation. The framework is based on three strands of literature: the Structure-Conduct-Performance model, New Institutional Economics, and Supply Chain Management and marketing. Zewdie *et al.* (2013) conducted research following the method proposed to assess the impacts of Volta Basin Integrated Crop-Livestock platforms in Ghana. They could not come to a strong conclusion about the power and appropriateness of the conceptual framework regarding impact evaluation for the Volta Basin platforms. The authors identified certain limitations that might undermine the econometric results used to test the framework: small number of observations, young age of the platforms and lack of a control group. They suggested the framework be appraised through further empirical validations before coming to a reliable conclusion regarding its effectiveness.

This paper attempts field validation of Cadilhon's (2013) conceptual framework, based on data collected from two MilkIT project dairy platforms at village level in Tanzania. The MilkIT project "Enhancing dairy-based livelihoods through feed innovation and value chain development approaches" aims to improve availability and reduce seasonality of dairy feed in villages in Morogoro and Tanga regions using institutional and technical interventions through innovation platforms. Innovation platforms have been established in a total of eight selected villages in the two regions during 2013 (Pham *et al.*, 2014). The research methodology is described in the next section. Section three discusses the research results, followed by main findings and limitations as well as suggestions for further research in the last section.

Materials and methods

The conceptual framework developed by Cadilhon (2013) is one of the first systematic models aiming at evaluating the impact of agrifood innovation platforms through a mixed approach of qualitative and econometric analysis. Figure 1 illustrates this framework with performance indicators adapted to the context of MilkIT project platforms in Tanzania.

Due to time limitations, Communication and Feed Availability were selected as focus indicators of Conduct and Performance constructs, respectively, for further analysis. The choice of communication as conduct focus element was based on previous literature acknowledging communication within innovation platforms as an essential facilitator of innovation processes (Victor *et al.*, 2013). The choice of feed availability as focus for performance indicators came from the realization that feed was one of the major perceived constraints to milk production in the study area (Pham *et al.*, 2014), reflecting also the emphasis of the MilkIT project.

IP "Structure"	**"Conduct" of IP members**	**IP "Performance" indicators**
- Membership composition & diversity - Decision making process - Committees - Source of funding - Staff availability **Individual 'structure'** - Type of chain stakeholder - Gender - Level of education - Indicator of wealth **External environment** - Legal and regulatory framework - Cultural norms	Information sharing Communication Coordination Joint planning Trust	- Adoption of new dairy production practices & activities - Year round availability of feed - Improved market access (milk) - Access to livestock inputs & services - Increased milk production & productivity - Increased income from milk - Policy influence

Figure 1. Illustration of different Structure, Conduct and Performance elements (Cadilhon, 2013) adapted to MilkIT Tanzania platforms

The data used for econometrically testing the framework was collected via 121 semi-structured interviews with questionnaires on Structure, Conduct and Performance information. Both the control and treatment samples were taken from the population of dairy livestock keepers in Mbuzii village, Lushoto District, and Sindeni village, Handeni District, in Tanga region, Tanzania. Treatment groups were platform members, defined by their attending at least one platform meeting. They included 31 platform members in Mbuzii and 28 members in Sindeni. Control groups were 30 and 32 dairy livestock keepers living in Mbuzii and Sindeni respectively; they had never attended any platform meeting. Due to the early stage and the composition of the platforms, all respondents were livestock keepers and hardly any of them played other roles in the studied value chains. During the two months of data collection in the field from December 2013 to February 2014, two focus group discussions were organized with about 10 platform members each in both villages. Together with multiple informal interviews with key informants, they provided qualitative information that helped in constructing the final analytical models and to support the econometrical results.

The methods used for questionnaire design and data analysis were identical to those described by Zewdie *et al.* (2013): quantitative data collected from individual farmers were analysed using principal components factor analysis followed by regression analysis. In this paper, the relationships between Structure and Conduct will not be examined and discussed. The two models constructed to study the relationships between Conduct and Performance of MilkIT innovation platforms in Tanzania are defined as:

$$F_{avai} = \beta_o + \beta_1 divorced + \beta_2 widowed + \beta_3 edu1 + \beta_4 Lncattleperacre + \beta_5 store + \beta_6 Comqf + \beta_7 source1 + \beta_8 source2 + \beta_9 source3$$

$$F_{acce} = \beta_o + \beta_1 divorced + \beta_2 widowed + \beta_3 share + \beta_4 Lncattle + \beta_5 training + \beta_6 Comqf + \beta_7 source1 + \beta_8 source2 + \beta_9 source3$$

F_avai is a result of the factor analysis on performance indicators and represents Feed availability during dry season. *F_acce* is another performance factor which can be described as Market access to larger variety and better feeds. *Divorced* and *widowed* are dummy variables with value 1 indicating the respondent is divorced or widowed. Dummy variable *edu1* indicates the respondent has never attended school if its value is 1. Dummy variable *training* indicates the respondent has attended at least a training course in dairy production or dairy feed and feeding. *Store* and *share* are also dummies with value 1 if the respondent stores crop residues for the dry season or the respondent shares production information with others, respectively. *Lncattleperacre* and *Lncattle* are natural logarithm of number of cattle per acre or of total number of cattle owned. *Comqf* is a result from the factor analysis on communication indicators; this factor can be described as the level of quality and frequency in communicating about feed and feeding. *Source1*, *source2*, and *source3* are factors combining different sources of communication and sharing information, indicating the level of exposure to information and interaction with stakeholders.

Results and discussion

No statistically significant difference was found between the control and treatment groups, in terms of Structure, Conduct and Performance data. This is probably due to the very young age of the platforms (4 months old): they are not yet providing any difference compared with "business as usual": sharing information and technologies with neighbours and within other types of farmers' organizations. Table 1 shows that improved quality and frequency of communication in feed and feeding issues enhanced respondents' perception of having enough feed for their cows during dry season.

Table 1. Regression results with Feed availability during dry season as dependent variable

Dependent Variable	Explanatory variables	Beta	t	P>|t|
Factor 1: Feed availability during dry season	Divorced	*0.180*	2.488	*0.014*
	Widowed	0.082	1.073	0.286
	Edu1	*-0.183*	-2.008	*0.047*
	Lncattleperacre	*-0.267*	-3.111	*0.002*
	Store	*0.178*	2.239	*0.027*
	Comqf	*0.201*	2.398	*0.018*

	Source1	0.164	1.967	0.052
	Source2	*0.169*	2.193	*0.031*
	Source3	-0.087	-1.018	0.311

Table 2 indicates that increased exposure to certain sources of information had a positive impact on accessing larger variety and better feed inputs.

Table 2. Regression results with market access to larger variety and better feeds as dependent variable

Dependent Variable	Explanatory variables	Beta	t	P>|t|
Factor 2: Market access to larger variety and better feeds	Divorced	*-0.189*	-2.387	*0.019*
	Widowed	0.114	1.419	0.159
	Share	0.204	1.838	0.069
	Lncattle	-0.170	-1.604	0.112
	training	*-0.226*	-2.468	*0.015*
	Comqf	0.078	0.826	0.411
	Source1	*0.270*	2.630	*0.010*
	Source2	*0.195*	2.046	*0.043*
	Source3	0.012	0.121	0.904

Listening to radio had a significant positive impact on both feed availability during dry season and feed access. Likewise, contacting input traders, extension officers for feed information and communication via paper-based materials like brochures and posters, among other information sources, connected livestock keepers to the market and make inputs for feed more accessible to them. Besides, communication quality and frequency also improve the availability of feed during dry seasons in a statistically significant way.

One apparently surprising relationship is the negative link between attending dairy and feed trainings and access to feed inputs. Information was gathered in Lushoto about a group of poorer livestock keepers who attended some training by some other projects in the past, but few of them have made significant improvement in dairy production. They probably remain more disadvantaged than average and have less access to feed inputs. The observation was more obvious in Handeni where more livestock keepers claimed they attended multiple training courses but hardly any of them agreed that they were applying the skills and know-hows learnt on their farms. The negative sign could probably be explained by the fact that the more disadvantaged farmers were usually selected for such kind of training and at the time of survey, such training had not made a difference to them in terms of feed availability and accessibility. However, explanations for this require further investigation to come to a clear conclusion.
One platform facilitator and research actor claimed that storing grass and crop residues should play an important role in improving feed availability, and this is proved to be true in the model, especially for livestock keepers in Lushoto, where number of cattle per household remains small. The number of cattle per acre of land negatively affects feed availability in both villages, regardless of the production scales and feeding systems. This is particularly crucial for Maasai people due to the long established tradition of increasing herd size for social status even if it may not be economically beneficial due to limited land and water.

Field observations indicated that never attending school and being a widowed woman undermined livestock production in general, especially in terms of access to market and feed availability. The regression model backs this finding only regarding the negative impact of being uneducated on feed availability during dry season. The significant impact of being divorced on the two dependent variables is surprising given that there is only one case in the sample, warranting further analysis.

Considering the fact that the regression models use psychometric measurements to capture behaviours and perceptions, the adjusted R-squared of 0.447 and 0.306 for feed availability model and feed accessibility model, respectively, do capture a significant part of the relationships among Structure, Conduct and Performance, as hypothesized by Cadilhon, (2013).

Conclusions

This research was designed to test a conceptual framework developed by Cadilhon. (2013) to evaluate impacts of

innovation platforms. The results of econometric models, backed by triangulation with qualitative data, indicate significant impacts of communication frequency and quality, as well as exposure to different sources of information, on livestock keepers' perceptions of feed availability and accessibility. Results also point to the significant roles of education, production scale and practices on the two performance indicators studied. These findings confirm that platform facilitators' investments into fostering communication between platform members are worthwhile because this communication has a positive impact on helping platform members reach their stated goals. Nonetheless, findings also point to individual situations described by the characteristics of members and their production system still playing a significant role in reaching stated productivity goals. Thus, innovation platform facilitators should also set up mechanisms that allow innovation processes to be compatible with the needs of individual members of the group.

Some of the relationships posited between elements of structure, conduct and performance of innovation platforms in Cadilhon's (2013) conceptual framework are empirically validated by this study. Future research is still needed to improve the framework's testing in other contexts. Number of observations should be increased further to improve the performance of regression models. Questionnaires should be adjusted to reflect better the individuality of platform members and the type of performance indicators selected according to platform objectives. This would help further to collect relevant variables and avoid missing some meaningful factors.

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Smallholder Dairy Production: Analysis of Development Constraints in the Dairy Value Chain of Southern Ethiopia

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Abstract
This study analyses development constraints of smallholder dairy production systems in the Dale and Shebedino Districts of southern Ethiopia. Data were collected from 120 dairy producers, six focus group discussions, and six key informant interviews. Two major dairy production systems were identified based on major agricultural activities: the coffee-based dairy production system predominantly found in Dale and the *enset*-coffee-based dairy production system predominantly found in Shebedino. Coffee-based dairy producers owned less local dairy cows and earned a higher income as compared to farmers in *enset*-coffee-based dairy production systems. The latter had relatively more income from off-farm activities. Shortage of feed resources, lack of access to improved breeds, to markets and to credit services were the major dairy development constraints in the two districts. Rapid urbanization, rising income, and population growth increase dairy demand and market opportunities for dairy development are expanding. In response to increasing demand for dairy products, most of the dairy producers were willing to expand their dairy farming. Sustainable dairy development can be achieved through improving access to key resources, inputs and services in the dairy value chain and markets.

Keywords: Access to credit, Dairy, Farming system, Inputs and services, Off-farm activities

Introduction

In Ethiopia, development creates opportunities for smallholder farmers and private investors (Mohamed *et al*., 2004) to increase dairy production. Over the next decades rapid urbanization and population growth are expected, which will increase domestic demand for milk and dairy products. It is also expected that policy will increasingly support market economy. Moreover, the large number and diversity of livestock genetic resources, and the existence of diverse agro-ecologies suitable for dairy production, imply that there is potential for dairy development in Ethiopia.

The dairy sub-sector contributes for 33% to the agricultural and for 12% to the total gross domestic product (Solomon *et al*., 2003). It also plays a vital role in the life of the dairy farmers, by providing a source of subsistence through household nutrition (milk and meat), supplementary income and generating employment opportunities (Tegegne and Gebrewold, 1998). Dairy development has been hampered by many factors such as sub-optimal genotypes, feed resources and feeding systems, lack of access to services and inputs, low adoption of improved technologies and limited marketing options. Various dairy research and development projects have been carried out. But, the impacts were unsatisfactory and failed to meet their objectives (Ahmed *et al*., 2003, Lobago *et al*., 2007) in part due to inability to identify appropriate technologies, which was related to insufficient understanding of dairy production practices and development constraints (Ayenew *et al*., 2009). Appropriate information and proper documentation of dairy farming systems will play a vital role in developing the dairy sector (Rey *et al*., 1993). Therefore, the present study had the aim to identify major dairy development constraints along the value chain to improve dairy production and marketing in the study area.

Methodology

Primary data were collected from 120 farmers in the Dale and Shebedino Districts in southern Ethiopia. Both have good dairy production potential and good road access, but they differ in ease of connection to the major markets of Awassa and Yirgalem. A multi-stage sampling procedure was followed to select six Peasant Associations (the smallest administrative unit in Ethiopia) in each district. Then, 43 and 77 households were selected from Dale and Shebedino District respectively. Finally, the sampled households were stratified into three wealth classes based on dairy cow holding (having 1 cow = low, 2 cows = medium and 3 cows = high wealth class). A structured survey was conducted to collect the relevant information for socio-economic characteristics, dairy production system characteristics, and development opportunities and constraints. In order to obtain in-depth information, six key informant interviews and six focus group discussions were conducted. Descriptive statistical tools (chi-square tests and one-way ANOVA) were used to analyses data.

Results

Sources of livelihoods and the role of dairy cattle

Based on the type of crop farming activities, two types of dairy production system were identified: *enset*-coffee and coffee based livestock production systems in Shebedino and Dale Districts, respectively. Agricultural activities were the main source of livelihood for smallholder farmers in both districts. However, relative importance of different livelihood income sources were significantly different between the two districts ($p<0.05$). In Dale and Shebedino Districts 79% and 99% of the respondents were engaged in agricultural activities, respectively, indicating the difference in importance of off-farm activities between the districts. The major purpose for keeping cattle was "milk and manure" in both districts. In Dale the banking function had additional importance and in Shebedino meat production. Wealth classes did not differ significantly with regard to importance of off-farm labour and livestock functions.

Table 1. Income source and purpose of dairy animals in the study districts and wealth class of dairy producers in the study areas (percentage of respondents)

Variables	Districts			Wealth class			
	Dale	Shebedino	P- Value	Low	Medium	High	P-Value
Income source							
Agriculture	79.1	98.7		92	92.7	86.7	
Trader	0	1.3		0.0	1.8	0.0	
Employment	11.6	0.0	0.0	6.0	3.6	0.0	0.23
Agriculture & trader	7	0.0		2.0	1.8	6.7	
Agriculture & employ	2.3	0.0		0.0	0.0	6.7	
Purpose of keeping dairy cattle							
Milk and manure	54.8	55.8		58.0	56.4	42.9	
Milk, meat and manure	7.1	37.7		24.0	29.1	28.6	
Milk, manure and banking	33.3	1.3		8.0	12.7	28.6	
Milk	2.4	1.3	0.0	4.0	0.0	0.0	0.67
Meat	0.0	1.3		2.0	0.0	0.0	
Milk and meat	0.9	1.3		2.0	0.0	0.0	
Banking/insurance	0.0	1.3		2.0	0.0	0.0	

Development constraints and opportunities

Shortage of feed and feed resources, limited access to improved breeds, to input and output markets, and to credit services were major development constraints identified by the respondents in the study areas.

Table 2. Major dairy development constraints by district and wealth class (percentage of respondents)

Major dairy	Districts			Wealth class			
Development Constraints	Dale	Shebedino	P-value	Low	Medium	High	P-value
Feed shortage	29.5	43.9		35.3	39.1	38.2	
Improved forage/pasture seed	14.3	0.7		5.9	6.1	11.8	
Improved dairy cow	0.9	0.0		1.0	0.0	0.0	
Market	10.7	20.9		18.6	14.8	14.7	
			0.03				0.69
Capital/credit service	17.0	17.3		18.6	17.4	11.8	
Artificial insemination Service	17.0	7.9		9.8	13.9	11.8	
Veterinary Service	5.4	7.2		6.9	6.1	5.9	
Training and consultancy	4.5	2.2		3.9	2.6	2.9	

Dale District had more access to inputs and services like AI, veterinary, credit, training and consultancy than Shebedino

District (P<0.05). In Dale District the respondents perceived that access to credit and AI services were the second most important constraint in dairy development, while in Shebedino District market access was mentioned as constraint next to feed shortages (Table 2). Accessibility of other dairy related services was less problematic in both districts and was not affected by wealth class (P>0.05) (Table 2).

Outcomes of focus group discussions as well as key informant interviews suggested that farmers were willing to improve and expand their farm if access to technology could be improved. However, there were still some dairy producers who were not willing to improve their farming practices due to various reasons. Particularly, producers in Shebedino District were less willing to improve than farmers in Dale District. According to response from key informant interviews, old farmers relied more on their years of farming knowledge and experience, and seemed to have difficulties in adopting new technologies. On the other hand farmers pointed out that demand for dairy products in the areas was rapidly increasing due to population growth. Key informant interviews and personal observation in the study areas revealed that the existing marketing structure involved different stakeholders such as dairy producers, farmer, trader, processors, cafeterias and restaurants, as well as retailers that buy and sell milk.

Discussion

Most parameters considered in the current study were not affected by wealth status of producers. This could be due to narrow range used to create wealth classes (having 1 cow = low, 2 cows = medium and 3 cows = high wealth class), which failed to show clear differences. Hence, the study focused on smallholder rural dairy producers having a minimum of one and a maximum of three dairy cows.

Some differences were observed between the roles and functions of dairy between the *enset*-coffee and coffee based livestock production systems in Shebedino and Dale Districts, respectively. This is in line with Tolera and Said (1992), Tesfaye *et al.* (2001), Zewdu *et al.* (2003) and Chewaka (2006). Dairy farming plays a vital role in the coffee-*enset* based livestock production system by providing organic fertilizer for *enset* crop production. However, in the coffee based livestock production system the dairy cows were used as a source of livelihood by selling milk and manure. Likewise, sources of income can potentially impact on dairy improvement efforts. Agriculture and off-farm activities were the main sources of income in Dale District, while in Shebedino District a majority of the respondents did not have any other option to get income other than selling cash crops. This is related to distance to the urban area and infrastructure. Dale District has better road infrastructure and is nearer to the urban area than Shebedino.

The current study showed that access to input supply and service provision is significantly different between the dairy production systems. Accessibility of input and services could have great impact on dairy sector development. This finding is in line with Gebremedhin *et al*. (2006). Availability of dairy-related inputs and services were higher in coffee-based dairy production than in *enset*-coffee based dairy production. This could be due to income source difference between farmers, i.e. those households based on coffee livelihood earned more income than those based on *enset*-coffee, and to differences in experience with using dairy related inputs and services. Under the former regime, more dairy development projects were executed in Dale than in Shebedino so that Dale farmers had better understanding and more experience in using dairy related inputs and services. As stated in Gebremedhin *et al*. (2006), such better access to input supply would have a significant contribution to dairy development.

Along with input constraints discussed in the previous sections, shortage of feed was more a constraint for dairy development in Shebedino than in Dale district. This could be due to the difference in the primary feed source between the two dairy production systems. In the Dale's coffee based dairy production systems the primary feed source was crop residues and farmers there had no extra land to allocate for grazing, while grazing was the main feed source for Shebedino's *enset*-coffee based production systems. However, very few dairy producers had sufficient access to improved forage/pasture seed. Tegegne *et al*. (2010) indicated that, marketing and access to market were the major common problems in both districts. As highlighted in the discussion with the key informants, the main reasons for weak market access included low integration and collaboration among stakeholders, distance to the markets, seasonal milk production, price fluctuations, lack of training and consultancy on how to handle and process milk and milk products. These results are in agreement with the report of Tegegne *et al.* (2010).

Most of the dairy producers had limited information about credit services for dairy-related activities, as was also noted in reports of Gebremedhin *et al*. (2006). Only few dairy producers in Dale District had access to credit service. In this study,

due to differences in income sources, market opportunities and objectives of dairying, Dale's coffee-based dairy farmers were more willing to continue and improve production than Shebedino's *enset*-coffee based dairy farmers. Dale District, in contrast to Shebedino, showed a rapid urbanization. As a result, demand for good quality and quantity dairy products was increasing. In order to improve dairy production in these districts, livestock departments from both districts' agriculture offices implemented estrus synchronization programs. This provides opportunity for smallholder producers to shorten the calving interval and improved dairy production. This provides opportunity for smallholder farmers to use land, labour and feed resources more efficiently and effectively to generate good livelihood income.

Conclusions and recommendations

The current study demonstrated that the majority of dairy producers in Dale District specialized and developed dairy production, and dairy farming became the second most important source of family income besides coffee. Development of the coffee-based dairy production here involved more frequent use of modern dairy technologies, with inputs leading to higher efficiency and a better product performance, as compared to the coffee-*enset* based system of Shebedino, which remained more a subsistence oriented farming system. Accessibility of farm resources, input supply, and service provision nevertheless are perceived as major constraints to dairy development in both systems. Implementation of synchronization programs as well as rapid population growth and urbanization of the regional capital, Awassa, and towns like Yirgalem and Dilla may provide huge opportunities for development of dairy farming in the region.

Dairy production in the studied areas can be improved by organizing farmers into small and medium commercial dairy enterprises. Moreover, smallholder dairy producers need crucial institutional support to promote efficient input and service provisions to improve their dairy production system. This includes creating better access to dairy related technology, particularly feed supply, marketing systems, veterinary and AI service, credit, extension and training. Another aspect of the production chain that deserves special attention is sustainable collaboration and integration of different value chain actors/stakeholders. Achievement of dairy development goals could be initiated from this.

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Smallholder pig producers in Uganda and their pork consumption practices

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Abstract

Pig production is thriving in Uganda and the demand for pork is increasing, therefore offering potential for increased income through small-scale pig production and marketing. A multi-disciplinary value chain assessment conducted by the International Livestock Research Institute and partners aimed to identify constraints and opportunities for value chain actors as well as shortcomings in the safety of pork products in three districts in Uganda. Prior to quantitative surveys and biological sampling at various nodes of the chain, participatory rural appraisals and focus group discussions were held with about 1,400 smallholder pig farmers to map out qualitative aspects including the various actors involved in pig rearing (e.g. input and service providers) and marketing (e.g. marketing channels and pricing). One particular aspect covered pork consumption habits as well as knowledge, attitudes and practices on pork safety among 294 participants, considering that they are also food consumers. Pork is widely popular, mostly consumed well-cooked or thoroughly pan-fried. The frequency of consumption follows seasonal patterns and increases from rural to more urban settings. Practices such as roasting may lead to the ingestion of undercooked pork, and accompanying dishes such as raw vegetables may lead to cross-contamination of the meat causing foodborne diseases. The scarcity of data on zoonotic pig pathogens, such as erysipelas, salmonellosis, brucellosis and pork-borne parasites requires further research.

Keywords: Participatory research, Pork safety, Quality attributes, Risk, Women

Introduction

Over the past three decades, pig numbers in Uganda have at least quadrupled (FAO, 2011; MAAIF/UBOS, 2009) and 70% of the estimated 3.2 million pigs are in the hands of smallholder farmers, many of them women (MAAIF/UBOS, 2009). Pork per capita consumption in Uganda currently ranks highest in East Africa at 3.4 Kg per year (FAO, 2011). In a consultative process, the CGIAR Research Program on Livestock and Fish (CRP L and F), led by the International

Livestock Research Institute (ILRI), has identified pigs in Uganda as one of nine selected livestock value chains where research for development has potential and is targeted to make an impact for poor producers and consumers (ILRI, 2011). Until 2012, little was known about how smallholder pig value chains in Uganda operate; where pigs come from and who eats them, constraints and opportunities in smallholder production systems and possible public health risks associated with pig farming and pork consumption. The present study describes knowledge, attitude, practices and perceptions related to pork consumption and quality at the consumers' node of the value chain.

Materials and Methods

The present study was carried out under the Safe Food, Fair Food project which aims to improve food safety in selected CRP L&F value chains, and was part of multidisciplinary, multi-project activities under the umbrella of the Smallholder Pig Value Chain Development project (SPVCD). From November 2012 to January 2013, qualitative assessments were carried out at the producers node to map out the various actors involved in pig rearing (e.g. input and service providers) and marketing (e.g. marketing channels and pricing) as well as to inform in-depth and quantitative assessments and prevalence surveys that followed in 2013 (ILRI and partners, forthcoming). Participatory rural appraisals, key informant interviews and focus group discussions were conducted in 35 villages, with about 1,400 smallholder pig farmers in Masaka and Mukono Districts of the Central region (436,400 pig-owning households; MAAIF/UBOS, 2009) and Kamuli District in the Eastern region (262,300 pig-owning households; MAAIF/UBOS, 2009) in Uganda. The farmers were engaged in discussions on feeds, breeds, marketing, animal health, and zoonoses including food safety, during four parallel sessions (Ouma *et al*., 2014).

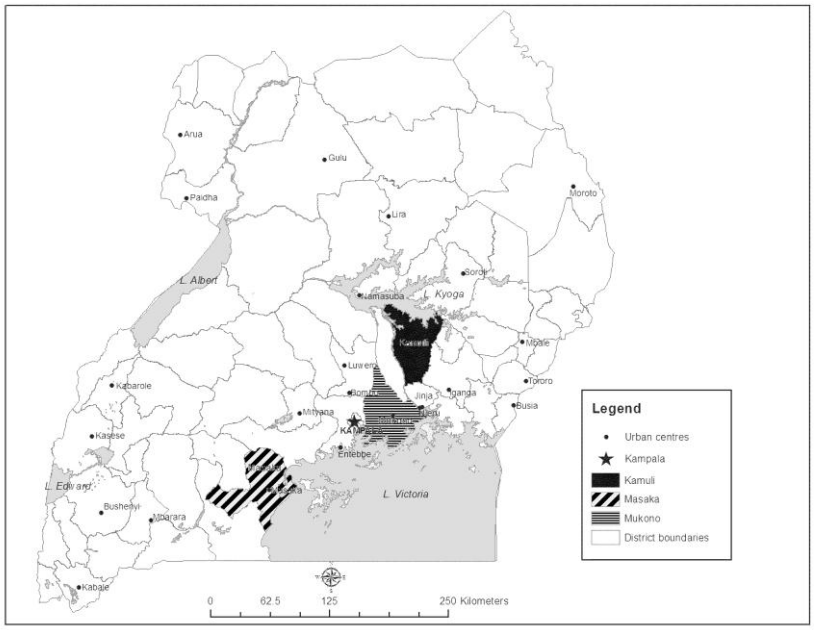


Figure 3. The study sites Kamuli, Masaka and Mukono Districts, Uganda

In the session on food safety and nutrition, qualitative and semi-quantitative data on pork consumption patterns, preparation methods as well as knowledge, attitudes and practices on pork safety was gathered from 294 randomly selected pig farmers (103 men and 191 women) in 34 villages in the above mentioned districts. Generic discussion guides were used with all groups and included tools from participatory epidemiology such as focus group discussions, ranking and scoring methods, Venn diagrams and seasonal calendars. These activities were used to answer a set of research questions, specifically: Who eats pork, when and why? What are reasons not to eat pork? What is the role of pork in farmers' diets? Are pig keepers pork eaters? How accessible is pork? Do pig feeds compete with human food? How does knowledge, attitudes and practices increase or reduce the risk of pork-borne diseases?

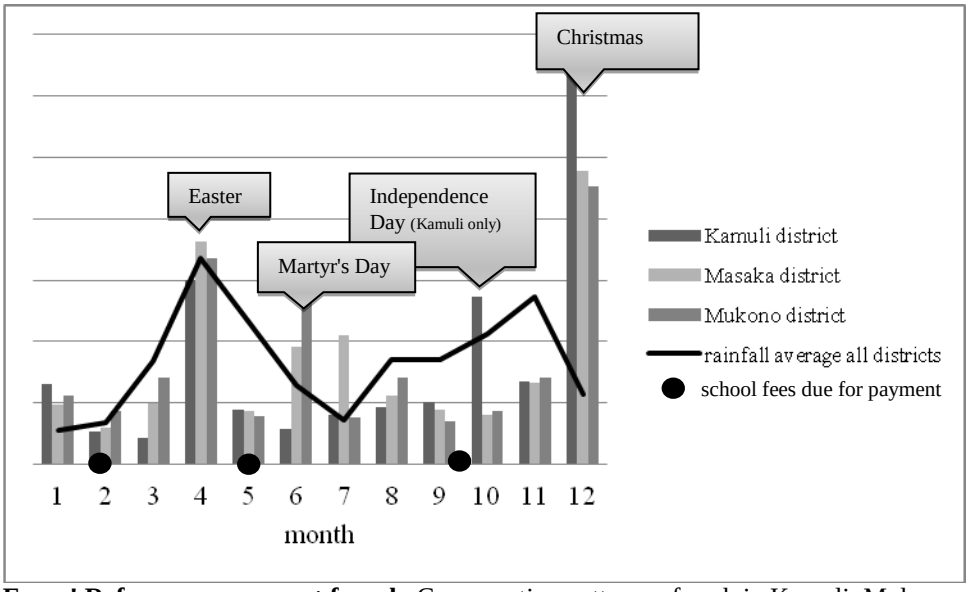
Table 3. Pork consumption assessment tools used by district in Uganda

Tools used	PRA guide producers	PRA guide consumers	FGD with mothers
Kamuli District	4	4	5
Masaka District	14	0	14
Mukono District	6	6	8
Total	24	10	27

The data was entered into MS Excel for basic descriptive analysis and visualization.
PRA - Participatory Rural Appraisals; FGD - Focus Group Discussions

Results

Pig producers were generally pork eaters; 80% of the pig farmers in the survey (n=294) consumed pork, whereas the proportion of male consumers was marginally higher (89%) than the female (74%). Consumption was mainly driven by festivals as shown in **Error! Reference source not found.**. More pork was consumed when cash was available, for instance after the coffee harvest in Masaka in the months of June/July. Less pork was consumed at the beginning of new school terms when pigs were sold to pay for school fees.



Error! Reference source not found.. Consumption patterns of pork in Kamuli, Mukono and Masaka Districts

Pork ranks second after chicken in terms of taste and was occasionally given to children under five years as food for good growth. In rural sites, pork is believed to clear the skin, cure measles and make “strong bones” whereas in the urban areas pork is sometimes believed to cure HIV/AIDS (Ejobi forthcoming). In the rural study sites, pig farmers rarely slaughtered their own animals as they used the money generated from sales of live pigs for meeting family needs such as school fees. The closer to urban centres, the more frequently pork and other animal sourced food was eaten, e.g. weekly to daily, and pigs were kept for both sale and home consumption. The biggest constraint for eating more pork in rural areas was low income; other factors include religion or traditional beliefs. Some of the women who did not eat pork claimed that they were raised at times when women were denied pork because men believed that eating it made women too strong and outspoken. Moreover, according to local tradition in rural Masaka District, elderly women were not supposed to eat pork, chicken and red meat. They were given eggs, fish and even bone marrow as this was believed to keep them strong. Almost all (93%) of the mothers emphasized that nobody ate offal, referring to white offal, partly because pigs ate anything including faeces and snakes. Farmers across all sites, especially in rural settings, indicated they may have eaten meat from diseased pigs if they cannot find a market for their animals. Food for people did not compete with pig feeds as the animals were fed with leftovers or fattened during “times of plenty”, shortly after the seasonal rains.

The main quality criteria that pig farmers considered as important when purchasing pork are presented in Figure 4. Cleanliness of the meat ranked first and was defined as meat free from visible dirt and flies; a moderate fat layer (ranked

second) was important because in the view of the discussants too thick may imply human disease (e.g. high blood pressure) and too thin could indicate pig disease (e.g. it did not gain weight because it was sick). Unbalanced feeding of pigs was not associated with the thickness of the subcutaneous fat layer. In Figure 3, the bars indicate proportions established by group consensus and have not been further quantified.

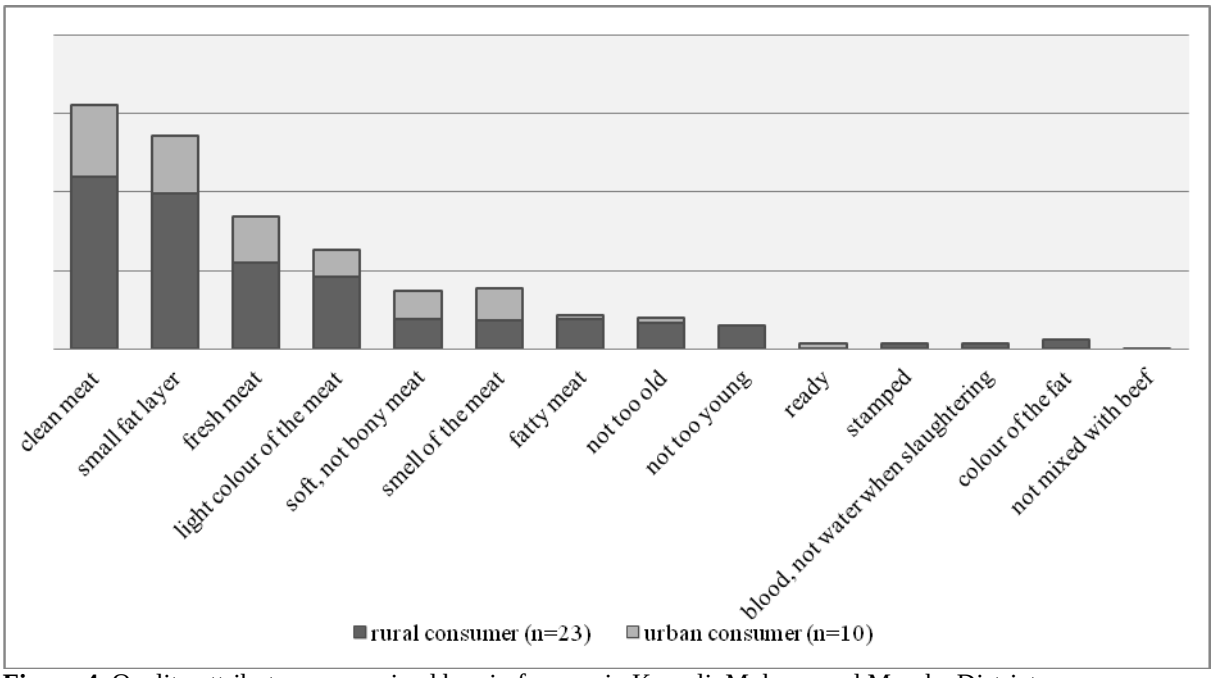


Figure 4. Quality attributes as perceived by pig farmers in Kamuli, Mukono and Masaka District.

Raw pork is considered unsafe for human consumption and a potential source of diseases across all sites. Pork ranked fifth after chicken, fish, beef and eggs in terms of perceived safety; milk ranked last. All pig farmers agreed that they can contract disease from pigs; symptoms described were worms (26%), stomach pain (20%), diarrhoea (16%) and fever (13%). It was believed that undercooked pork caused madness or epilepsy in humans. Fifty percent of the participants had heard about food borne diseases in their community and 31% of them agreed that children were most affected. Food borne diseases were not considered fatal but weaken the person affected and reduce his or her ability to concentrate or work. At home, pork was thoroughly cooked for at least one hour and attempts are made to preserve the shelf-life of raw pork, for instance by smoking and roasting. When eaten outside of the homes, fried or roasted meat is usually consumed with raw vegetables such as tomatoes, cabbage and onions.

People had access to pork in all study sites, and about 70% was consumed outside the homes in pork joints. In the rural areas, consumers had less choice of butchers and the retailers were reported to slaughter diseased animals or sell products in a dirty and unsafe environment (**Error! Reference source not found.**). The figure shows Venn diagrams developed by the group discussants to describe availability, accessibility and preferences for sources of pork. (left: Baluboinewa village in rural Kamuli District; right: Kitete village in urban Mukono District; the size of the circle represents the relative importance of the source).

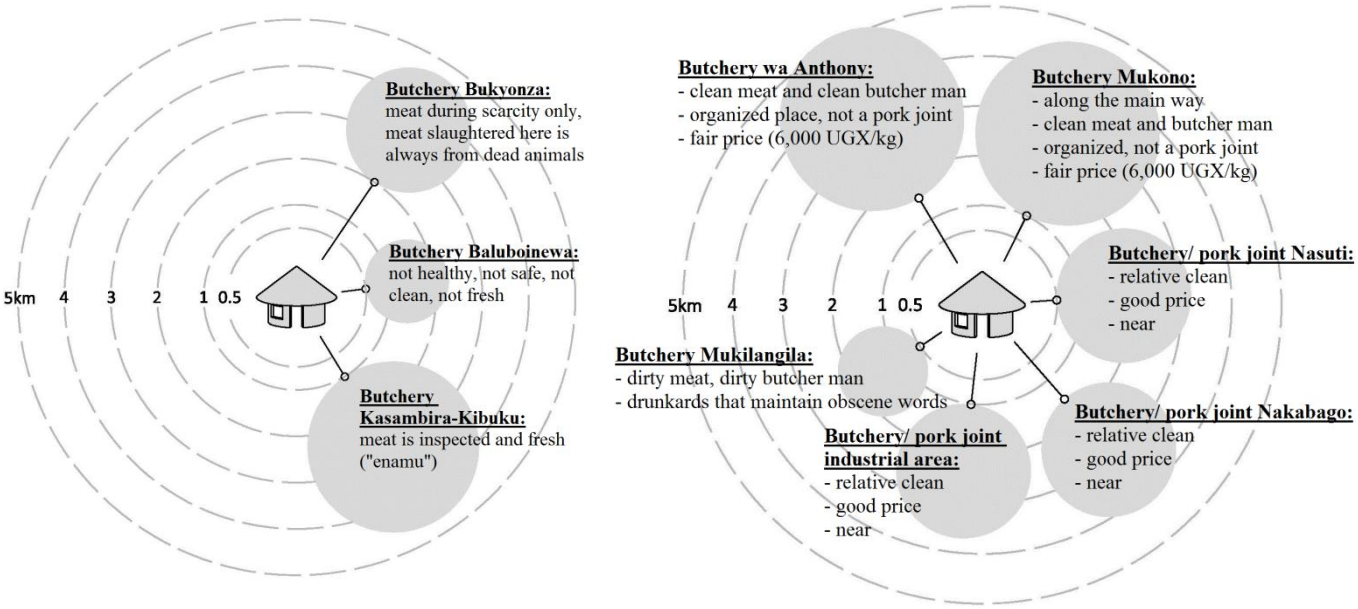


Figure 5. Venn diagrams developed by the group discussants to describe availability, accessibility and preferences for sources of pork.

Discussion and conclusion

Pork is consumed widely and consumers have access to pork in all study sites but quality seems to be neglected in the rural sites where consumers reported less sources of pork and more meat sold from unsanitary outlets. Pork consumption on the occasion of Easter and Christmas often coincided with times of food scarcity. A safe product can therefore contribute to the protein supply of poor farmers and their families during seasons of food shortage.

Offal refers to the internal organs and entrails of an animal slaughtered for meat. The consumption of offal was not commonly accepted in the study sites and may need promotion as it provides a source of protein to those who cannot afford to buy pig meat. While the farmers in the study sites cooked red offal (heart, tongue, lungs, spleen and kidneys), white offal were only partly used. Meat was scraped off of feet and heads, and in Masaka District bone marrow was sometimes given to old people to help them maintain their body strength. Brains and genital parts including the uterus and teats were not eaten at all. The pancreas (sweet breads) was usually discarded in the open by the butchers together with the slaughtered animal's stomach, intestines, blood and faeces, to be left for scavengers, potentially contributing to spread of diseases and environmental pollution.

While the meat is consumed hot, the preparation of pork dishes with raw vegetables on the side may lead to cross-contamination with foodborne pathogens. The pathognomonic signs of diamond skin disease (*Erysipelothrix rhusiopathiae*) were reported in Kamuli District and posed a risk to people handling raw pork like butchers and house wives preparing the meat. The common misperception of the life cycle of *Taenia solium* caused inefficient management of the disease risks. More research is required and currently conducted on pork parasites such as trichinosis and both porcine and human cysticercosis due to the common practice of roasting pork which may lead to the ingestion of parasitic larvae.

Acknowledgements

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Vaccination as a way forward? A case study on how a poultry vaccination intervention influences poultry keeping in Kenya

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Abstract

Poultry is important for many poor smallholder farmers, but infectious diseases, such as Newcastle disease can drastically reduce the poultry population in a village, affecting food security and livelihoods. Newcastle disease vaccination can reduce the spread of disease, but may be hard to access for small-holders if there is not a supportive system in place. In this paper a district in Kenya is studied where there has been support for vaccination. It is shown that households in villages which had support were more likely to vaccinate, had more chickens and also know better the basic principle of a vaccine. The vaccinators themselves also reported that vaccination had improved the poultry keeping and the knowledge of the farmers. It is concluded that a supportive system is beneficial for increased vaccination.

Introduction

Poultry are crucial for the livelihoods of rural people all over the developing world (Alders and Pym, 2009) and they are often kept by poor small-holders. Poultry can be an important source of income and protein in the form of meat and eggs for households. In addition, profits from sales can be used to pay for other foods, school fees, clothes, etc. Commonly, poultry is reared by the women in the household (Bagnol, 2009). The relatively low cost of purchase, rapid reproduction and the fact that they are easily marketed make them a reliable source of income for the family, affordable even for poorer households.

In addition to this, poultry production is one of the major growing industries in both developed and developing countries (Mack *et al*., 2013). In commercial production, poultry diseases hamper productivity and cause financial losses, whereas in small-holder farming, poultry diseases may severely affect the livelihood of families.

Newcastle disease (ND) is a viral poultry disease that can have a high mortality in outbreaks and poultry owners may suffer from large losses of birds (Gallili and Ben-Nathan; 1998; Alexander, 2001). However, the occurrence of ND in backyard poultry often passes unreported and thus estimates of the true incidence is unknown (Alexander *et al*., 2004). While many European countries have legislation requiring stamping out of infected poultry, vaccination is the only means of protection available in most parts of the world (Gallili and Ben-Nathan, 1998). Different strains of ND virus are more or less pathogenic and strains which cause little or no disease are used as vaccines (Gallili and Ben-Nathan, 1998; Seal *et al*., 2000). There are several different commercial Newcastle disease vaccines available today, although these vaccines are often produced for commercial industry, with vials containing hundreds of doses, which are unaffordable and impractical for smallholder farmers (Spradrow and Copland, 1996). Therefore a good option in rural areas is to have a delivery system where a vial is distributed to many different households (Bagnol *et al.*, 2013). In order to aid vaccine dissemination and with the goal to improve productivity in smallholder farming, vaccination programs are often launched in different areas with different duration.

In Kenya, some villages are covered by community vaccinators, which reports to the district veterinarian. There are also active interventions to improve vaccinations, and a not-for-profit company, Farm Input Promotions Africa (FIPS-Africa), are supporting vaccinations through a system of village-based advisors, coordinated by a district coordinator. The coordinator receives batches of vaccines and sells these to the village-based advisors, which earn their living from vaccinating chickens in their village. The vaccine available for vaccination in 2011 in Kenya was the La Sota strain. In 2013 FIPS-Africa started distributing I-2 ND vaccine, a live, thermotolerant vaccine (Alders and Spradbrow, 2001). In this study we evaluate the influence of this intervention on poultry keeping in a district in Kenya.

Material and methods

Study areas and data collection

In Kibwezi District, Kenya, FIPS-Africa, has been promoting vaccination against ND through village-based advisors since 2009. For this study a sampling frame of villages in Kibwezi was obtained and five villages that had benefited from the vaccination support by FIPS were randomly selected, as well as five villages that had not benefited. In each village 32 households were randomly selected for interview by trained enumerators and a total of 316 interviews were conducted during September 2011.

Data were collected on the participant's sex and age, gender of the household head, animals kept in the households, which animals were considered most important, and if poultry was considered important, the reasons for this. Further, data were collected on the losses of poultry during the previous year, if vaccination had ever been done and, if so for how long, and who decided on the vaccination, and who performed it. In 2013 a follow up on was performed and the FIPS-Africa district coordinator, seven village-based advisors and three community vaccinators were interviewed about vaccination routines, campaigns and how they perceived the impact of vaccination.

Data analyses

Descriptive statistics were performed using STATA 13 (STATA corp, Texas, USA). Univariable associations between count and continuous data were tested using t-test.

Results

Results from the 2011 survey

In Kibwezi, 50.6% of the interviewed households were in villages that had received vaccination support. Only two households in unsupported villages in Kenya had ever used the ND vaccine. Of all households that had used ND vaccines, 72.9% (78/107) continued to use it after the first month. The majority of the households, 73%, reported having lost chickens during the last year to what they believed was ND. In villages where FIPS-Africa was active in 2011, the average number of chickens per household was 13.9, whereas in non-supported villages it was 11.1 ($p=0.003$). Households which had used the vaccine had on average 14.6 chickens, whereas the other households had 11.4 on average ($p=0.001$). In the village that had not received support, 23.1% correctly answered the question about what a vaccine does, that it protects against a specific disease, whereas in the FIPS-Africa supported villages, 48.8% knew this ($p<0.001$). In the majority of

households, 72.8%, the household heads were male. Male-headed households had on average two more chickens than female-headed households (13.1 and 10.9 chickens respectively).

Results from the 2013 follow-up interviews

In 2011, all vaccinators had used La Sota ND vaccines, but in 2013 all village-based advisors reported using the I-2, whereas the community vaccinators still acquired La Sota vaccines from the local stores. Each vaccinator covered between one and 14 villages. All vaccinators stated that due the on-going vaccination work, fewer chickens were dying of ND and farmers were more knowledgeable about vaccinations and had more chickens per household. All village-based advisors knew that chickens should be vaccinated at least three vaccinations per year with I2. When asked to estimate how many households vaccinated at least 90% of the birds at least three times per year, the vaccinators stated between 20 and 94%, average 57%.

Discussion

This paper reports the influence of vaccination support in villages in Kenya, through a not-for-profit company FIPS-Africa. The use of vaccine was highly associated with vaccination support in the village; only two households from villages without support had ever vaccinated their chickens. The survey in 2011 showed that households in supported villages had better knowledge that a vaccine protects against a specific disease. The vaccinators in 2013 reported that farmers are becoming more knowledgeable. Correct knowledge about vaccines, especially that a vaccine only protects against a specific disease and that multiple vaccinations are required for full protection, is important for attitudes and continued vaccine use. Expectations that the vaccine will protect against all diseases are likely to make famers disappointed and more negative (Alders *et al*., 2002) and incorrect vaccination routines may result in vaccination failure, which may cause farmers to be less positive towards continued use.

La Sota vaccine should be stored and transported under strict cold chain conditions, and this can be a challenge in remote villages (Foster *et al*., 1999). High temperatures may reduce the efficacy of the vaccine, which could make farmers perceive that the vaccine is not working. The I-2 strain was especially selected for its thermotolerant capacities to be used in developing countries (Bensink and Spradbrow, 1999). The strain has been shown to give a good immunity and work well in village poultry (Tu *et al*., 1998; Wambura *et al*., 2000). All vaccinators that had changed vaccine during 2013 reported the benefits of this.

There was no direct assessment of how many households actually vaccinated chickens the recommended three times a year in 2011; however the data suggested only a minority of farmers were vaccinating at this frequency. This is in accordance with a previous study in Tanzania (Knueppel *et al*., 2010) that showed that only a small proportion of households (13-20%) vaccinated the required amount of times, even if the vaccine was provided free by a project, or provided at a low cost. This is also in accordance with the reports of the vaccinators in 2013 with estimates as low as 20% of the number correctly vaccinating three times per year.

The estimates on the number of chickens lost to ND in the households were based on the farmers' own perception. ND can be peracute and fatal without preceding clinical signs, and signs can also be very diverse, and not pathognomonic (Alexander *et al.*, 2004). There may therefore be some inaccuracies in these numbers, but farmers' perceptions of chicken mortality are part of what informs their decisions and it is an important factor in understanding attitudes towards vaccination.

All vaccinators reported increased knowledge about the effects of vaccines, and the positive effects of increased vaccination on poultry production. This is in accordance with studies showing that vaccination support projects increase the food security and egg consumption of mothers and children (Knueppel *et al*., 2010). In conclusion, a supportive vaccination system is important for sustainable and productive small-holder chicken farming.

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A framework for environmental ex-ante impact assessment of livestock value chains

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Abstract

Livestock and fish industries are a significant source of livelihoods and income globally. They are organised in complex market chains that employ at least 1.3 billion people globally and directly support the livelihoods of 600 million poor smallholder farmers in the developing world. Livestock and fish production, processing and marketing as well as the waste produced along the value chain also cause important environmental impacts. They include atmospheric and water pollution, global warming, soil degradation, water use and pollution and biodiversity loss. Efforts to maximize yields of milk and meat, and to 'intensify' livestock and fish production, need to be balanced with long-term sustainability and

overall efficiency. We must figure out how to produce, process and market livestock and fish in ways that work for individuals, communities and the planet alike. It is thus important to assess environmental impacts before embarking on large-scale development projects geared towards livestock production and aquaculture intensification and value chain transformation. Here we present a generic conceptual framework for environmental ex-ante impact assessment of livestock and fish value chains. It is taking into account all value chain components, different spatial and temporal scales and environmental impacts across different dimensions. The framework guides users through a step-wise procedure for assessing how interventions are likely to change the production system and value chain. Through providing rapid results and flagging the main environmental issues, it can support evidence-based discussions of alternative development pathways.

Keywords: Sustainability, Impact assessment, Development, Eco-efficiency

Introduction

Livestock and fish, as part of global ecological and food production systems, are key commodities for human well-being. Their importance in the provisioning of food, incomes, employment, nutrients and risk insurance to mankind is widely recognized (Herrero *et al*., 2010; Hall *et al*., 2011). Livestock and aquaculture systems, especially in developing countries, are changing rapidly in response to a variety of drivers. Globally, human population is expected to increase from around 7.2 billion today to more than 9 billion by 2050 (UN, 2012). Rapid urbanisation and increases in income are expected to continue in developing countries, and as a consequence the global demand for livestock and fish products will continue to increase significantly in the coming decades. Livestock and fish production as well as processing, transport, marketing and waste, however, , can be the cause of important environmental impacts, such as greenhouse gas emissions contributing to global warming, soil degradation, water appropriation and pollution and biodiversity loss.

Most life cycle assessment studies that consider the whole value chain estimate that in developing countries on-farm activities are the greatest contributor to environmental impact (Fraval, 2014). The production of livestock and fish indeed depends on a variety of natural resources, such as animal and plant genetic resources, energy, water, air, land and its nutrients. Feed is grown on huge tracks of land thereby using water and extracting soil nutrients and thus impacting on soil fertility. Steinfeld *et al*. (2008) approximate that livestock utilise 3.4 billion hectares for grazing and 0.5 million hectares of cropland for the production of feeds (33% of arable land). This land use is closely linked to water cycles. Recent research (Heinke, in prep.) suggests that globally, the production of feed for the livestock sector appropriates 5,315 km^3/year of evapotranspiration (ET) (9% of global ET). The authors found that feed production from croplands uses 37% of water allocated for crop production globally, and the biomass consumed by livestock from grazing lands appropriates 32% of the total ET from grazing lands.

In terms of nutrients, livestock manure –considered a serious problem in the developed world– is a critical resource for agriculture in large parts of Africa, where soils are inherently poor (Rufino *et al.*, 2006). Liu *et al*. (2010) estimated that manure contributes between 12-24% of the nitrogen input in nitrogen cycles on cropland in the developing world. Although animal manure can be a very effective soil amendment, in systems where the land supports livestock production, its availability at the farm level is often very limited. Bouwman *et al*. (2009) conclude that it was the introduction of synthetic fertilizers that allowed the explosive increase in livestock production. However, it has also been shown that heavy application of pesticides and fertilizers results in losses of plant and animal species (Reid *et al*., 2010) as well as secondary cascading effects on a larger scale e.g. destruction of coral reefs (Koop *et al*., 2001).

Livestock production and aquaculture also impact biodiversity in several other significant ways. For example, land use with continuous cultivation of feed crops, e.g. soy monocultures, simplifies agricultural systems resulting in major biodiversity loss. Many livestock systems have, however, evolved over long periods and have a high level of biodiversity and impacts are consequently not always negative. Also, recent intensification has increased the productivity of livestock and fish production. Thus, fewer land resources are required per kg of produced product resulting in a decoupling of the linear relationship between production increases and environmental degradation (Reid *et al.*, 2010).

Apart from using, competing for and impacting on the quality of water, soil and biodiversity, livestock are also an important contributor to global greenhouse gas emissions. Estimates range from 8.5% to 18% of global anthropogenic GHG (O'Mara, 2011). According to Steinfeld *et al*. (2008), methane from enteric fermentation, nitrous oxide from manure management and carbon dioxide from land use, contribute 25, 31 and 36% to the emissions of the livestock sector

respectively. Further along the value-chain (VC), key resources used for meat, milk and fish processing include water, raw materials and energy. Processing often produces blood by-products and waste streams, while the facilities are also prone to disease spread. Food waste doesn't only have a direct impact through e.g. emissions from landfills but plays an especially important indirect role. When food is wasted, the energy and resources that go into producing that food are also wasted and greenhouse gas emissions were needlessly produced. FAO (2013) estimate that roughly one third of the food produced in the world gets lost or wasted.

Considering that the demand for meat, milk and fish is increasing, and these are only two of many sectors that will need to grow to satisfy human demands, more competition for natural resource can be expected, and existing and new trade-offs between food security, incomes and environmental sustainability are likely to occur. A revised agenda for managing sustainable growth of the livestock and fish sectors requires development of mechanisms for assessing the environmental impacts of interventions and investments in the sector, and identification of trade-offs between resource appropriation and ecosystem functioning. Consultations with environmental experts and local stakeholders from East Africa confirmed a clear demand for a tool that can flag potential environmental impacts of proposed interventions, often conceived for improving incomes and food security.

This paper therefore presents a new framework for ex-ante assessments of environmental impacts of development interventions in livestock and fish value chains. It is developed based on reviews of existing frameworks and expert consultations and is able to address environmental impacts along the whole value chain. The framework is meant to support decision making and help prioritising development action of governments, donors, NGOs and farmer organisations. It is therefore envisioned to be implemented through a user-friendly tool allowing relatively rapid ex-ante estimation of multi-dimensional environmental impacts. The Comprehensive Livestock and fish Environmental Assessment for improved Nutrition, a secured Environment and sustainable Development framework (CLEANED). The CLEANED framework is an indicator framework that takes the full value chain into account. It estimates biomass, water and nutrient flows and assesses four dimensions of environmental impacts across different spatial and temporal scales.

Value chain concept

Although the majority of the environmental impacts of livestock and fish value chains can be observed pre-farmgate, natural resource and energy use during the production of inputs, processing or transport can be significant, thus assessment methods benefit from assessment and proper identification along the complete value chain. The main VC modules included in the framework are (i) the natural resource base, where feed is produced or retrieved, (ii) production of livestock or fish, (iii) processing, (iv) marketing, and (v) consumption. In addition, "waste management" is given special attention as a component that stretches along the entire value chain. These modules can be flexibly combined into a full value chain as appropriate in the local context. Although the flows, stocks and processes at the earlier stages of the value chain are treated with greater detail, the framework also considers user-input about flows and losses at later stages. An estimate of total food losses will be used to reduce natural resource efficiencies and thereby influence the size of the environmental impacts.

Stocks and flows across scales

The processes that are considered in the CLEANED framework include (i) nutrient flows, specifically N and P, (ii) the use of land resources, (iii) water and biomass use, and (iv) waste. Different processes, stocks and interactions play out at different scales. Scales are therein defined as logical groupings of land areas referring to the size of the unit over which processes operate or at which a problem is analysed. Examples include the field scale with e.g. the processes of infiltration and drainage. While water and nutrients also flow through the landscape, crop-livestock interactions and differences in manure and fertiliser application are mostly determined at the farm scale. Land use changes are mostly implemented at the farm scale, while indirect land-use changes often play out at the regional scale. The greenhouse effect on climate on the other hand is a global issue. The spatial scales explicit in the framework include farm, landscape and regional/global.

Environmental impacts and pathways at different time scales

Any intervention along the value chain can change the biomass, water and nutrient stocks and flows and by doing so cause environmental impacts. Some of the impacts are caused directly by the action and occur at the short temporal and small spatial scales. Some impacts, however, are indirect, are likely to occur in the future or as (unintended) externalities. The framework therefore takes the direct and indirect as well as immediate and long-term impacts into account.

Key indicators

The main environmental impact categories the framework aims to assess are: water use and quality, soil health, biodiversity and climate change. Table 1 lists the specific indicators to be estimated under each category. The trade-offs between these impact categories is an important consideration in the overall environmental assessment. Different existing methods can be utilised to quantify the indicators in terms of total use as well as efficiencies - per area and/or per livestock produce. Specific impacts and impact indicators are linked to one or several spatial scales and to specific temporal scales. The projected impacts will be compared against baselines and limiting constraints.

Table 1. Main impact categories, associated indicators and scales

Impact category	Subcategory	Indicator	Rapid quantification ideas	Spatial scale	Temporal scale*
Water	Water quantity	Soil moisture used for biomass production (m^3 per time step of analysis)	Cropwat , Kc-value estimation	Farm, landscape	short term: 1 yr
	Water quantity	Streamflow and aquifers (m^3 per time step of analysis)	Water balance partitioning	Landscape, regional /global	short to medium term: 1-10 yrs
	Water quality	Organic pollution in stream	Manure management and application	Landscape	short term: 1 yr
	Water quality	Inorganic pollution in stream	Risk scoring of fertilizer and pesticide application rates and locations	Landscape	short term
Soil	Soil erosion	Sediment loss (kg/ha/timestep)	RUSLE	Farm, landscape	short to medium term: 1-10 yrs
	Soil organic matter	Soil organic matter	IPCC – Tier 1	Farm	medium to long term: 10-50 yrs
	Soil fertility	N, P content in the soil	Nutrient budget (NUTMON)	Farm	short to medium term: 1-10 yrs
Biodiversity	Crop and pasture diversity	Diversity index	Species distribution modelling	Farm, landscape	short to medium term: 1-10 yrs
	Animal genetic resources	Diversity index	Species distribution modelling	Regional	medium to long term: 10-50 yrs
	Landscape multifunctionality	Number of landuses	LU/LC	Landscape	medium to long term: 10-50 yrs
Climate change	Emissions	CH4 emission	IPCC guidelines,	Regional/global	long term: 50/100 yrs
		N2O emission	GLEAM, RUMIANT,	Regional/global	long term: 50/100 yrs
		CO2	LCA	Regional/global	long term: 50/100 yrs

Operationalizing the framework

The framework guides users through a step-wise procedure. In a first step the baselines are set. A second step entails the actual ex-ante impact assessment so that the potential impacts can be compared against the baselines (figure 1).

Setting the baseline

Smallholder farming systems and livestock and fish value chains are highly heterogeneous, diverse and dynamic. These differences influence both the applicability and the potential impacts of interventions. This first baseline step therefore involves stratifying the region of interest in different strata or simulation units, assumed to respond homogeneously to the proposed changes, and describing each regarding (i) land use and management practises; (ii) stocks and flows at different spatial scales, (iii) the livestock or fish value chain in which it is embedded, and (iv) vulnerable and limiting resources. Different data sources feed into this step, such as existing databases, participatory mapping exercises, household surveys and expert opinion.

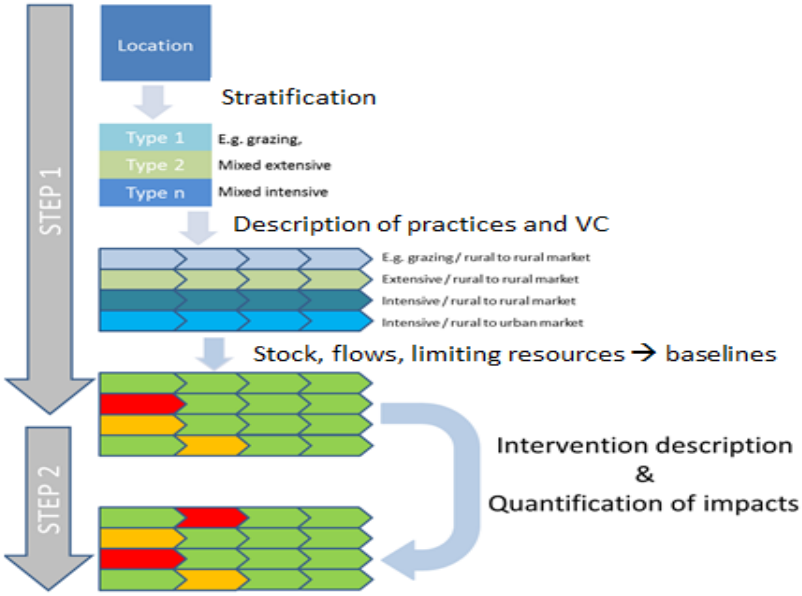

Figure 1. Operationalization of the CLEANED framework

Ex-ante impact assessment

When assessing the potential impacts of interventions, scenarios of alternative intervention strategies need to be constructed and compared in reference to a baseline. The sub-steps are:

(i) The description of the envisioned intervention(s): a myriad of interventions are possible. Examples include changing the cropping pattern and management, feeding practices, animal or herd management, milk treatment, transport or processing. A fairly detailed description of the envisioned interventions will need to be provided. The level of detail thereby needs to be in line with the envisioned assessment methods. Changes in relevant input variables will have to be specified or expected impacts qualified. The description of the intervention also needs to clarify suitability to or applicability in different environmental contexts and VCs;

(ii) The assessment of local impacts: the calculation of quantitative indicator values can be done through the use of models or simple equations. These impact values will be combined with waste and re-use estimates to come up with overall impacts. A qualitative assessment, based on qualitative scores of input variables, is possible through the translation of these scores into quantitative input variables for quantitative output calculations. These can in turn be translated into a qualitative impact score based on the potential ranges estimated from existing data, literature review or expert opinion;

(iii) Out-scaling: the stratification of the study area under step 1 aims at capturing the heterogeneity found in the region of interest. The assumption made for out-scaling is that agricultural strategies are likely to have the same relevance for areas falling in the same stratum and that the impacts can be widely applied across the landscape, region or country. Regional impacts are then calculated based on estimated levels of adoption of the promoted technology and a particular distribution of strata/simulation units. For some technologies and impact dimensions, specific models exist that estimate impacts at a larger scale, taking for example landscape or international trade interactions into account. In such case, and if time and resources allow, a more complex out-scaling exercise can be carried out, through the definition of spatially-explicit "scenarios" and feeding these into the larger-scale models;

(iv) Flagging the potential risks: in a last step the projected impacts need to be compared with a critical value or assessed against identified constraints and limiting resources. The aim is to be able to flag important context-specific issues and provide a visualization of the overall environmental impact of the intervention and trade-offs between environmental dimensions at different time scales.

Discussion and conclusion

Food security, poverty and nutrition are high on the global development agenda. Improving yields and farmer incomes are often seen as priorities and development actions are thus designed with these specific aims in mind. However, many proposed farming practices might damage the environment and generate greenhouse gases (GHG). In addition, there is increased competition for land, water, energy, and other inputs into food production.

This framework is therefore designed to ensure that actions designed to improve incomes and food security in livestock and aquaculture value chains have a minimum environmental footprint while at the same time lifting people out of poverty. It is focusing on environmental impacts and is meant to complement other more commonly applied assessments such as cost/benefit analyses and feasibility studies. We envisage that the framework would be used in a range of ways. With up-to-date information and knowledge on production systems, it should help users to identify the likely impacts of the implementation of specific technologies. Second, the framework can be used as rapid screening and discussion tool, to screen sets of interventions in farming systems at the early stages of their development. For this, many of the data are likely to be qualitative in nature. A third practice would be to use the framework to quickly evaluate the impacts of a wide range of interventions, to identify sub-sets of promising specific interventions for evaluating using more detailed quantitative information, to estimate aggregated impacts in certain regions, or to link them to global and regional change models.

The target audience for the framework are decision makers at different levels such as donors, government agencies and NGOs. It aims to provide them with a rapid ex-ante assessment highlighting potential positive and negative environmental impacts at multiple spatial and temporal scales and the trade-offs between them. Specific uses include evaluation of project proposals by donors and providing input in investment decisions of local implementers, both in the private and public sphere. An important question remains how to ensure its actual integration in the decision-making processes of these target audiences at different levels and a variety of local contexts.

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Knowledge of livestock grading and market participation among small ruminant producers in northern Somalia

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Abstract

This study focused on market participation and producers knowledge of the indigenous livestock grading and pricing system applied in small ruminants marketing in Somaliland. Data was collected from a random sample of 144 men and women producers in 3 livelihood zones: Hawd pastoral, West Golis pastoral, and Togdheer agro-pastoral zones. Results confirmed the importance of small ruminants as sources of income in producer households. Knowledge about the grading system was generally widespread, save for extreme details but this had no effect on market participation. Rather, factors that significantly influenced market participation included number of animals kept, gender of sales, decision maker, age of household head and livelihood zone.

Keywords: Livestock, Farmers, Grading system, Market participation

Introduction

Livestock is the leading economic sector in Somalia where animal production and marketing (both domestic and export selling) have persisted despite over 20 years of war and instability. According to FAO (2012), the livestock sector in Somali accounts for 40% of the country's GDP and 80% of foreign exchange earnings. At the household level, over 65% of the population is engaged in various ways in the livestock industry. Income earned from animal sales and other livestock related activities is used to buy food and other necessities thus impacting directly on food security and poverty.

Sheep and goats are among the most important livestock species reared and marketed in Somalia. In 2011, over 3 million sheep and goats worth over USD 200 million were exported to the Middle Eastern countries (mainly Saudi Arabia) at the port of Barbera (SLCCIA, 2013). Besides export, a significant number of small ruminants are marketed domestically generating employment to the local population especially women who are popularly involved in domestic meat selling and production of useful by-products such as soap and ornamentals.

To understand how market access for Somali livestock can be enhanced Terra Nuova and ILRI conducted value chain studies on livestock export in Somalia (Negasa *et al.*, 2008; Mugunieri *et al.*, 2012). The studies documented usage of an indigenous animal grading system in markets. Based on levels of important traits including age, conformation, body condition, and sex (only male animals are exported), animals are grouped into grades I, II, III, and local quality. Grade I marks the highest quality animals and these fetch the best price. Lower grades are discounted. The studies noted that the grading system offered an opportunity for producers and other intermediaries to make higher profits through quality improvement of animals sold.

Although the studies by Negasa *et al.* (2008) and Mugunieri *et al.* (2012) generated useful information for enhancing market access by actors in export marketing of livestock in Somalia, they failed to include farmers in their analysis. This is despite the importance of livestock producers in the value chain both in terms of numbers and also the role that they perform. To address this dearth of information, the current study focuses on market participation and awareness about the livestock grading and pricing system among the Somali sheep and goats producers. The study is motivated by the realization that producers cannot make deliberate efforts to exploit the grading system to realize higher incomes if they are not aware about it.

Materials and methods

Sampling

Data for this study was collected from a random sample of 144 pastoral and agro-pastoral households who reared sheep and goats in Somaliland. The study area covered 3 livelihood zones including (i) West Golis pastoral zone where goats, camel, and sheep were the main species of livestock kept, (ii) Togdheer agro-pastoral zone where rearing of sheep, goats and also vegetable production were the main agricultural activities, and (iii) Hawd pastoral zone where rearing of sheep and goats was the main activity.

Human settlements in each livelihood zone were categorized into those located close to the market (within a 20km radius) and those located far from the market. From each settlement category, 2 settlements were randomly picked. A list of households that kept sheep and goats in each selected settlement was prepared with the help of local leaders. Subsequently, 12 households were randomly selected. A semi structured questionnaire was administered on the most senior male and/or female in the sample households. If a sample household was not willing to be interviewed, it was dropped and replaced with a spare household.

Data analysis

Descriptive statistics (means and frequencies) were used to evaluate the level of awareness about the grading system and also to investigate whether the producers made any deliberate efforts to exploit the grading system for higher returns. A Heckman (1979) two stage model was used to evaluate the effect of producers' knowledge of the indigenous livestock grading system and other factors on market participation.

For the purpose of this analysis market participation was only represented as number of sheep and goats sold while purchases were ignored as buying was rather scarce in the data set. Market participation has a censored distribution and involves 2 decisions: (i) whether or not to participate in the market and (ii) how much to sell conditional on having decided to be a market participant. Under these conditions, use of a Heckman 2 stage selection model rather than ordinary Tobit regression to evaluate determinants of market participation was favoured as the latter yields parameter estimates that are biased (Bellemare and Barrett, 2005).

To model producers' decision on whether or not to participate in markets a Probit model was used. Denoting market participation as a dummy variable, Z_i which takes a value of 1if the ith producer decides to participate and 0 otherwise, the Probit model was formulated as follows:

$$Z_i = 1 \quad if \quad Z_i^* = W_i\gamma + u_i > 0 \qquad (1)$$
$$Z_i = 0 \quad if \quad Z_i^* = W_i\gamma + u_i \leq 0$$

Prob (Z_i=1|W_i)=$\phi(W_i\ \gamma)$

Where Z_i^* is an unobservable random variable representing utility derived from market participation, W_i is a set of explanatory variables influencing market participation, γ is a vector of parameters to be estimated, u_i is a vector of stochastic error terms and Φ(•) is the standard normal cumulative distribution function. It is assumed that u_i ~N(0, 1).

In the second stage of modelling (modelling the intensity of market participation), number animals sold was expressed as a function of a set of explanatory variables with the inverse of mills ratio (IMR) also included as a regressor in the equation (Equation 2). In the model IMR is represented as $\frac{\varphi(-W_i\gamma)}{1-\Phi(-W_i\gamma)}$ and serves to correct for the bias attributable to non-use of observations where no sales had taken place; φ denotes the normal probability density function; X_i is a vector of explanatory variables influencing intensity of market participation; β is a vector of parameters to be estimated; ε_i is a vector of stochastic error terms and is N(0,σ_ε^2) ; τ is an unknown parameter computed as $\rho_{\varepsilon u}\sigma_\varepsilon$ where $\rho_{\varepsilon u}$ is the correlation coefficient between the error terms ε_i and u_i.

$$Y_i = X_i\beta + \tau\frac{\varphi(-W_i\gamma)}{1-\Phi(-W_i\gamma)} + \varepsilon_i \quad if \quad Z_i = 1 \qquad (2)$$

The 2 sets of explanatory variables (W_i and X_i) comprise of same variables except for "number of sheep and goats kept" which only appear as a determinant of market participation. Essentially, the selection equation should contain at least one explanatory variable more than in the intensity of market participation equation in order to avoid the problem of week identification of parameters. Explanatory variables in the 2 equations included producers' knowledge about grading; gender, age and level of education of household head; gender of sales decision maker; and type of livelihood zone. Knowledge about the grading system was inferred from two issues ("respondents ability to correctly describe the grading system" and "knowledge of export quality grades") and was expressed on a scale of 0 to 2 depending on whether a producer had no knowledge of both issues (0), was correct on only one (1), or was right on both (2).

Results

Demographic features of surveyed households

Table 1 presents a summary of the demographic features of the surveyed households. Although majority of the households were male-headed, women accounted for majority (56%) of respondents.

Table 1. Demographic characteristics of the surveyed households

Number of households interviewed		144
Gender of respondents (% of households)	Male	44
	Female	56
Gender of household head in surveyed households (% of households)	Male	85
	Female	15
Age of household	Mean	46
	Std. deviation	13
Frequency of household heads with different levels of education	None	77
	Elementary	12
	Intermediate	8
	Secondary Graduate	3
Number of sheep and goats kept	Mean	53
	Std. deviation	44
Number of sheep and goats sold during the last 12 months	Mean	9
	Std. deviation	20
Owners of sheep and goats in households (% of	Household head only	48

households)	Spouse only	4
	Jointly by household head and spouse	48
	Others (Male child/relatives/ Business partners)	8
	Jointly in the household	53
Providers of labor for sheep and goats activities in households (% of households)	Male child	23
	A woman in the household	12
	Others(man/female child/business partner)	13
	Jointly in the household	45
Decision makers on sales and purchases of sheep and goats in households (% of households)	A woman in the household	10
	Man in the household	39
	Others (Male child/relatives/ Business partners)	9

In households where men were unavailable, a common explanation was that they were away in the bush with their livestock or they were just hanging out in market centres. Literacy levels were low with 77% of the household heads having had no formal education at all. The high incidence of illiteracy is attributable to the many years fighting which has disrupted provision of formal education in Somalia. On average a household kept 53 shoats. Commonly, shoats either solely belonged to a male head of household or to both the male household head and his wife/wives (48% of households in each case). Beside small ruminants, numerous farmers also kept other species of livestock including camel, donkeys, cattle and chicken. Rearing of camels was the most popular alternative livestock activity both in terms of numbers of farmers involved (19% to 31%) and also stocks of animals kept (on average 5.2 to 8.5 animals).

Awareness about grades

Awareness about the grading system was high with only 6% of male and 18% of women respondents being unaware. The 2 percentages were however statistically different at 1% level. Three different answers emerged when respondents who claimed to be aware about the system were asked to describe the categorisation of animals under the grading system. Majority of farmers (94% of men and 97% of women) correctly mentioned all the four grades of animals. A few famers however erroneously left out the local grade in their description (2% of men and 1% of women) while others (4% of men and 4% of women) said that the system comprised of only 2 grades.

Many farmers were also spot-on when they were probed about the factors/attributes determining grade. Over 90% of men and also women knew that age, body conformation and nutritional status were important determinants of grade. Conversely, small numbers of men (8%) and also women (5%) were unaware that breed plays no role in influencing grade in sheep and goats. Interestingly, many farmers (about 90% of men and 91%-96% of women) viewed sex as an important determinant of grade perhaps because grading was commonly performed on male animals for export.

Participation in markets

Most households (81-83%) had sold some sheep and/or goats during the previous 12 months. On average a household had sold 9 animals (sd=20). This high number of farmers reporting sales of sheep and goats and also the relative high number of animals sold authenticate the importance of small ruminants as sources of household income. Sales tended to be higher where sales decisions were made by men (mean=14.2 animals) and lowest in cases the women made these decisions (mean=4.4 animals). Grade I and II accounted for the largest proportions of the animals sold (35% and 38%, respectively) with grade III and the local grade accounting for only 14% and 13% respectively. On average, a grade I animal fetched USD 67.4 – 76.1 compared to USD 58.6 – 66.7 for grade II, USD 42.8 – 54.7 for grade III and USD 29.4 – 52.4 for the local quality grade.

Table 6 shows the Heckman two stage model results. As the dependent variable, that is, “number of sheep and goats sold during the preceding 12 months” was positively skewed, it was included in the model in logarithmic form. The model size was 138 observations (out of which 8 were censored) and the goodness of fit was statistically significant at 1% level. The parameter “rho” which represents the correlation between the error terms in “market participation” and the “intensity of market participation” model equations was also statistically significant (P=0.03) justifying the use of the Heckman’s selection model over ordinary Tobit regression.

Determinants of probability of market participation

Factors that were significant in influencing market participation included “numbers of sheep and goats kept” and “age of household head”. As expected, the size of flocks of sheep and goats kept had a positive effect on the probability of market participation. In this export orientated small ruminant production and marketing system, animals sold are often males

while females are retained for breeding. Where flocks are small, production of male animals for sale is likely to be low thus minimising the chance of producers participating in markets as sellers. Also, producers with fewer animals may give priority to building up their stocks before engaging in any selling.

Probability of market participation was significantly higher in cases where household heads were relatively younger (P=0.05). This finding perhaps reflects the higher demand for income often faced by relatively younger parents at a stage where many of their children are highly dependent on them. Also, such young adults may not have accumulated much wealth in other forms making them more dependent on sale of sheep and goats whose production is relatively easier to get into.

Awareness about the livestock grading system had no significant effect on the probability of market participation. This lack of significance may be attributable to the fact that knowledge of the fundamental issues about the grading system is already widespread (section 5.4) and that fine issues such as ability to correctly describe the grading system and also knowledge of which grades of animals are exported does not make any difference with respect to market participation.

Table 2. Heckman's two stage model estimates of factors influencing market participation and also participation intensity

		Market Intensity Coef.	Participation Std. Err.	Market Participation (0,1) Coef.	Std. Err.
Constant		1.15***	0.38	0.87	1.18
Gender of household head (1=man; 0=woman)		-0.33	0.22	0.15	0.84
Knowledge of the grading system		0.06	0.10	0.14	0.30
Age of household head (years)		0.00	0.01	-0.04**	0.02
Level of education of household head		-0.04	0.08	0.42	0.48
Sales decision maker (base of comparison=a female in the household)	Male household head	0.73***	0.21	0.04	0.69
	Jointly by spouses	0.37*	0.20	0.15	0.65
Survey region (base of comparison=Togdheere agro-pastoral)	Hawd pastoral	0.35**	0.18	0.42	0.67
	West Golis pastoral	0.54***	0.19	0.24	0.63
Number of sheep and goats kept				0.04**	0.02
/athrho		-0.74	0.31		0.02
/lnsigma		-0.26	0.07		0.00
rho		-0.63	0.19		
sigma		0.77	0.05		
lambda		-0.49	0.16		
Number of obs = 138	Prob > chi2=0.0001				
Censored obs =8	Log likelihood = -168.4				
Uncensored obs=130	LR test of independence of eqns. (rho = 0): chi2(1) = 4.46 Prob > chi2 = 0.03				
Wald chi2(8)=31.71					

***,**, and * indicate that the dependent variable is statistically significant at 1%, 5% and 10% level respectively

Determinants of intensity of market participation

Consistent with results of the descriptive statistics, gender of household head had no significant effect on intensity of market participation. On the other hand, households where sales decisions were made by either a male household head or collectively by both spouses tended to have more intensive participation (P=0.01 and 0.1, respectively) compared to cases where these decisions were solely made by women. The strong effect of sales decision making by male household heads on intensity of market participation perhaps relates to a trend that has been reported in past studies of men assuming greater control of activities in cases where these tend to be important sources of household cash income.

It was also found that producers in West Golis and Hawd participated in the market more intensively compared to their counterparts in Togdheere. This finding perhaps relates to differences in livelihoods in the 3 study sites. Unlike Togdheere which is agro-pastoral, West Golis and Hawd are strictly pastoral with only livestock as the main source of livelihood. In the absence of crop production, livestock producers in West Golis and Hawd may need to sell more animals to raise all the amount of money they need to finance their food purchases. Again, knowledge of the livestock grading system had a no significant effect on intensity of market participation.

Conclusions and Recommendations

This study focused on market participation and awareness about the indigenous livestock grading and pricing system among small ruminants' producers Somaliland. Results confirmed the importance of these animals as a source of income to producer households. Consistent with findings in previous studies, participation by women in the rearing and marketing of small ruminants was found to be strong implying that these activities provide a good entry point in promoting gender parity in economic welfare in producer households in Northern Somalia.

Producers were well versed about the grading system safe for a few minute details but this had no significant effect on market participation and participation intensity. Both market participation and participation intensity were higher among pastoralists compared to agro-pastoralists which underscore the huge importance of sheep and goats among the pastoralists. Number of animals kept significantly influenced market participation justifying interventions designed to safeguard stocks of small ruminants held by producers. Market participation intensity was significantly lower where sales decisions were made by women pointing to a need to search for ways to correct this situation.

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Kenyan milk consumers' behaviour and perceptions of aflatoxin

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Abstract
Aflatoxin contamination in food is a human health threat in many developing countries. This study examines Kenyan milk consumers' behavior related to, and perception of aflatoxin contamination. The study considered two groups of respondents: raw milk consumers mainly located in peri-urban areas of Nairobi, and processed milk consumers located in urban areas. Results indicate that practically all raw milk consumers and the majority of processed milk consumers boiled the milk before its consumption believing that the product was completely safe after boiling. Aflatoxin awareness was very high for the urban milk consumers and relatively high for the peri-urban ones. In both groups, almost half of the respondents who had heard about aflatoxin knew that it can be transferred into milk. Most respondents, however, did not know how to avoid aflatoxin-contaminated milk. Given the credence characteristic of aflatoxin consumer education and awareness raising programs alone will not be able to solve the problem. Efforts along the whole value chain and at the level of government are needed to reduce the use of aflotoxin spoiled feed and secure aflatoxin safe milk at the consumer level.

Keywords: Aflatoxin, Consumers, Health, Kenya, Milk

Introduction

Aflatoxins are mycotoxins produced by certain species of moulds, mainly *Aspergillus flavus* and *Aspergillus parasiticus.* The problem is rooted throughout the food chain, and as freedom of choice in food is limited for a poor and food-insecure population, exposure to aflatoxin is a widespread and important public health threat in the developing world. Chronic exposure to aflatoxins increases the risk of liver cancer, suppresses the human immune system and has been estimated to cause about 26,000 deaths in sub-Saharan Africa (Grace and Unnevehr, 2013). Estimates suggest that there are more than five billion people worldwide at risk of chronic exposure to aflatoxins (Williams *et al.,* 2004; WHO, 2005).

Because Kenya´s climate is favorable to the growth of aflatoxin-producing moulds, the country faces a high risk of mycotoxin-related livestock and human poisoning (Lanyasunya *et al.,* 2005). Humans are exposed to aflatoxins not only through staple foods such as cereals, but also through animal-sourced food such as meat, eggs, viscera and, especially, milk (Jarvis, 2002). When lactating animals consume significant amounts of aflatoxin-contaminated feed, the aflatoxin is metabolized, and a part of the metabolites is transferred into the milk (Lanyasunya *et al.*, 2005; Lizárraga-Paulin *et al.*, 2011). The most effective means of controlling aflatoxin in milk is therefore by restricting its presence in the cattle´s feed (FAO, 2005).

As the partnership for aflatoxin control in Africa (PACA) (2013) highlights, one major challenge is the low level of awareness of the problem of aflatoxin – not only among resource-poor consumers and farmers, but also among decision makers, health professionals and extension workers. The current study is one step towards a better understanding of consumers´ awareness of aflatoxin. As the analysis also aims at revealing important insights in Kenyans´ milk purchase and consumption behavior it can serve as a starting point for future actions with respect to aflatoxin.

Materials and methods

The surveys were conducted in July and August 2013 using face-to-face interviews with consumers/ buyers of raw and processed milk on public streets of the greater area of Nairobi, the capital city of Kenya. Nairobi District is a very representative area for milk production and consumption due to its intensive dairy production systems and high human and cattle populations (Omore *et al.,* 2005). Data for raw milk were collected in Dagoretti, a peri-urban poor area of Nairobi, which is situated in the west of Nairobi city. The processed milk survey was conducted in different urban areas of Nairobi characterized by mainly middle-income inhabitants such as Buru-Buru, Nairobi West and South C.

For the selection of respondents, systematic sampling was conducted, pursuant to assumptions of randomness over time. Completion of each interview was followed by the contact with a subsequent interviewee. Refusal to participate (an early

concern of the authors) was negligible making systematic bias concerning respondents´ characteristics unlikely. All categories of consumers were targeted, by carrying out the survey across different periods of time. This involved data collection from Tuesday until Saturday from 9 am to 6 pm for a 3-week period. Four interviewers led to a total sample size of 310 respondents for the raw milk questionnaire and 299 for the processed milk questionnaire.

Results and discussion

In the raw as well as in the processed milk survey there were almost equal proportions of male and females who answered the questionnaire. The majority of the interviewed consumers (around 80%) were between 21 and 40 years old. Respondents were asked about their milk purchase habits (Table 1). While in Dagoretti, and thus in the poorer peri-urban area of Nairobi, raw milk was the first choice for the great majority of respondents, consumers in the urban areas in general indicated that they preferred processed milk. Cow milk consumption had been a sample selection criterion and thus all respondents consumed cow milk. Other types of milk, such as goat and camel milk, played a negligible role in respondents' milk consumption.

Table 1. Milk purchase habits of Kenyan citizens: results based on the raw and processed milk survey

Characteristic	Raw milk sample (n=310)		Processed milk sample (n=299)	
	Characteristic level	%	Characteristic level	%
Quantity of milk bought/purchase occasion	0.5 litre	12	0.3 litre	1
	0.6 litre	18	0.5 litre	57
	1.0 litre	38	1.0 litre	20
	2.0 litres	9	2.0 litres and more	12
			I don´t remember	10
Price per litre	40 KES/litre	12	80 KES/litre	20
	50 KES/litre	21	90 KES/litre	43
	60 KES/litre	20	100 KES/litre	11
	65 KES/litre	14	Other	10
	70 KES/litre	14	I don´t remember	16
Place of purchase*	Shop	41	Shop	65
	Producer/farmer	25	Super-/Hypermarket	77
	Milk bar	25	Milk bar	1
	Kiosk	15	Kiosk	6
	Hawker	10	Hawker	1
Frequency of milk purchase	More than once a day	22	More than once a day	14
	Once a day	69	Once a day	55
	Once/week< <once/day	5	Once/week < <once/day	20
	Once a week	0	Once a week	7
	Less than once a week	4	Less than once a week	4

*Multiple selection was possible

Women were significantly more often responsible for the household´s milk purchase than are men. The place where people buy their milk varies in the two surveys and thus, by area. More than 40% of respondents in Dagoretti, the peri-urban area of Nairobi normally buy their raw milk in a shop. However, 25% prefer to purchase it directly from producers/farmers and the same proportion from a milk bar. Kiosks (15%) and hawkers (10%) are the least common buying places. Since most people in regions such as Dagoretti cannot afford refrigerators, they have no possibilities to cool their milk. Accordingly, more than 90% buy milk once or more than once a day in order to ensure freshness. Regarding the 'processed milk survey' carried out in middle income areas of Nairobi, the results reveal that this milk is normally bought in a super-/hypermarket (77%) or in a shop (65%). Kiosks, milk bars, and hawkers only play a minor role as purchase places. More than half of the respondents buy milk once a day and 14 % more than once a day. These numbers reflect the consumers´ concerns with respect to the freshness and quality of milk.

About 60% of raw milk consumers report not knowing who has produced the milk they are buying. The remaining 40%, who do, were asked how much they trust the farmer to provide hygienically produced raw milk. Almost 95% indicate that they fully or mostly trust the producer; only five percent do not trust at all. Moreover, all respondents were asked how much they trust the seller to provide hygienic raw milk. Again, the results reveal a high level of trust. Among the processed milk consumers, about 75% know who has produced the milk they are buying and almost 90% fully or mostly trust that the producer provides hygienically produced milk.

There is a considerable variation with respect to the price raw milk respondents pay for their milk. This ranges from 30 KES/litre to 95 KES/litre, though most consumers pay between 40 KES/litre and 70 KES/litre, which could suggest possible adulteration of milk through water addition. This could suggest that almost every respondent knew how much raw milk they recently purchased, as well as how much they had to pay, which indicates that they are very price-sensitive. Results of processed milk consumers differ. First, packaged milk is more expensive: prices per litre primarily ranged between 80 KES and 100 KES. Second, ten percent of the processed milk respondents did not remember the amount of milk and 16% did not know the price of the milk they recently bought. Compared to the peri-urban raw milk consumers, significantly more urban milk buyers neither remember the amount of milk bought nor the price of it. This indicates that the urban population compared to the peri-urban one has less concern about prices of necessities.

Survey results for consumption habits are presented in table 2. Almost all respondents report boiling raw milk prior to consumption and around 95% believe milk is totally safe after boiling. Results are similar for processed milk consumers, except that the share of consumers boiling their milk prior to consumption is with 80% smaller. Health and hygiene concerns are the main reasons stated for boiling the milk, followed by “because everybody does it”. This holds for raw as well as processed milk consumers.

Table 2. Milk consumption habits of Kenyan citizens: results based on the raw and processed milk survey

Characteristic	Raw milk sample (n=310)		Processed milk sample (n=299)	
	Characteristic level	%	Characteristic level	%
Boiling milk prior to consumption	Yes	99	Yes	79
	No	1	No	21
Milk is safe after boiling	Yes	95	Yes	93
	No	5	No	7
Reasons for boiling the milk*	Health concerns	77	Health concerns	53
	Hygienic concerns	64	Hygienic concerns	34
	No refrigeration	18	No refrigeration	3
	Uncertainty about milk´s freshness	11	Uncertainty about milk´s freshness	8
	Because everybody is doing it	21	Because everybody is doing it	10
			To warm the milk	14
Personal Consumption Frequency	Daily	43	Daily	48
	Several times per week	5	Several times per week	8
	Occasionally	31	Occasionally	31
	Never	21	Never	13
Own infants´ Consumption Frequency	Daily	67	Daily	65
	Occasionally	9	Occasionally	3
	Never	21	Never	13
	I don´t know	3	I don´t know	19
Own children´s Consumption Frequency	Daily	55	Daily	58
	Several times per week	4	Several times per week	0
	Occasionally	18	Occasionally	13
	Never	8	Never	7
	I don´t know	15	I don´t know	22

*Multiple selection was possible

Almost half of the respondents drink milk on a daily basis where the quantities of 300 ml, 600ml and 900 ml are the most frequently reported among raw milk consumers and 250 ml, 300 ml and 500 ml among processed milk consumers.

To obtain more detailed information on milk consumption of respondents’ children, infants (younger than 3 years) were distinguished from older children (from three to 18 years of age). Around 20% of the interviewed persons´ households in

the raw and processed milk survey had children younger than three years. Of those children, around 65% consume milk daily. Most infants from raw milk consuming households drink between 300 ml and one litre milk per day. The respective amount among processed milk consuming infants with 150ml to 300 ml per day considerable lower. Almost half of the respondents in both surveys have children aged between three and 18 years in their household. Around 55% of those children consume milk on a daily basis. However, 20 to 30% of infants and children never or only occasionally consume milk.

When comparing the two groups regarding milk consumption, it is noticeable that a considerably higher number of the urban population neither knows about the amount of milk consumed by their infants or children nor the frequency of their respective consumption. This can be explained by the fact that urban parents more often employ a nanny who takes care for their children than peri-urban ones do. Besides, people in low-income areas consume significantly more milk than middle-income groups. This might be because of their limited food choices due to availability and individual financial restrictions that force them to cover their nutrient requirements with those products that are easily available and affordable.

Table 3 summarizes important findings with respect to consumers' aflatoxin awareness. Regarding the raw milk questionnaire, results show that 55% of respondents had previously heard about aflatoxin. More than half of the people who had heard about aflatoxin believe, or know, that it can be transferred into milk. Some 45% had never heard about aflatoxin. Nevertheless, 34% of that group believe that the toxins can be transferred into milk. Without distinguishing between those two groups, almost half of the 312 respondents believe or assume that aflatoxins in cattle feed can be transferred into the cow´s milk.

Table 3. Aflatoxin awareness of Kenyan citizens: results based on the raw and processed milk survey

Characteristic	Characteristic level	Raw Milk %	Proc. Milk %
Heard about aflatoxin	Yes	55	80
	No	45	20
Aflatoxins can be transferred into milk	Yes	45	45
	No	14	9
	Don´t know	41	46
People who have heard about aflatoxin	Aflatoxin can be transferred	54	51
	Aflatoxin cannot be transferred	17	9
	Don´t know if Aflatoxin can be transferred	29	40
People who have not heard about aflatoxin	Aflatoxin can be transferred	34	18
	Aflatoxin cannot be transferred	12	10
	Don´t know if Aflatoxin can be transferred	54	72
Health impact on humans	Serious threat	53	71
	Medium threat	19	16
	Minor threat	10	2
	No threat at all	3	1
	I don´t know	15	10
Possible to make contaminated milk safe	Yes	37	23
	No	27	29
	I don´t know	36	48
Options to make contaminated milk safe	Boiling	75	62
	Processing/pasteurizing/purification	10	--
	Treating with chemicals or herbs	9	--
	Not feeding contaminated feed	6	--
	Use of new technologies or/and chemicals	--	31
	Controlling/testing of milk or/and feed	--	14

Among processed milk consumers, the share of respondents who had previously heard about aflatoxin is much higher (80%) than in the other sample (55%). In addition, the vast majority (72%) of those who had never heard about aflatoxin indicate that they don't know whether it can be transferred (raw milk sample 54%). Without distinguishing between those who have heard or not have heard about aflotoxin, almost half of the 299 respondents in the processed milk survey believe that aflatoxins in feed can be transferred into the milk.

Further, respondents were asked to assess the health impact on humans when consuming contaminated milk. The majority perceive a serious or medium threat. They were also asked if it is possible to make contaminated milk safe for human consumption. There is no substantial difference in the answers given, between persons that knew about aflatoxin before, and those that did not. Of raw milk consumers, 37% assume that it is, 27% think it is not, and 36% do not know if it possible to make contaminated milk safe. These shares are different for processed milk consumers. 23% of this group think that there are ways to make contaminated milk safe, 29% assume it is not possible, and 48 % indicate that they do not know. Respondents who indicated that they believe it is possible to make contaminated milk safe for human consumption were also asked how this can be done (an open-ended question). In both surveys the majority of consumers (in the raw milk survey 75%; in the processed milk survey 63%) answered boiling, including extensive boiling and the combination of boiling and refrigeration, with the latter being the most provided answer. However, in fact boiling the milk will not help to make aflatoxin contaminated milk safe.

Besides, the survey assessed milk consumers´ main sources of information. Multiple answers were allowed and the results are consistent with those achieved by USAID in 2010. Television is the most popular source of information, stated by more than 80 %. This is followed by radio, newspaper and internet. Consequently, TV and radio are the most efficient channels to inform people in peri-urban as well as urban areas. These communication means are available to organizations in order to spread information about health threats such as aflatoxins.

Conclusion and implications

This study reveals important insights into Kenyans´ attitudes and behaviour regarding milk purchase and consumption as well as citizens' knowledge with respect to aflatoxin. The results show that the majority of Kenyans boil their milk before consumption. Hence, most zoonotic agents are eliminated and the risk of being exposed to pathogens such as *Brucella* spp. and *Escherichia coli* are minimal (Omore *et al.*, 2005). However, boiling the milk does not eliminate aflatoxin as mycotoxins are heat-stable. The study shows that people are not aware of this. They have insufficient knowledge about aflatoxin and its associated health risks in milk. Thus, it seems essential to enhance consumers´ understanding about this. Only in this case consumers can realise the danger associated with aflatoxin contaminated milk and can appreciate efforts in the food value chain to eliminate those risks. The latter likely will induce higher costs and lead to higher milk prices. There are trade-offs between the negative nutritional impacts of reducing milk consumption and the positive health impacts of reduced exposure to aflatoxins.

However, consumers' awareness and appreciation alone will not be sufficient to tackle the health risk. 'Aflatoxin safe" is a credence characteristic of milk which is not easily detected by consumers, either before or after the purchase of the milk. Thus, it is essential that the dairy sector acknowledges its responsibility in producing milk that is safe for consumers by better controlling aflatoxin contamination throughout the milk value chain. Research and policy need to support producers in those efforts. Policy, in addition, needs to control the level of aflatoxin in milk given its detrimental effects for the most vulnerable groups of the Kenyan population, children.

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Adoption of East Coast fever vaccine among smallholder dairy farmers in Kenya: the case of North Rift Kenya

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Abstract

Diseases are a major constraint limiting dairy cattle production, with East Coast Fever (ECF) ranking among those of high economic importance. The high cost of ECF control and treatment led to the development of the ECF vaccine which is envisaged to be safer, cheaper and effective. This paper takes the case of 181 randomly sampled smallholder farmers from North Rift Kenya, to estimate the determinants of uptake of East Coast Fever (ECF) vaccine in dairy areas. Among other results, the paper shows that the vaccine was likely to be adopted by relatively well-off households whose main source of income was off-farm employment, had relatively large herd sizes and could afford to practice on-farm tick control. Farmers with higher levels of education and advanced in age were also likely to adopt the vaccine. The paper derives important policy implications for enhanced dairy goat technology uptake in the Kenyan highlands.

Keywords: East Coast Fever vaccine, Dairy cattle, Adoption, Kenya

Introduction

Cattle are an integral part of farming in Sub-Saharan Africa. In Kenya, development of the dairy subsector has been the focus of national development strategies as evidenced by the Agricultural Sector Development Support Programme (ASDSP), Vision 2030, the National Livestock Policy and Feed the Future (FtF) Programme. Milk is the most economically important livestock product with an estimated value of KES 257.811 billion in 2009 and an estimated 70% of the total gross value of livestock's contribution to the agricultural sector (Behnke and Muthami, 2011). Diseases are a

major constraint limiting dairy cattle production with East Coast Fever (ECF) ranking among those of high economic importance.

The ECF is caused by *Theileria parva* parasite and transmitted by the *Rhipicephalus appendiculatus* tick. The high cost of ECF control and treatment increases production costs through its high cost of control and treatment making it inadequate and unsustainable thus led to the development of immunization methods envisaged to be safer, cheaper and more effective (Mukhebi and Perry, 1993). One such vaccine is the 'Muguga cocktail' live vaccine.

Muguga cocktail has mainly been used within pastoral cattle production systems and proven effective, but its administration in smallholder dairy cattle systems is not well documented. Thus, an initiative to immunize dairy cattle was implemented in 2010- 2011 in North Rift Kenya by VETAID with technical support from the Department of Veterinary Services (DVS), International Livestock Research Institute (ILRI) and Kenya Agricultural Research Institute (KARI). The main aim of the project was to promote use of the vaccine and evaluate its effectiveness under smallholder dairy production systems.

VETAID created and potential of the ECF vaccine and conducted immunizations among willing households in the target areas, with impressive results on the performance of the vaccine (Turasha, 2011, Mugambi *et al*., 2013). However, information on factors influencing adoption of the vaccine remains scanty. In an attempt to fill this knowledge gap, this case study paper analyzes the determinants of ECF vaccine adoption in North Rift Kenya where promotion of the vaccine was conducted. It hypothesizes that the adoption of vaccine is influenced by, among other factors, socioeconomic, demographic and dairy cattle enterprise management characteristics of households.

It is expected that an understanding of the importance of these factors will guide targeting of farmers and regions, and prioritization of ECF vaccine awareness campaigns for enhanced uptake even after withdrawal of funded programmes.

The following section provides the methodology, the variables used, hypotheses being tested in the study and the empirical model, while the third and fourth discuss the results and conclusions respectively.

Methodology

The study area

The study was conducted in Uasin Gishu (Ziwa and Sirikwa sites), Kericho (Kipkelion site) and Nakuru (Olenguruone site) Counties which are located in the North Rift Kenyan region. The three counties are similar in many aspects including agro-ecological conditions, farming systems, population densities, cultural and economic activities. They were selected for this study as a follow-up to a pilot project implemented by VetAID-Kenya and financed by the Food and Agriculture Organization of the United Nations (FAO-Kenya) which focused on immunization of dairy cattle using the Muguga Cocktail ECF vaccine from December 2010. Immunizations were conducted in smallholder dairy production systems in the region.

Data collection procedures

The study utilized primary data collected in a household survey conducted between August-September 2013. Ziwa and Sirikwa sites were selected in Uasin Gishu County, Kipkelion site in Kericho County and Olenguruone site in Nakuru County were purposively selected, the criterion being those that participated in the ECF vaccine pilot delivery project.

Selection of the sites was guided by key informant interviews conducted with VetAID, Kenya Dairy Farmers Federation (KDFF) and Heifer International. Within each site, a cooling/chilling plant was the focal point during the ECF vaccine pilot delivery project where vaccinations were conducted among members of the milk cooling chilling plants. With the guidance of personnel in each cooling/chilling plant, sampling frames consisting of members whose cattle had been vaccinated were developed, and those who had not participated in the ECF vaccination programme. From these, a total of 181 households were randomly selected. The sampled households were interviewed by trained enumerators using a semi-structured questionnaire which had been pretested. In addition to socioeconomic and demographic characteristics, data on cattle production practices and ECF vaccination characteristics was also collected.

The Empirical Model

The econometric model developed in this study is based on the random utility theorem (Gujarati, 2003) which postulates that consumers (in this case, farmers) will choose or adopt a technology which can maximize their utility. The decision to adopt a technology or not is a binary decision which can be represented as a qualitative variable whose range is actually limited since it can only take on two values: adopt or not adopt. An adopter in this study is defined as any farmer who had vaccinated cattle (at least one) against ECF at the time of the study. Thus adoption at the farm level describes the realization of farmers' decision to apply a new technology in the production process (Rogers, 1995).

An empirical model (Equation 1) was derived for econometric analysis and analyzed using probit regression.

$$VACC\_ADOPT = \beta_0 + \beta_1 AGE + \beta_2\ GENDER + \beta_3\ EDUCATION + \beta_4\ OCCUPATION + \beta_5\ EXOTC\_BREED + \beta_6\ CATTLE\_NUM + \beta_7\ MKTD\_MILK + \beta_8\ GRAZE\_SYS + \beta_9\ TICK\_CONT + \beta_{10}\ EXP\_ECF + \varepsilon \quad \text{(Equation 1)}$$

Description of variables and hypotheses

The explanatory variables (independent variables) used in this study include demographic characteristics, socioeconomic and dairy cattle enterprise characteristics. Their definitions and hypotheses are presented in Table 1. The dependent variable is VACC_ADOPT (adoption of ECF vaccine technology). It is coded 1 if a household has vaccinated against ECF, and 0 if otherwise.

Table 1. Definition of explanatory variables

Variable	Definition	Hypothesis
Gender	Sex of the household head (1=Male, 0=Female)	+
Education	Education level of the household head in years	+
Occupation	Main occupation of the household head (1=Farming 0=Off-farm)	-
Age	Age of the household head in years	+
Mktd_milk	Whether the household markets more milk than consumed / calf fed (1=Yes 0=No)	+
Tick_cont	Method of tick control (1=Spraying 0=Dipping)	+/-
Exotc_breed	Breed of cattle (1=Exotic /crossbred 0=Indigenous)	+
Cattle_num	Number of cattle kept	+
Exp_ECF	Whether the household has experienced ECF (1=Yes 0=No)	-
Graze_syst	Whether the cattle management system is zero grazing (1=Yes 0=No)	+

The rationale for selection of the variables was based on literature review of similar agricultural technology adoption studies. Demographic factors are represented by the variables AGE and GENDER which are hypothesized to have a positive influence on adoption of ECF vaccine just like in other adoption studies (Adesina and Chianu, 2000; Baltenweck and Staal, 2000).

Among the socio-economic variables, the education level of the household head (EDUCATION) is likely to influence the adoption decision positively as been demonstrated in dairy cattle studies (Baltenweck and Staal, 2000; Staal *et al.*, 2002). The main occupation (OCCUPATION) of the household head is hypothesized to negatively influence the adoption decision because farmers with an off-farm income source are more willing and able to pay for the vaccine.

Dairy cattle enterprise characteristics include breed of cattle (EXOTC_BREED) and size of herd (CATTLE_NUM). It is expected that farmers with relatively large cattle herds and with exotic breeds would be willing to make additional investments to improve the productivity of their dairy cattle enterprises. It is also hypothesized that those producing milk and selling a higher proportion than the quantity consumed at the household level (MKTD_MILK) would be willing to take measures to reduce production costs and ensure minimal disruptions to the income flow obtained from the enterprise. Experience with ECF incidences in the past (EXP_ECF) are hypothesized to expose farmers to the high cost of treatment of ECF or death of the infected animal thus prompting the farmer to ensure other cattle in the herd are protected. The grazing system (GRAZE_SYS) and method of tick control (TICK_CONT) are proxies for the farmer's willingness and ability to invest into the dairy cattle enterprise.

Data management

Data coding, entry and cleaning was done using SPSS Version 19 software. Descriptive statistics which included frequencies, means and cross-tabulations were generated using SPSS and used to characterize households' socioeconomic

and demographic characteristics and practices. The econometric probit model was analyzed using LIMDEP statistical software.

Results and discussion

Descriptive statistics of the sample households

Farming was the main occupation for majority (72.8%) of the households while 21.1% were salaried workers and 6.1% were self-employed off-farm. Majority (92.2%) of the sampled households were male-headed with the mean age of the household heads being 50 years. Ninety five percent (95%) of the household heads had at least acquired basic education with the mean number of years of formal education being 10 years. This indicates that most of the households in the research area had acquired the basic primary education level. Majority of the households (85%) were married and living together with their spouses while the rest comprised of those married but with one of the spouses living away, single and widowed.

Factors determining adoption of ECF vaccine

The results of the Probit model are presented in Table 2. The model correctly predicted 84% of the responses and the Chi-square value (53.96) was highly significant at less than 0.001%. The Psuedo R^2 was 26% which is within the range allowed with the kind of data being analyzed in this study (Mbata, 1997; Greene, 2003). The other model statistics are presented at the bottom of Table 2.

Table 2. Probit results - factors influencing adoption of ECF vaccine

Variable	Coefficient	Std. Error	t-ratio
Constant	-2.046**	0.814	-2.513
Gender	-0.368	0.443	-0.832
Education	0.065**	0.031	2.102
Occupation	-0.562**	0.270	-2.082
Age	0.026***	0.009	2.816
Mktd_milk	-0.057	0.230	-0.250
Tick_cont	0.720***	0.252	2.853
Exotc_breed	0.056	0.262	0.215
Cattle_num	0.087***	0.022	3.997
Exp_ECF	-0.217	0.229	-0.948
Graze_syst	0.424	0.543	0.781

Log likelihood function -92.35
Restricted log likelihood -119.33
Chi-squared = 53.96***
Pseudo R^2 = 0.259
No. of observations = 180
** and *** = significant at 5% and 1% levels, respectively

The Probit model results showed that except for GENDER and MKTD_MILK, all the other variables had the hypothesized signs. Thus, our hypotheses that male farmers and those who market higher quantities of milk than what they use by the household (consumed and fed to calves) were more likely to vaccinate their cattle against ECF, could be proved by this study. The coefficients of these variables are however not significant and thus would not make sense to discuss them further.

Among the household head's characteristics, EDUCATION and AGE of the household head emerged as key variables that significantly and positively influenced the probability of adption of the ECF vaccine. The positive coefficients of these factors indicate that farmers who were more educated were more likely to understand the benefits of the vaccine hence vaccinated their cattle against ECF, while those more advanced in age were likely to have more experience in cattle rearing, hence understand the likelihood of cattle getting ECF and the associated negative effects, thus vaccinating against the disease. OCCUPATION of the household head had a significant albeit negative influence on the farmer's likelihood to vaccinate against ECF. This factor indicates that farmers whose main occupation was off-farm employment were more

likely to vaccinate their cattle against ECF compared to full-time farmers. This relationship may be attributed to the higher purchasing power of off-farm employees hence their ability to meet the cost of vaccination.

As hypothesized, TICK_CONT (method used in control of ticks in a herd) had the positive influence on adoption of the vaccine. Farmers spraying cattle as a tick control practice were more likely to adopt the vaccine. Spraying as a tick control method was indicative of a relatively well-off farmer implied by the ability to purchase equipment and acaricides, and employ labour required for spraying at the farm level. CATTLE_NUM had a positive significant influence on adoption of the vaccine. This factor indicates that households with larger herd sizes had a higher propensity to vaccinate against ECF than those with smaller ones. This may be attributed to the ease in selling cattle or cattle products (e.g. milk) to meet the cost of vaccination for other cattle in the herd.

Conclusions and recommendations

This study made an attempt to estimate empirically factors that influence farmers' uptake of the East Coast Fever vaccine. The study identified characteristics of farmers likely to adopt this technology. The factors generated can therefore assist in identifying and targeting farmers who are likely to adopt the vaccine in the future. To some extent these results could also be used in prioritizing ECF vaccine technology awareness campaigns.

The paper has shown that the likelihood of adopting the vaccine is positively linked to off-farm occupation, relatively large cattle herds and on-farm tick control methods (spraying). These factors are indicators of relatively well-off farmers. Thus, to enhance adoption, farmers with these characteristics can be targeted since they are more likely to adopt the technology than their resource-poor counterparts. In addition, to ensure that their resource-poor counterparts are not marginalized in adopting the technology, lobbying for subsidies targeting them would accelerate their adoption thus enhancing equitable access to benefits of the technology.

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POSTER PRESENTATION

Analysis of the economic performance of peri-urban smallholder pig production enterprise in Masaka and Mukono Districts, Uganda

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Abstract

The study examined the performance of the smallholder pig farmers in Mukono and Masaka Districts of Uganda. The benchmarking survey was carried out in four sub-counties of these districts using structured questionnaire interviews on a random sample of 132pig farmers. The analysis of the performance was based on gross margin assessments. The results showed that smallholder pig farmers earn positive gross margins (USD 51 per pig unit). The pig farmers located in peri-urban and urban areas (urban-urban value chain) make higher gross margins than those in the rural areas (rural-urban value chains). Several interventions were identified to further improve the performance of smallholder pig producers. These include improved linkages to markets and business development service providers through collective action and other simple and affordable technology innovations to reduce on feed costs.

Keywords: Performance, Pig units, Herd inflows and outflows, Peri-urban.

Introduction

Piggery is an important enterprise in Uganda. About 1.1 million households are involved in pig production as a source of food and income (UBOS, 2012). Uganda has the highest per capita consumption of pork in East Africa estimated at 3.4 kg/ year in 2010. At the national level, pork is the second most consumed type of meat after beef hence making it an important source of proteins. Pork production in Uganda in 2012 has been estimated at 115,000 metric tonnes from 1,916,000 slaughtered animals (FAOSTAT, 2014). In Kampala alone an average of 300-500 pigs are slaughtered in a day (Tatwangire, 2012). Although pig production is gaining prominence among smallholders, it is non-existent in the Uganda government livestock sector prioritization of enterprises that could get smallholders out of poverty (Malaiyandi *et al*., 2010). In Uganda piggery is considered to be too risky for investment due to the endemic presence of African swine fever (Netherlands Embassy, 2012). However, there is a huge potential for growth in the pig sector if constraints are minimized. At the production level, some of the constraints include parasites and diseases, high cost of inputs, inadequate capital, expensive feeds as a result of erratic feed supply associated with price fluctuation and seasonal availability, inadequate advisory services, lack of good quality breeding stock, poor and unorganized marketing, expensive veterinary drugs and uncontrolled pig movement (Ouma *et al*., 2014) . Although many smallholders are involved in the pig enterprise, there is lack of information on the economic performance of the enterprise in Uganda. This paper aims to fill this gap by generating evidence on the economic performance of smallholder peri-urban pig farms in Masaka and Mukono Districts of Uganda using household survey data.

Materials and Methods

Producer level household surveys were conducted between May to June 2013 in Masaka and Mukono Districts of Uganda. These districts were selected due to their high pig population density and potentials of the enterprise for pro-poor development (Ouma *et al*., 2014). Four sub-counties and ten villages representing peri-urban pig production areas including Katwe-Butego and Kabonera in Masaka District; Mukono Town Council and Kyampisi in Mukono District were covered. Kabonera and Kyampisi were included in the survey, though compared to the rest, they are relatively far from urban towns but target the urban markets. Katwe-Butego and Mukono Town Council are typical urban-urban value chains[5]. The sampling frame of the study was pig keeping households in the study sites. Lists of pig keeping households

were generated by the Veterinary departments in both districts, in collaboration with the local councils of the respective villages within the sub-counties. A random sample of 132 pig keeping households was then drawn for interviews by using STATA 11 software from the lists of pig farmers. The data was analysed using statistical package of STATA 11 and Microsoft Excel 10.

Data concerning herd inflows and outflows, revenues and costs associated with the pig enterprise were collected. To assess the performance of the smallholder pig production, gross margins were estimated. To calculate the revenues, the pig sales of the preceding 12 months were determined and the inventory was valued so that the total revenue of the household could be valued. Several variable costs including labour, feeds, veterinary costs and breeding services were covered.

The gross margins were calculated per pig unit. In order to define a pig unit, a table of live weights was adopted from Mutua (2012) that had estimated pig weights in Uganda (Table 1).

Table 1. Estimated pig weights in Uganda

	Average actual live weights of pigs in Uganda, kg	Pig Units equivalency
Young Pigs≤ 5 months	17.7	0.3
Market age pigs>5 and≤10	38.2	0.6
Breeding Pigs>10 months	62.2	1

Source: (Mutua, 2012)

A pig unit was defined as equivalent to a breeding sow of more than 10 months of age which has an average live weight of 62.2 kg. Based on these, equivalence pig units were estimated for the different categories of animals (Table 2).

Table 2. Pig units for different pig categories

Category	**Pig units**
Piglet/weaner	0.3
Gilts/finisher	0.6
Sow	1.0
Boar*	1.2

* A boar was assumed to be slightly heavier than the sow (74.6 kg live weight)

Gross margins

To calculate the gross margins the following formulae was adopted:

$$GM = \sum_j P_j Q_j - \sum_i P_i X_i$$

Where GM is the annual gross margin in Uganda shillings per pig unit; $\sum_j P_j Q_j$ is the total revenue from the pig enterprise and consist of the following parameters; sales of pigs, value of the inventory and boar service. P_j is a vector of price associated with the output/service; Q_j is the annual number of pigs sold, owned or number of times the boar serviced; P_i is a vector of input prices X_i is the annual quantity of the ith input used in the pig enterprise and $\sum_i P_i X_i$ is the summation of all the variable costs.

The revenue sources that were considered included sales, the inventory (pigs, piglets, gilts, finishers, weaners, sows and boars) that farmers held and the revenue got from boars servicing the sows in the neighborhood. The inventory value was calculated using the market prices of the different pig type categories. The costs included feeds (swill, fodder crops and feed concentrates), labor (family and hired labor), veterinary health costs (drugs and treatment fees), breeding services (taking the sow to the boar) and the losses.

Results

Gross margins

The average gross margin per pig unit for the two districts under study was Uganda shillings 126,815 for one year ($51) (Table 4). Producers held a slightly higher value of animals than what they sold off per pig unit (inventory value, UShs 155,861 per PU *vs.* total sales UShs 117,028 per PU). When the sources of feeds were analyzed, concentrate feeds cost the highest (UShs 85,926 per PU) while the fodder crops were the least cost (UShs 965 per PU). Considering the only two

sources of labor, family labor cost (UShs 27,585 per pig unit) more than hired labor (UShs 9,158 per PU) showing high labor investments by smallholders in the pig enterprise. This may proxy the importance of the enterprise to the household livelihoods. Total losses were UShs 36,129 per PU, mainly due to piglet mortality, but theft was also a major source of losses. The payment for boar services was also included, because it represents a change in inventory, given that the service is paid mostly in kind in the form of one piglet to the boar owner.

Table 4. Annual gross margins in Uganda shillings per pig unit in the study area

	Variable	n	Mean	SEM
Revenue	Pig Units	132	6.48	1.7
	Total sales	132	117,028	117,292.6
	Inventory Value	132	155,861	117,516.5
	Boar Service Revenue	132	29,579	91,095.5
	Total Revenue	132	302,468	
Variable costs	Concentrates feeds cost	132	85,926	93,946.8
	Fodder crops cost	132	964	4,118.3
	Swill cost	132	2,839	7,101.1
	Family Labor	132	27,582	23,541.8
	Hired Labor	132	9,158	19,009.2
	Veterinary health cost	132	8,644	8,617.0
	Boar service Cost	132	4,411	5,257.2
	Total Costs	132	139,524	
Losses	Mortality losses	132	29,589	43,949.2
	Other losses	132	6,539	8,947.5
	Total losses	132	36,128	
Margins	Gross margins	132	126,815	

1 USD = 2500 Uganda shilling at the time of study

When we compare the different value chain domains the urban-urban value chains had higher gross margins (UShs 136,157 - 170,160 per PU) than the rural-urban value chains (UShs 76025-124,918 per PU) (Table 5). Generally, Mukono District had higher gross margins per pig unit compared to Masaka District, possibly due to its close proximity to Kampala city, which represents a large demand centre.

Table 5. Gross margins per value chain domain

Value chain domain type	District	Gross Margins
Urban-urban	Masaka	136,157
	Mukono	170,160
Rural-urban	Masaka	76,025
	Mukono	124,918
Effective mean		126,815

Discussion

In general, pig production is a profitable enterprise for the smallholder pig farmers, since it yields positive gross margins. In Nigeria and Malawi similar studies have been done on the pig production systems have also positive gross margins (Ezeibe, 2010) and (Mbaso and Kamwana, 2013). The producers located in peri-urban and urban areas (urban-urban value chain) make higher gross margins than those in the rural areas(rural-urban value chains). The reasons for the higher margins in the urban areas are; close proximity to the lucrative markets, less transaction costs, especially on transportation and having much more accessibility to market information than their counterparts in the rural areas. For the same reasons mentioned earlier farmers in Mukono District have higher gross margins than Masaka because of the close proximity to the biggest pork consuming area in Uganda (Kampala city). The highest cost component was on feeding, especially from purchased concentrate feeds. Efforts to minimize such costs through alternative feeding strategies from technological innovations such as balanced diets that utilize locally available feed resource may go a long way to further improve smallholder performance. For example, farmers need to make better use of the nutritious but cheaply available fodders, such as sweet potato vines, cassava and yam leaves while applying smart and strategic use of concentrates for supplementation.

Economic losses can also be reduced if farmers control early piglet deaths, which represent on average UShs 29,589 per pig unit. Proper feeding of the sows to increase milk production, and good hygiene to reduce diarrheas are some of the management measures that will help to reduce mortality in piglets.

In conclusion, the pig enterprise is a profitable and important enterprise for the pig farmers in Uganda. It performs better in the urban areas than in the rural areas and can be better improved through linkages with lucrative markets and service providers through collective action and other simple and affordable technology innovations.

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Determinants of milk market participation among Sahiwal farmers in Kajiado and Narok Counties, Kenya

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Abstract

Pastoralists mostly depend on livestock production and small scale crop production for food and income. To improve pastoralists' livelihoods, Sahiwal cattle were introduced by Kenya Agricultural Research Institute (KARI). This breed of cattle is resilient and dual purpose in nature with the benefits of both improved milk and beef production and better adapted to harsh conditions that pertain to Arid and Semi-Arid Lands (ASALs). With potential expected increase in milk production, the market profiles both in terms of output levels and channels are likely to change, yet the underlying factors of this change are unclear. Using a random sample of 384 pastoralist households from Narok and Kajiado Counties, this study analyzed factors that influence market development in pastoral areas, using Double hurdle (DH) model in order to provide information on possible effects on the output market changes contingent on increased production as a result of increase in number of Sahiwal cattle breed for milk market development. From the results it was noted that factors influencing decisions in marketing had different effects on decision to participate and extent of participation. The results indicated that the Sahiwal cattle increased market participation because of increased marketable surplus. Farmers who had high income levels participated in market because they could meet transaction costs associated with marketing and increased distance reduced level of participation because of increased transaction costs. Groups were a source of market information and they therefore reduced the level of information asymmetry. Training of farmers in diversification on farm sources of income and group formation was necessary to increase market participation.

Keywords: Double hurdle, Milk market participation, Pastoralists, Sahiwal.

Introduction

With its adaptability to the ASAL climate, Sahiwal genetic resources can contribute to increased milk production and hence offer a source of livelihood. For this to be realized, access to market for the surplus milk is inevitable. Nonetheless, access to rural markets is characterized by many factors that determine the ability of farmers to participate in these markets or not. Several studies have evaluated the factors that determine market participation and the extent to which farmers involve themselves in different markets. In these studies, various factors have been observed to influence decisions on market participation. For example Bellemare and Barret (2004) in their study on determinants of livestock market participation in Kenya and Ethiopia found that high transaction cost that was determined by market accessibility negatively influenced the decisions by farmers to participate in the market. This was emphasized by Makhura *et al*. (2001), Ehui *et al.* (2009) and Omiti *et al.* (2009) who noted that factors that lowered transaction cost were likely to influence farmers to participate in markets. Conditions and circumstances in different areas vary and also with different products in the market.

This shows that decisions on market participation are likely to be influenced by environment and situations that surround the farmer. Unfortunately, most of the market participation studies have not been conducted in areas where the Sahiwal genetic resource have been introduced as a dual purpose breed, and one that have a likely effect on market participation. Although livestock dynamics are expected to allow the rural poor to contribute to the growing market most pastoralists lack reliable marketing outlets that could provide full benefit especially from Sahiwal cattle genetic resources (Devendra, 2001; Omore *et al.*, 2004). There are constraints that restrain farmers in pastoral areas from selling cattle milk thereby failing to get the benefits from the market. To achieve these benefits it is necessary to address constraints within the milk

marketing system and ensure that the farmers participate in milk markets. This study therefore aims at determining the factors that influence participation in milk markets among the pastoralists. The information generated from this study can be used to draw insight on relevant interventions to ensure pastoralists participation in milk market enhancing market development.

Methodology

Study area

Narok County lies within latitude 0º 50' and 2º 05' South and within longitudes 35º 58' and 36º 05' East. It has a population of about 850,920 persons with poverty rate of 38.3% (GoK, 2009). About 70% of the people in Narok have primary education and only about 7% have attained secondary education (GoK, 2009). Kajiado County lies within latitude 01º 53' South and within longitudes 36º 47' East. It has a population of about 687,312 persons with poverty rate of 11.6% (GoK, ibid). About 62% have primary education and about 12% have attained secondary education (GoK, ibid).

Data collection

Narok and Kajiado Counties were purposively selected because of the presence of pastoralists having a priority of keeping Sahiwal cattle. Multistage sampling technique was then used. The sample unit constituted of individual households from pastoralist and three hundred and eighty four households were sampled. Data was collected in December 2012 and January 2013 using a pretested structured questionnaire through personal interviews.

Empirical model

To determine the factors influencing decision and extent of market participation a Double hurdle model was used. The choice of this model was based on the fact that the decisions to participate in the market and how much or the level of participation can be made jointly or separately by the farmer (Berhanu and Swinton, 2003). Other models such as Tobit model assumes that the two decisions are affected by the same set of factors (Greene, 2000). When censored data models such as Tobit are used in market participation analysis, the factors leading to participation are assumed to be the same as those that determine the intensity of participation. If a given farmer characteristic is known to have positive influence on decision to participate in the market then it may lead to prediction that a farmer will choose to participate in the market (Teklewold *et al*., 2006). Double-hurdle model generalizes the Tobit model by allowing for a separate first hurdle which represents a farmers' decision to participate in market, and a second hurdle which represents the decision about how much to sell in the market. A sale is realized only after both hurdles are cleared, the two decisions can be modeled as dependent on or independent of each other (Cragg, 1971). Explanatory variables may appear in both equations or in either of one and a variable appearing in both equations may have opposite effects in the two equations (Teklewold *et al*., 2006).

In the double hurdle model, it is assumed that if a household make a decision to participate in the market, the resulting observation for sale is positive and the Double-hurdle model is then represented as;

$$P(Y_1 = 1) = P(Q_s > 0) = Z_1\alpha + e \qquad (1)$$

Y_1 defines the market participation decision and takes the value of 1 if the household made a decision to participate in market and a value of 0 if no participation, Q_s represents quantity or value sold in the market, Z_1 is the set of variables that enter the first hurdle defining factors that affect the discrete probability of market participation, α is a parameters to be estimated and *e* is an error term that is normally and independently distributed with a mean of zero. When $Y_1 = 1$ then the quantity sold is represented in an equation as;

$$Q_s = X_1\beta + u \quad (2)$$

where, Q_s represents quantity or value sold in the market, X_1 are set of variables that enter the second hurdle defining factors that affect the discrete probability of intensity of participation, β is a parameter to be estimated, *u* is an error term that is normally and independently distributed with a mean of zero. The dependent variable (participation) refers to whether the farmer had sold milk or not and the dependent variable in the second hurdle refers to the amount of milk that was sold.

Description of variable used in the analysis

Herdsze (the total number of cattle owned by the household) is a continuous variable measured by number of cattle kept. A marginal increase in herd size is expected to positively influence decision on market channel choice and market participation because of the expected marketable surplus. Bardhan *et al*. (2012) found that increased production of milk positively influenced market participation among the smallholder dairy farmers in Uttarakhand.

Education_Level (the education level of the household head) is a categorical variable indicating the number of years that the household head has schooled. Household with more years of education are more likely to accept new ideas to improve household income as well as find information on production and market therefore enhancing market participation. In a study by Holloway *et al*. (2000) education was found to have a positive effect on quantity of milk supplied to the markets in Ethiopian highlands. The variable *Occupation* (the main occupation of the household head) is a categorical variable showing various activities that farmers engaged in to earn their livelihoods. Main occupation of the household head is likely to influence the level of income thereby positively or negatively influencing the choice of marketing channels and market participation. *Age* (age of the household head) is a categorical variable and is often used as a proxy for experience in farming. Studies by Tiunza *et al*. (2001) and Ouma *et al.* (2010) reported positive effect of age on market participation.

Tldsze (total land size owned by the household in acres) is a continuous variable measured in acres. Land may have a positive influence on participation by enabling pastoralists to produce more milk generating surpluses for selling as observed by Omiti *et al*. (2009). A study by Bardhan *et al*. (2012) noted a negative influence on market participation with more land for the household because dependence on dairying as supplementary income decreased with increase in land size.

The variable *Grupmebersp* (household member belonging to a group or association) is a dummy with 1 indicating group membership and 0 indicating non membership to groups. Participation of household to groups increases access to information important both in production and marketing. Variable *Totacattle_milkprod* (total amount of milk produced per day) is a continuous variable measured by litres of milk produced by the household. A marginal increase in amount of milk produced is expected to have significant effect on amount of milk surplus marketable and consequently have an influence on decision to participate in the market. *Femaleown_milk* (who make decision on use of milk) is a dummy variable with value of 1 for wife, 0 others. Women have been observed to own and market most of the milk among the pastoralists and therefore women ownership of milk is likely to positively influence participation in the milk market.

Income (total income from live animal sales plus milk sale per year) is a continuous variable measured in KES with the annual income from sale of all livestock and livestock products. Pastoralists with high total incomes are likely to participate in markets because they are able to meet transaction costs such as transportation of milk to the market. Increased income is also likely to enable farmers invest on Sahiwal cattle and other input leading to increased production positively influencing market participation. *Tdist* (total distance covered to the point of milk sale) is included in the model to capture transaction costs and its role in influencing market participation. Many studies have found distance to influence decisions in market participation. For example Omiti *et al*. (2009) and Ouma *et al.* (2010) noted that long distances reduced market participation and the amount sold due to increased transaction costs. It is expected that farmers located far from the markets increase travel time and costs which impact negatively on market participation.

Tsah (total number of Sahiwal cattle owned) is a continuous variable, the higher the number of Sahiwal breed a farmer has the more likely they are to participate in the market and to have marketable surplus. *Acs_road* (access to all weather roads) is a dummy variable introduced to capture effect of market access on milk marketing decisions expected to influence market participation positively. Markets are sources of information and likely centers for milk collection by the buyers. Ease of access to marketing points increases interaction between farmers and buyers reducing transaction costs. *Narok* (Narok County) is a location dummy introduced to get the effect of location of the farmer. The influence on market participation is likely to be positive or negative. The variable *buyer* (milk sell points) is a categorical variable representing marketing channel choices by the farmers. Presence of different types of buyers is expected to influence farmers differently participate in milk markets.

Results and discussion

Analysis of descriptive results

This section provides descriptive summaries of famers' socio-economic factors. Tables 1 and 2 presents the descriptive statistics of key variables used in this study. Chi square (χ^2) or *t*-test were used where appropriate for statistical significance or else, for differences between Counties. Several variables showed significant mean differences between Counties in the study area.

Descriptive statistics for farmers' socio-economic characteristics
Table 1 presents the means and standard deviations of socio-economic characteristics of the respondents.

Table 4. Descriptive statistics for variables used in the analysis

Variable	Mean	Standard deviation
Amount of milk sold	30.090	45.373
Age Below 35	0.177	0.382
Age 35-45years	0.260	0.439
Age Over 45 years	0.564	0.497
Distance to the market	4.305	6.975
Access to good roads	0.275	0.447
ln income	13.223	1.185
Female milk use decision	0.826	0.380
Retailer buyer	0.195	0.397
Processor buyer	0.086	0.280
Middlemen buyer	0.379	0.486
Neighbor buyer	0.096	0.295
Average milk price	34.036	11.096
ln amount of milk sold	3.102	1.028
ln total number of cattle sold	3.445	0.966
ln total Number Sahiwal	3.677	1.471
ln total land size	4.249	1.708
ln Herd size	4.275	0.973
Group membership	0.468	0.500
Occupation farmer	0.849	0.358
Agro-pastoralist	0.636	0.482
No formal education	0.400	0.491
Primary education	0.249	0.433
Secondary education	0.184	0.388
Tertiary education	0.166	0.373

The data revealed varied trend in the mean and standard deviation of the variables considered.

Econometric results
The results from the empirical analysis are presented below in two sub-sections. In the first section determinants milk market participation are presented and discussed. Then, the determinants of level of participation in milk market are presented and discussed in the second section. STATA version 11 was used in data management and analysis.

Factors influencing milk market participation
Table 3 presents the double hurdle results on market participation. The variable representing income earned from livestock sales had positive significant influence on milk market participation. The households with high levels of income from livestock sales had a higher probability of participating in milk markets. Lapar et al. (2003) observed that farmers with high level of income participated in milk markets because they could bear risk associated with marketing. This suggests that well-off households in terms of high income levels participated in milk markets possibly because they could meet the transaction cost of participating in markets.

There was positive significant relationship between amount of milk produced and the decision to participate in milk market as presented in Table 3. Households that produced more milk had a higher probability of participating in milk markets. This indicated that with increase in amount of milk produced the pastoralists were likely to make a decision to sell milk possibly because of increased marketable surplus. The results are consistent with findings by Bardhan et al.

(2012) in their study among smallholder dairy farmers in Uttarakhand who found that increase in production increased farmers participating in markets.

Table 3. Double hurdle coefficients of factors influencing milk market participation

Variables	Whole sample	Kajiado	Narok
Neighbor buyer	1.935 (0.612)*	1.982 (1.153)***	7.648 (8.858)***
Middlemen buyer	2.154 (0.364)*	2.693 (0.728)*	2.690 (0.787)*
Processor buyer	1.461 (0.542) *	1.013 (0.834) ***	2.036 (1.068)
Retailer buyer	1.734 (0.529)*	2.234 (0.792)*	6.435 (7.473)**
Female owner	-0.192 (0.412)	0.693 (0.690)	-1.307 (0.957)
Narok county	0.631 (0.245) *	-	-
Age over 45yrs	0.473 (0.377)	1.874(1.332)	0.391 (0.662)
Age 35_45yrs	0.167 (0.436)***	0.950(1.364)	-0.454 (0.807)
Primary education	-0.103 (0.330)	1.415(1.456)	-0.696 (0.538)
Secondary education	-0.272 (0.383)**	-0.617(0.895)**	-0.507 (0.587)
Access to good roads	0.591 (0.283) **	1.164 (0.476)*	0.371 (0.442)
ln Income	0.161 (0.188) *	0.2238 (0.313) *	0.289 (0.326)**
Distance to market	0.719 (0.172)	0.925 (0.242)	0.994 (0.311)
Number of Sahiwal	0.012 (0.001) *	0.001 (0.000) ***	0.051 (0.000) *
Herd size	-0.011 (0.002) *	-0.001 (0.002)	-0.010 (0.000) ***
Group member	0.291 (0.305) ***	0.437 (0.493) ***	0.806 (0.793) ***
Milk produced	0.784 (0.301)*	1.468 (0.628)**	-0.021 (0.621)
Land size	-0.111 (0.093)	0.132 (0.168)	-0.224 (0.195)
Constant	-3.150 (2.029)**	-7.258 (3.601)**	-1.074 (3.427)**

	Whole sample	Kajiado	Narok
Number of observations	334	148	186
Wald chi2(17)	71.250	32.070	18.980
Prob > chi2	0.000	0.001	0.089
Log likelihood	-1214.004	-484.705	-708.164

Note: *, ** and *** denote significance at 10%, 5% and 1%, respectively, Standard errors are in parenthesis
Source: Survey data, 2013.

The location of the farm had a positive significant influence on decisions of the farmers to participate in the milk markets. From the result farmers from Narok County were more likely to participate in milk markets. This is probably because farmers in Narok County produced more average milk as observed in differences between County means and this was likely to increase amount of milk available for marketing positively influencing market participation.

There was a positive significant relationship between the neighbours, middlemen, processors and the retailer buyers on farmer's decision to participate in milk market in the whole sample. The middlemen had the highest influenced followed by the neighbours. The plausible reason could be that the neighbours and the middlemen were easily accessible to the farmers and they provided an easily accessible market for sale of the surplus milk. These findings were in tandem with Enete (2009) who found that presence of buyers who were easily accessible to the farmers made them to sell surplus produce. These buyers also offered average higher prices and this could possibly influence the farmers to participate in milk markets. This indicated that presence of milk buyer influenced decision of the pastoralists in participating in milk markets.

The education level (secondary education) of the household head had a negative significant influence on decision to participate in the milk market as compared to farmers with no formal education. This is probably because with more

education the farmers are able to look for other jobs and diversify income sources and consequently use milk for consumption at home. This was in line with Lapar *et al.* (2003) in a study on smallholder livestock producers in Philippines who established that educated farmers had opportunities for off-farm employment. These findings were inconsistent with Holloway *et al.* (2000) in a study on Transaction Costs, Cooperatives and Milk-Market Development in the Ethiopian highlands and found that educated farmers were able to gather more information influencing market participation.

Ownership of Sahiwal cattle significantly influenced the decision to participate in milk markets positively; the influence was highest in Narok County because on average they had higher numbers of Sahiwal breeds than their counterparts in Kajiado. Farmers in Narok County had large number Sahiwal cattle as observed from the means in chapter four, table 2, consequently farmers in Narok County produced more milk than their counterparts in Kajiado. High milk production from Sahiwal cattle was likely to influence marketing of surplus milk. Sahiwal cattle represent an asset base for milk production in pastoralist area and an increase in asset base is likely to influence participation. This was in line with Dovonan and Poole (2014) and Amanikwah *et al.* (2012) who indicated that investment in assets scaled up the level of production positively influencing participation.

Access to all weather roads had a significant positive influence on market participation significant in Kajiado County as presented in Table 3. The households that had access good roads that were accessible at all times were likely to participate in milk markets. Buyers in the rural areas bulk milk from various households or collection points, ease of access to this households and collection points maximizes on the profits by reduction of transaction costs associated with poor road infrastructure. Dovonan and Poole (2014) observed that improvement of market access through accessible roads increased probability of market participation.

Pastoralists' membership to groups and associations positively and significantly influenced the decision to participate in the milk markets as presented in Table 3. The households that were members of organized groups had a higher probability of participating in milk markets. This implied that groups were a source of market information and this reduced the level of information asymmetry between the farmers and milk traders. Barret and Christopher (2008) stated that smallholder farmer participation to groups influenced the decision to sell farm produce.

The herd size negatively and significantly influenced participation in whole sample and Narok County. Households with large herd sizes were unlikely to participate in milk markets. This indicated that dependence on dairying as additional source of income decreased with increase in herd size. Herd size indicated level of wealth in a household and the higher the income from cattle sale the less likely a household was to look for supplementing incomes. Bardhan *et al. (*2012) in their study noted that farmers with low incomes sold more milk to supplement their lower incomes.

The ages between 35 to 45 had a positive and significant influence on market participation as presented in Table 3. With increase age of the household heads it was likely that the farmers would sell milk. The possible reason could be that with increase in age farmers were likely to be more experienced and needed more resources to cater for the growing family needs. With increase in age farmers were likely to have high capital which increases level of production, positively influencing market participation.

Factors influencing the level of participation in milk

Table 4 presents the double hurdle results on extent of milk market participation. The household income had positive significant influence on amount of milk sold in the market in whole sample and Narok County. This indicated that poor households sold little amount of milk in the market. This could be explained by low level of production among the poor households or inability to meet the transaction costs that are associated with increased volumes marketed.

The amount of milk produced had a positive significant relationship with amount of milk sold as presented in Table 4 This indicated that increased milk production increased the amount that was sold. This was in tandem with the findings by Omiti *et al.* (2007) who found that increased production led increased level of market participation.

Table 4. Double hurdle coefficients of factors influencing the level of participation in milk market

Variables	Whole sample	Kajiado	Narok
Neighbour buyer	-43.542 (13.505)*	-39.801 (22.032)***	-44.183 (18.454)**
Middlemen buyer	-11.291 (9.337) ***	-1.748 (9.802) **	-21.263 (14.295)

Processor buyer	3.302 (5.194)***	7.072 (3.273) **	0.272 (4.591)
Retailer buyer	-13.616 (10.856) ***	3.166 (11.212)	-23.984 (17.030)***
Female owner	-2.222 (9.000)	17.622 (13.068)	-8.465 (12.712)
Narok county	-4.23 (3.130)	-	-
Age over 45yrs	4.047 (9.283)**	13.782(13.285)**	5.489 (11.474)***
Age 35_45yrs	4.980 (10.429)	5.343(14.709)	3.041 (12.626)
Primary education	10.893 (8.168)	19.384(12.152)	3.624 (10.034)
Secondary education	-7.167 (9.738)	-8.716(14.580)	-3.788 (10.889)
Access to good roads	6.502 (7.621)***	-2.722 (8.411)	7.676 (11.320)
ln Income	12.099 (6.086)**	5.037 (7.378)	16.011 (8.718)***
Distance to market	-0.483 (3.430)***	2.020 (3.942)	-1.827 (5.530)
Number of Sahiwal	7.878 (3.988)**	4.812 (3.786)	13.107 (7.275)***
Herd size	-0.037 (0.019)*	-0.023 (0.015) ***	-0.041 (0.029) **
Group member	2.603 (7.225)	-1.075 (8.897)	3. 440 (10.258)
Milk produced	101.400 (8.881)*	91.094 (9.140)*	107.262 (14.922)*
Land size	-0.073 (2.228)*	-0.401 (3.558)	-1.144 (3.300)*
Constant	-513.630 (76.023)*	-393.081 (96.421)*	-556.117 (105.899)*
sigma cons	34.484 (2.243)*	25.803 (2.395)*	37.815 (3.285)*

	Whole sample	Kajiado	Narok
Number of obs	334	148	186
Wald chi2(17)	71.250	32.070	18.980
Prob > chi2	0.000	0.001	0.089
Log likelihood	-1214.004	-484.705	-708.164

Note: *, ** and *** denote significance at 10%, 5% and 1% confidence level, respectively. Standard errors are in parenthesis; Source: Survey data, 2013.

Though land size did not significantly influence decision to participate in milk market in whole sample and Narok County as presented in table 3 in previous section, it had a negative significant influence on amount sold as presented in Table 4 Pastoralists are likely to keep breeds that produce meat if they had large land sizes and this is likely to explain the inverse relationship between extent of participation and land size.

The number of Sahiwal cattle owned per household had a positive significant relationship with amount of milk sold. Farmers who had large number Sahiwal cattle were likely to produce more milk consequently having more marketable surplus. When farmers raise their asset base in production in increasing number producing units, more is likely to be produced for sale. These findings are in tandem with those of Amanikwah *et al.* (2012) who found that increased capital base led to increased level of market participation which resulted from increased production.

The amount of milk sold in the market was positively and significantly influenced by the age of the household head (age category of over 45 years) as presented in Table 4 Level of investment and experience is highly correlated with age. Farmers are likely to have high level of production and networks for milk market with age. This corroborated with findings Staal *et al.* (2006) who established that experience which was highly correlated with age influenced the level of market participation.

When the available buyers for the surplus milk were the neighbors, middlemen and the retailer buyers, their influence on amount of milk was negative and significant. This implied that these buyers could not buy large quantities of milk because of possibly their low handling capacity and they were not in a position to trade with large milk capacities. The processors had a positive relationship with amount of milk sold in the market probably because of their capability to handle large amount of milk.

The distance covered to the market hand a negative significant influence on amount of milk sold. The distance increases the cost of transaction that the farmers incur in delivering milk to the market and this is likely to reduce amount sold. Barret and Christopher (2008) in their study on Smallholder Market Participation in Eastern and Southern Africa found that reduced cost of transaction by improvement of market infrastructure positively influenced amount sold.

Conclusion

In enhancing market participation among the pastoralist actors should note that household total income play a significant role. This therefore indicates that innovations to increase income among the poor households can be instrumental in exploiting marketing opportunities. Interventions to reduce risk of household reduced income are pivotal by training farmers on diversification on income generating enterprises. Increasing number of Sahiwal cattle breeds owned by the farmers through breeding programs and awareness is essential. The groups provided information and financial services to the farmers and these are critical in accessing market opportunities. Increasing social capital among the pastoralists is therefore of great value in enhancing access to markets. Development agencies need to focus on infrastructure development to ensure that farmers can easily access the markets.

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Milk supply contracts and default incidence in Kenya

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Abstract
Using cross sectional data from all 47 Counties in Kenya, the presence of contract breaches between the producers and chain intermediary node was investigated. Most farmers did not engage in contracting and for those who did, many of these contracts were found to be informal. In addition, most of these contracts (whether formal or informal) were breached. However, some buyers appeared to be associated with contract breaches. A distinct pattern emerges showing that larger milk producers were more likely to make formal contracts than small producers while the results also confirm that most of the contracts between farmers and individual consumers as well as traders and middlemen are informal and subject to contract breaches. Using a multiple correspondence analysis, these associations between contract breaches and farmer characteristics were explored. Results indicate that collective action institutions encouraged formalization of contracts while households that did not engage in some form of collective action engagements in most cases make informal contracts although both formal and informal contracts are equally subject to contract breaches. An examination of the underlying institutional, psychological and sociological drivers to contract breaches is recommended as such information can reveal how best to upgrade successful contract farming arrangements.

Introduction

Though dairy production in Kenya is the most commercialised in the Eastern African region, there are few production contracts at producer level linked to cooperatives, self-help groups, milk bulking/cooling centres and processors (Pelrine, 2009). With a share of almost 80% in raw milk supplies, small-scale farmers dominate dairy sector in Kenya. While only a small fraction of milk produced enters the formal market, the growth in demand for value-added dairy products, not only in the country but also within the East African Community (EAC), offers opportunities for making dairy farming more profitable for smallholders. To make this value chain more inclusive requires assurances of a stable supply of raw milk meeting food safety and quality standards, reduction in production and transaction costs thereby making raw milk supply a more stable and remunerative enterprise for smallholders. Many constraints confront smallholder farmers who often find it difficult to participate in markets for their products. Milk is perishable and bulky and moreover, in many occasions, producers cannot make short term investment decisions to cease production e.g. milk producers have already committed up-front investments and cannot easily abandon such investments at the drop of a hat. Low production by dispersed producers can also result in further power imbalances between buyers and sellers especially when producers act alone and have low access to market information. High transaction costs can also result from the lack of assured markets, high marketing costs (due to fragmented value chains), high costs of monitoring and quality assurance, high transport as well as dealing with contract breaches. Furthermore, seasonal volatility of raw milk supplies is pronounced due to predominantly rain-fed production system where many smallholders do not apply supplementary feeding mainly due to high feed prices.

Following the deregulation of milk prices in 1992, many milk marketing innovations emerged to complement the then state controlled Kenya Co-operatives Creameries. Compared to other commodities (e.g. maize) facing high price volatility, the dairy sector stabilized somewhat though some volatility persisted with one of the main causes being weather related factors (Karanja *et al.*, 2003). This can be further compounded by climate change which a study by Kabubo-Mariara (2008) suggesting that livestock enterprise choices can be influenced by climate change variables such as temperatures reducing the probability of farmers keeping dairy cattle and increasing the probability of holding beef cattle.

Contract farming (CF) involving forward agreements specifying obligations of partners in a business transaction can be an avenue for some to bridge these barriers or share the imminent risks present in production and marketing in uncertain environments. Contracts can be efficient in linking producers to markets and are also effective in integrating smallholders into mainstream markets (Costales and Catelo, 2009). However, contracts per se are not a panacea for all these challenges though successful CF models share in a number of characteristics. These include being able to fairly share value between business partners who have a voice to influence key decisions, including business risks and rewards (Vermuelen and Cotula, 2010).

In the dairy sector, some farmers have made such contracts with firms while other farmer groups are vertically integrated and have ventured into both processing and distribution of milk and milk products. However, this number is still small and still, many farmers still appear to prefer spot market transactions. Abdulai and Birachi (2008) identified three coordination mechanisms employed by producers and traders in the dairy value chain and showed that written contracts were sparingly used compared to verbal contracts and spot market transactions. They also demonstrated that the extent of advance price information as well as time taken to sell milk and physical distance separating players in the business transaction tend to influence the type of coordination mechanism chosen by market players. Fischer and Qaim (2011) also demonstrate that in the case of bananas in Kenya, more diversified farmers are less likely to market collectively though previous benefits from collective marketing positively influence their intensity of group participation.

Peer pressure from groups on the other hand can reduce behaviors such as side selling (Fafchamps, 2004) and trust based relationships nurtured over time can act as an enforcement mechanism (Fafchamps and Minten, 2001). In Kenya the success of the horticulture industry is partly attributable to CF and Hoeffler (2006) and Wainaina *et al.* (2012) argue that CF is beneficial to both potato and poultry farmers respectively. There is still debate about the definitive role of CF in Sub-Saharan Africa (Oya, 2011) though CF is credited to have played a significant role especially during the immediate post colonial period in Kenya when tea and coffee farmers were able to form cooperatives to market their produce.

Cases of side selling outside the contract are real however, and which, from a firm's perspective, maintain supply risks for which contracts are entered into in the first place (Glover and Kusterer, 1990). Reasons for contract breach include poor contract design, mistrust between contact partners or even contracts not made on sound analysis and planning by both parties. For instance, using an experimental approach on contract design in Vietnam, Saenger *et al.* (2012) show that

although sanctions on farmers to produce milk of high quality can induce quality increases, they are not as effective as bonus payments.

In another paper from that study population, a gender dimension suggests that female farmers decision to trust in a contract arrangement may be different from that of men—they are less likely to trust when the cost of trusting is higher (e.g. in the presence of collusion) but are more trusting overall (Torero and Viceisza, 2011). A number of research articles have also shown that trust improves the outcomes in exchange implying that contractual arrangements—especially verbal ones relying on trust can still function with little enforcement if trust is maintained between the parties in the contract (Fafchamps and Minten, 2001). Will (2013) puts special emphasis on the importance of trust in CF relationships (see pp. 22, 25, 28). An information asymmetry advantage can be gained by sellers who if in long term interactions, can lower prices to some clients—who Granovetter, 2005a refers to as "known others"—a situation that can enhance fragmentation of the market and inhibit formation of a single equilibrium price. Fehr and Schmidt (1999), Fehr *et al.* (2007) suggest that fairness considerations can also determine the presence of contracts if some societal members are inequality averse, which in turn has support from some insights from psychology such as loss aversion (see Kahneman 2003).

This paper briefly summarizes the contractual landscape for milk at the farm level and describes the relationship between milk producers and the business partners whom they supply raw milk. The paper goes further and attempts to make links between contractual failure and some business partner characteristics.

Methodology

Data used in this paper comes from a recent (2013) nationally representative sample of households in 47 counties commissioned by the Agricultural Sector Development Support Programme (ASDSP). A total of 12,654 farming households were interviewed after being selected using the proportionate to population size technique, based on the total number of farming households in each county. Actual data collection was performed by enumerators drawn from respective counties and who in turn were supervised by a county coordinator who oversaw their recruitment and training after going through similar introduction to the study objectives and tools. A structured questionnaire was used to capture data necessary for the exercise.

This survey instrument was designed to capture a range of indicators for use by the ASDSP in its monitoring activities. Among the comprehensive list of parameters measured in this survey were household socio-economic characteristics, level of production and productivity for major agricultural and livestock commodities, consumption, marketing, and food/ nutrition security, access to financial and insurance services. Following enumerator recruitment was a pre-test of the instrument after which actual data collection commenced in late September 2013 and ended in October 2013 while data entry was undertaken thereafter by clerks recruited and trained for the purpose.

In this paper, the authors explore for overt reasons and/ or characteristics that maybe associated with contract breaches. This paper does however not try to establish the existence of different business models employable. Many studies on contract farming employ a transaction cost economics approach. This study does not take that route; rather, it relies on simple questions relating to the existence of contracts between milk producers and buyers of their product and tries to relate these variables to explore for patterns. The characteristics of milk producers (households) that may influence the choice of contract include membership to organizations/associations which other authors (Shiferaw *et al.,* 2006) suggest are important in overcoming some of the market failures. Such groups are a source of solidarity where members have a sense of moral economy and sense of group identity conferring a normative and extra economic meaning to economic action (Granovetter, 2005b).

Productivity of milk (measured by the amount of milk produced over the course of 12 months) is also used as a parameter where high production expected to force producers to gravitate towards contracting due to issues of bulkiness and perishability of milk (Goldsmith, 1985 cited in Baumann, 2000, p.20). Milk production data for each household is estimated and ranked from highest to lowest from which four groups of equal frequency. The notion of bounded rationality comes into play since farmers are limited by the amount of knowledge they have when making the contract. Access to market information is important to farmers since it reduces risks in the way of making them likely to choose the best contract partner. Distance to output markets is used as a measure of the costs involved in bringing milk into the market. Respondents also gave responses about the partner with whom they made contracts with, the type of contract (whether formal or informal) as well as whether the contract was breached or not.

Using this information, the authors use an exploratory technique to explore and establish the nature of associations between these sets of variables. We employ Multiple Correspondence Analysis (MCA); a technique that can reveal latent patterns in complex data sets, thereby helping to describe these patterns geometrically by locating each variable as a point in low-dimensional space. To implement this analysis, we use the FactoMineR (Husson *et al*., 2007) a package for multivariate data analysis with R (R Development Core Team 2014).

Results and discussion

Close to 47.3% (5,985) of the 12,654 respondent households produced milk from camels, cattle, goats or sheep. Of the milk producers, 16.7% had contracts for the sale of milk during the 12 month reference period. Many of these contracts were informal (64%) while the remainder were formal. These contracts were made between milk producers and cooperatives, institutions (public & private), traders, consumers, processors, hotels or even supermarkets. The most common parties with whom milk producers made contracts with included traders (hawkers, middlemen e.t.c) and individuals; contracts that in most cases are informal. This complements the findings in many sector reports which show the informal milk marketing system to be handling most of the milk output.

Cooperatives as well as milk processors make up another category of buyers who mainly made formal contracts with milk producers. Institutions (both private and public) as well as hotels also made contracts with producers though the frequency of these contracts was comparatively small (Table 1). Most of the contracts were breached (60%) while for the remainder, respondents said there wasn't breach of contract—although a portion of them were not committal with their answer or avoided it altogether.

Table 5. Number of milk sale contracts, types and the status of contract

Type of contract	With whom contract was made	Was contract honoured?		
		No	Yes	Silent[a]
Formal	Cooperatives	57	33	25
	Hotels	10	2	1
	Individuals	8	7	2
	Private institutions	6	1	2
	Processors	66	19	18
	Public institutions	5	2	2
	Traders	27	7	8
Informal	Cooperatives	20	6	11
	Hotels	38	9	6
	Individuals	105	52	42
	Private institutions	5	3	1
	Processors	14	1	1
	Public institutions	6	1	0
	Traders	139	42	38

[a] Respondents failed to divulge the status of these contracts

Households contracting with private institutions (though a small number) produced an average 20,600 litres during the year whereas those selling to processors produced an average 14,700 litres during the same period. Those contracting with hotels on the other hand were producing 11,200 litres whereas farmers contracting with traders and hawkers were producing about 6,900 litres a year. Those contracting with public institutions and individual consumers were producing an average 5,600 litres and 4,100 litres on average. As shown on table 1 above, many contracts were made with individual milk consumers as well as traders and were mainly informal contracts.

Of these households that had some form of milk sale contract, majority (70%) did not have a member of the household belonging to an agricultural group/association during the preceding 12 months. Of those that had household members belonging to these groups, membership was dominated by produce marketing types (53%), while input access and marketing comprised 11% of these groups while the remainder were groups of various shades such as seed production groups, savings and credit, soil and water conservation groups, water resource management among others types. Slightly

over half (54%) of the respondents with contracts had a household member accessing market information in the last 12 months preceding the interviews.

This is in contrast to a figure of 35% for all milk farmers in the sample signifying that households that have contracts go out of their way to obtain market related information. These results suggest that farmers who enter into contracts seek market information and are more likely to be engaged in common interest groups that have an interest in serving farmer's need for marketing assistance.

Results from the MCA are summarized on figure 1 below.

- Quadrant 1: Contracts appear to be made by farmers who have the lowest production indices selling their milk mainly to individual consumers. These farmers in addition do not seek for market information and output markets are far[6] from the farm. This group of farmers is also likely to be without representation in agricultural groups and many contracts are breached.
- Quadrant 2: Farmers enter into formal agreements with cooperatives and among this particular group of farmers; some of their household members participate in produce marketing groups.
- Quadrant 3: Farmers making contracts with private and public institutions as well as processors are informed (have access to market information) and this group appears to also have comparatively higher production indices. These farmers have household members belonging to input access and marketing groups as well as other collective action group types.
- Quadrant 4: Farmers here make informal contracts with hotels and traders.

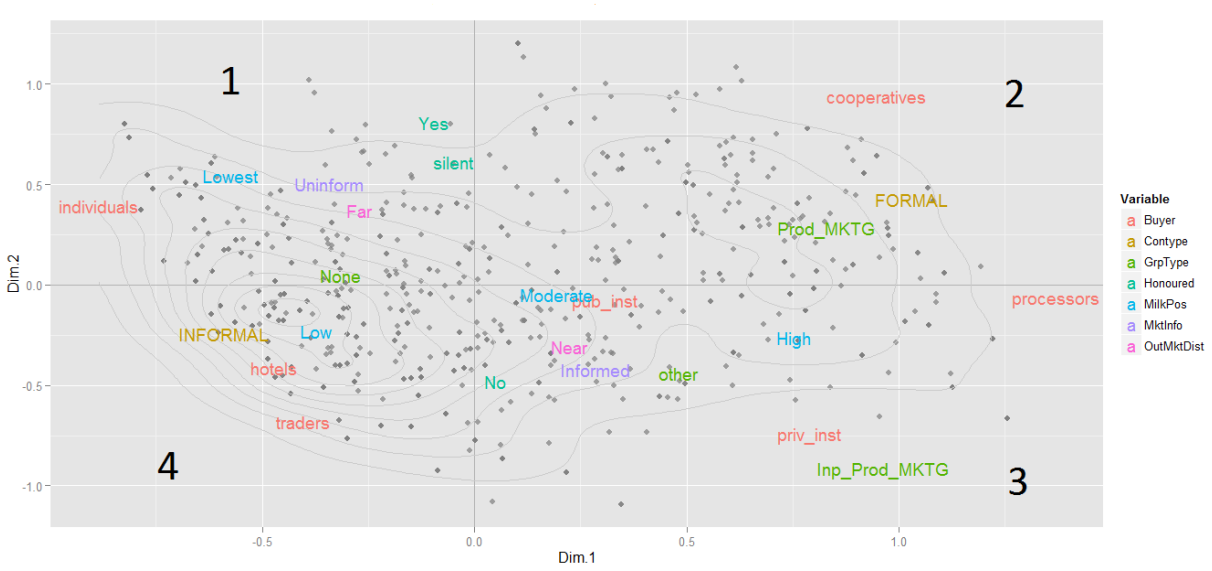

Figure 6. MCA plot of variables using R package FactoMineR

Conclusion and recommendation

These results provide a glimpse into the contractual landscape that describes the Kenyan case and suggests that contracts are entered into by farmers whose production is fairly higher than average. Contract breaches have an institutional dimension and do not depend much on the formality of the contract. The findings illustrate that informal and formal CF co-exist with none of the types guaranteeing more reliable compliance or featuring higher risks of default. Given the diversity of situations, business attitudes, farmer and buyer capacities, socio-cultural structures and local environments, it seems rather difficult to come up with a blueprint for designing farming contracts. On the contrary, agreements have to be negotiated case by case. Further studies utilizing data on psychological and sociological profiles of players engaged in milk market contracting (which would enrich the analysis) may be required to tease out the drivers of the patterns

[6] In this paper, we use a 35km cutoff radius to represent far-off markets while markets within this distance are assumed to be near.

described in the paper. Results from the MCA give interesting insights into structural particularities and possible success factors of different CF scenarios. While the prevailing situation in quadrant 1 suggests a need to promote the upgrading and up-scaling of existing informal CF as well as local cottage level value addition through capacity building measures, quadrants 2 to 4 lend themselves to a more in-depth assessment to identify good practices for up-scaling more CF agreements.

In conclusion, CF schemes will only be sustainable if both parties realise a profit (incentive for compliance) and if risks are shared with both partners working towards minimising risks of the joint CF venture. Experience shows that a farming contract is not worth being referred to as such if there is no trust between farmers and buyers and special attention has to be paid to assure fair give-and-take relations, open communication, transparent information and a fair voice for farmers in contract negotiations.

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An analysis of indigenous chicken marketing participation decisions: The case of producers from Makueni County, Kenya

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Abstract
Indigenous chicken(IC) are important in Kenya for food security, income generation, employment and improved livelihoods. However despite these benefits the producers are constrained in participating in the high value markets. A purposive Multi-stage sampling was used to sample 130 households from Makueni County. The data was collected using a structured questionnaire, key informant interviews and focus group discussions. This data was then analysed using descriptive statistics and a probit econometric model. The decision to participate in IC high value market was significantly influenced by education level of household head, processing, the age of household heads, group membership, the flock size and Region. Therefore it is recommended to form farmer groups for increased productivity, collective marketing and enhanced value addition.

Introduction

Agriculture contributes 25% to the Kenyan GDP (Gross Domestic Product), through export earnings (65%) and by offering informal employments to 18% of the Kenyan citizens (GoK, 2010). There is a strong link between the agriculture sector and the growth of the economy, which is shown by the prominent role of Agriculture in the Vision 2030 (GoK, 2010). According to GoK (2010) the Livestock sector is one of the major sub-sectors in agriculture. The sub-sector includes the dairy, beef, camel, poultry and other emerging livestock such as fishery and bee keeping. First it provides raw materials to other industries such as agro processing. Secondly it uses inputs from other industries. Consequently any external interference to this sub - sector impacts on the supply chain and the economy of Kenya. The indigenous chicken (*Gallus domesticus*) is found within the livestock subsector and constitutes 76% of the poultry flock in Kenya (GoK, 2010). Nearly all rural and peri-urban families in Kenya keep a small flock of free range chicken, which has an average number of 13 birds, which contributes to the social, economic and cultural welfare (Nyaga,

2007). There is an increase in chicken consumption in sub-Sahara Africa including countries like Kenya (Hazell, 2007). The per capita consumption in meat has risen from 14.9 kg in 1991 to 16 kg in 2007 and is expected to rise to 22 kg in the year 2050 (FAO, 2009).This rise has been due to preference given to IC in comparison to exotic chicken and red meats (Upton, 2000). The IC is lean, with an organic origin and fetches a premium in the markets (Ndegwa *et al*., 2000). Finally urbanization has also been a factor associated with this rise in demand of IC in the urban and peri-urban areas (Delgado, 2005). The IC market has three levels that vary in terms of the operations, products, location and number of participants that are found at each level (Bett *et al*., 2012). At the third level the consumers are willing to pay higher prices to get safe and quality products; with product differentiation, value addition, packaging of products and no division of IC into smaller units (Gamba *et al*., 2005). Makueni County is one of the main producers of IC in Kenya, however there are challenges faced by producers of indigenous chicken in production and marketing of IC. These challenges prevent the producers from fully participating in the IC high value markets. This consequently impedes on the ability of IC to alleviate poverty and improve livelihoods of the producers. Therefore there is a need to determine the influence of socioeconomic factors on producer participation decision in IC high value market. These consequently result into recommendations on improving the participation of producers in the IC high value market. The overall objective of this research was to analyse the participation of producers of indigenous chicken from Makueni County in the high value markets. This was achieved through determining the factors that affect decision to participate in IC high value market. Zeberga (2010) studied the marketing of eggs in Yigrelam and Alaba regions of Ethiopia. Bett *et al*. (2012) did a study on Linking utilisation and conservation of indigenous chicken genetic resources to value chains. A few of these studies have attempted to analyse the participation of producers in specific market segments. Most of the studies have looked at participation in the broad market for an agricultural product. One of these segments is the high value market (high end) segment in the IC market. Consequently there is a gap on information on participation of producers in the IC high value market. It is this gap that this study attempted to fill.

Methodology

Study Site

Makueni District lies between Latitude 10 35′, South and Longitude 37010′ East and 38030′ East. It covers 8,009 Km^2 with an altitude of 600-1900m. Rainfall ranges between 800 and 1200mm per year in the hilly areas and less than 500mm per year in the other regions. The Temperature range in the District is 20.2^0C-24.6^0C (GoK, 2005).The study area was one of the areas that were targeted by KAPAP project for intervention in the meat value chains for enhanced income to producers and poverty alleviation for improved livelihoods.

Sampling Design and Sample Size

The sampling design that was used was a survey design. This was comprised of three stages. First a purposive random sampling was used to select Makueni area from among IC producing areas in Kenya. Secondly a simple random sampling was used to select three regions (divisions).This divisions were Kee, Kaiti, and Wote in Makueni from where 130 households were selected using a simple random sample. A structured questionnaire was then used for data collection.

Data Collection

The data collection was done by trained enumerators from the locality to overcome challenges in language and due to their familiarity with the locality. The study used both primary and secondary data.

Data Analysis

The data obtained was analysed through qualitative and quantitative means. The Data collected was used to analyse the participation in the high value markets. This section presents the methods that were used to analyse data collected from the households.

The Probit model

It is also assumed that the dependant variable follows a normal distribution. The Probit model was used to identify the factors that affect the decision to participate by producers from Makueni County in the high value market. This equation was a Maximum likelihood Probit equation. The dependent variable is a dummy showing the decision to participate in the indigenous chicken high value market (PHVM).

$Y=X1\beta1+U1 \qquad U\sim N(0, 1)$

PHVM=1 if Y>Y* PHVM=0 if Y≤ Y*, where PHVM is Participation in indigenous chicken high value market. Where Y1i is latent dependant variable which is not observed and Y*=0.X1 is a vector of variables that were assumed to affect the household decision to participate in indigenous chicken market.β1 is a vector of the unknown parameter in the participation equation.U1 is the residuals that were independently and normally distributed with a mean of zero and a constant variance.

Results and discussions

Factors influencing participation in Indigenous chicken high value market

There are 6 out of the 12 independent variables that influence the decision to participate in the IC high value market. These included age of house hold head, education of the house hold head, family size, number of IC owned and the region dummy as shown in Table 2.

Age of household head had a negative effect on the decision to participate in IC high value markets. This may imply that household head are less likely to decide to participate in IC high value market as age increases. The results are consistent with those of a study by Berhanu *et al*. (2011) that found a negative relationship between age of household head and participation in milk value addition by dairy farmers in Ethiopia.

The education of the house hold head has a positive effect on the decision to participate in IC high value market. This may imply that household heads that were literate made the decision to participate. The literate households may have information on the benefits of high value market. This may lead them to decide to participate in IC high value market. The findings are consistent with the findings by Bett *et al*. (2012) that found education to positively influence participation in IC market in Kenya.

Table 1. Summary of results of household socioeconomic characteristics

Variable	Mean	Std deviation	Min	Max
Age of Household head (years)	43.89	13.77	21.00	86
Distance to main road (Kms)	3.24	2.33	0.30	11
Distance to market (Kms)	6.45	3.43	0.50	15
Credit access(KES)	4,776.54	6,828.05	0.00	70,000
Family size (Number)	6.07	2.17	2	11
Total indigenous chicken owned(Number)	13.03	9.15	0	50
Other livestock 6.45 Owned (Number)	5.27	0		28

Source: Survey data (2013) n=130

Table 2. Results of Probit equation

Variable Coefficient		Std error	Z	P>z
Age of household head	-0.02	0.01	-2.00	0.07*
Sex of household head	0.01	0.25	0.04	0.98
Education of household head	0.69	0.32	2.16	0.03**
Family size	-0.04	0.07	-0.57	0.58
Land size	-0.03	0.06	0.50	0.69
Other livestock unit	-0.04	0.03	-1.33	0.16
Distance to road	0.21	0.29	0.72	0.47

Distance to market	0.48	0.30	-1.60	0.11
Market price	-0.00	0.00	-0.00	0.89
Flock size	0.03	0.01	3.00	0.03**
Group member	0.52	0.25	2.10	0.04**
Processing	0.66	0.34	1.94	0.05**
Region	0.50	0.27	1.85	0.06*
Constant	2.35	1.55	1.52	0.13

*, **, significant at 10%, 5%, respectively; n=130

The results show that the being a member of a farmer group has a positive influence on the decision to participate in IC high value market. The producers that belong to farmer groups are likely to participate in IC high value market. This may be as a result of the benefits that are offered by operating as a group of farmers. These benefits may include better access market information, discounts and bargain power. These results are consistent with those of Jagwe *et al*. (2010) that show that farmers who belonged to farmer groups were likely to participate in the banana markets in Burundi, Rwanda and Democratic republic of Congo.

The number of indigenous chicken owned has positive influence on decision to participate in IC high value market. This may imply that those with more IC are likely to make the decision to participate in IC high value market. This may be due to the fact that they are sure of continuous supply of IC. These results are consistent with those of Bett *et al*. (2012) that showed that the number of IC owned positively influence participation in IC market since the size of the flock size allowed producers to participate in IC market.

The form in which indigenous chicken is sold has a positive influence on the decision to participate in IC high value market. This may imply that producers that sold their IC after slaughter were likely to decide to participate in IC high value market. It may also imply that IC high value market accepted processed IC. The results are consistent with those of Agbogo *et al*. (2011) that showed a positive relationship between processing and participation by women in cassava markets in Nigeria.

The results show that the region where the producer is found has a positive influence on the decision to participate in the IC high value market. Jagwe *et al*. (2010) reported that region positively influenced participation of farmers in banana marketing.

Conclusions and recommendations

The aim of this study was to determine the factors that have an effect on the decision of producers to participate in IC high value market. The decision to participate in high value market was significantly influenced by processing of IC, age of household heads, education level of household heads, farmer group membership, flock size (number of IC owned) and Region where producer comes from. Therefore it is recommended that and collective action should be used to enhance productivity, processing and marketing of IC .The Government should also improve on the infrastructure ,while improving on dissemination of technology through extension and access to market information that will enhance productivity.

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ABSTRACTS

An overview of the status of Dorper Sheep value chain in Kenya

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The arid and semi-arid lands (ASAL), make up over 80% of Kenya's total land surface, supports over 25% of the human population and over half the livestock population. These areas are characterized by a very fragile ecosystem with frequent drought occurrence, scarce and erratic rainfall. The main economic activity of the ASAL is nomadic pastoralism, which utilizes 24.2 million hectares (50%), while ranching and other livestock keeping utilizes 15.1 million hectares (31%.). The remaining 9.1 million hectares or 19% is used for crop agriculture including agro-pastoralism. The livestock sub-sector contributes 10%-15% of GDP and 30% of AgDP for both red meat sub-sector (cattle, sheep, goats, and camels), the white meat sub-sector (pigs, poultry) and other products (milk, hides/skins). Kenya is estimated to have about 28 million goats and 18 million sheep, majority being indigenous breeds. Majority of small ruminants reared in Kenya (over 58% sheep and 66% goats) are kept in ASAL zones which predominantly practice pastoral-nomadic system of livestock production. These are zones where breeding strategies for the small ruminant flocks face a delicate balance between adaptation and productivity. The small ruminant breed for this harsh environment is determined by their ability to withstand prolonged severe droughts, walk over long distances in search of water and pastures, and utilise poor quality forages for their physiological needs.

AFRICA'S HUMAN CAPACITY CHALLENGE FOR ANIMAL AGRICULTURE WHICH WAY NOW?

ORALLY PRESENTED

Institutional framework for enhancing the efficiency and effectiveness of livestock genetics research for development in, and for, sub-Saharan Africa

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Abstract

The aim of this paper is to provide a synthesis of the e-conference held from 8th March to 20th April 2011. The e-conference aimed at collating views that would inform the development of a sustainable institutional framework that would meet future research for development (R4D). The e-conference attracted participants from Bangladesh, Cameroon, Canada, Egypt, Ethiopia, Ghana, Italy, Kenya, Malawi, Nigeria, South Africa, Spain, Sudan, Sweden, Tanzania, UK, and Zimbabwe. The e-conference demonstrated that the R4D institutions in Sub-Saharan Africa vary very variedly in terms of both the physical and human capacity. Equally varied is the level of utilisation of these institutions. In terms of training in Animal Breeding and Genetics, although most universities/colleges have programmes in Animal Science and teach animal breeding and genetics, there are very few practicing animal breeders. Lack of mentorship programmes and collaboration contributes to this 'leaking pipeline' phenomenon. Further, the participants in the e-conference expressed concerns over the low profile of animal breeding and genetics in different Sub-Saharan Africa (SSA) countries. Despite the fact that this is one of the few disciplines that brings about permanent change and improvement in livestock it is very often undersold especially to the policy makers. There is a disconnect between what the animal geneticist do and the needs by smallholder farmers. This is an area that needs urgent attention. Several suggestions were made that have the potential to mitigate some of the limiting factors to genetic improvement in Sub-Saharan Africa. Some of these were; (1) The need to rethink breeding and genetics as part of a bigger dynamic system of innovation in agriculture and rural development, (2) Collaboration both within Africa and with those in the Diaspora was felt to be one of the aspects of R4D that remains untapped as a source of capacity, (3) Initiative such as pooling data from across institution and even across countries and analysing such data with appropriate statistical models that account for regional and country differences would provide some fundamental information and training platform for students and young scientists. Concluding, drivers that have the potential to enhance the efficiency and effectiveness of livestock genetics research for development in, and for, sub-Saharan Africa were highlighted.

Introduction

Livestock are an important asset in Sub-Saharan Africa (SSA) and have been shown to contribute significantly to rural development through the provision of food, cash, manure and general livelihoods in the rural and peri-urban households (Agyemang, 2005; Zabet *et al.*, 2011). However, this contribution is neither optimal nor sustained in most parts of SSA. Some of the reasons for this retarded contribution are, low capacity (human and infrastructural) for livestock genetics; high cost of livestock genetics and breeding research for development (R4D) infrastructure; limited and disjointed R4D efforts within countries; limited effort to share the available capacity between countries; and, inappropriate imported genetic technologies (genotypes and genetic improvement technologies and methods) which have often failed to deliver the expected results. However, there are some technologies developed elsewhere (in either the North or South) which offer opportunities for Africa. These may need to be tested in, and adapted for, local contexts. Further, rapid developments in genetics and genomics offer opportunity which remains relatively unharnessed in, and for, Africa's development.

A sustainable institutional framework that would meet future research for R4D needs for livestock genetics is urgently required. This would be a kind of framework that would interface with overall livestock and agriculture development in sub-Saharan Africa. This in turn would enhance the efficiency and effectiveness for delivering livestock genetics R4D that would address high priority constraints for sub-Saharan Africa. Developing such a framework requires the involvement of a wide range of players. Establishing avenues of consultation, engagement and support from both local and international research and development community is a vital part of this process. From 8th March to 20th April 2011, an e-conference

aimed at collating views, that would inform the development of such a framework was conducted. Animal Scientists, Agricultural Economists, Agronomists and experts in Agricultural Research not only from Africa but from other countries around the globe participated in the e-conference. The participants were from Bangladesh, Cameroon, Canada, Egypt, Ethiopia, Ghana, Italy, Kenya, Malawi, Nigeria, South Africa, Spain, Sudan, Sweden, Tanzania, UK, and Zimbabwe. The e-conference was hosted by the animal genetics listserv (animalgenetics@sympa.sun.ac.za) based at Stellenbosch University in South Africa. In the e-conference, a framework was defined as 'a basic structure underlying a system' and could take a variety of forms.

During the e-conference period, a moderator introduced the theme for discussion together with some guiding questions for the participants to discuss and debate. The scope and definition of the framework were introduced at the beginning of the e-conference. The following were the envisioned aims of the framework: a) providing a mechanism for leveraging available individual expertise and institutional capacities on the continent; b) creating functioning and effective mechanisms for harnessing available collaborative opportunities within Africa and between Africa and the international R4D community, including Africa's Diaspora; c) on-going development of technical and human capacity in genetics and breeding on the continent to provide the required critical mass; d) generating technologies that can be applied at scale in multiple countries (i.e. international public goods) to address high priority constraints; e) increasing efficiency and return to R4D investments; and f) catalyzing the evolution of sustainable R4D platform(s) on the continent. This paper provides a synthesis of the e-conference and highlights some drivers that were identified to have the potential to enhance the efficiency and effectiveness of livestock genetics research for development in, and for, sub-Saharan Africa.

Current status

Institutional capacity

In the e-conference it became apparent that infrastructure in animal breeding and genetics comprises the hard infrastructure and soft infrastructure. Hard infrastructure is the physical and organizational structures needed for the delivery of technological innovations and R4D in animal breeding and genetics. Soft infrastructure all the operational and quality assurance capacity that promote and facilitate the implementation of the technological know-how generated from the R4D. There was a general agreement on the existence of some premier and other potentially premier institutions for animal genetics and breeding R4D on the continent. The discussion demonstrated that these institutions are very varied in terms of both the physical and human capacity. Equally varied is the level of utilisation of these institutions. Specific examples were given from countries like Zimbabwe, South Africa, Malawi, Kenya and Nigeria. The majority of these are public institutions in the form of universities and research centres. Very few of these have long-term experiments and research programmes running. Where some long term experiments and research programmes are running, they do not seem to be well supported and their value not well appreciated.

Although difficult to maintain and at times to economically justify, long-term experiments and research programmes have valuable scientific resources providing data and continuity. The following are some examples of long-term experiments and research programs that are still running albeit not at full capacity. In Zimbabwe, Matopos Research Station runs a beef crossbreeding experiment and is also home of the only known flock of indigenous Sabi sheep. Again in Zimbabwe, Makhoholi Research Station maintains a Mashona beef herd while The Grassland Research Station keeps a Tuli cattle herd. In Malawi, Mbawa Research station has a pure Malawi Zebu breed which is used in a crossbreeding programme with the Brahman breed. These centres have the potential of hosting and maintaining nucleus herds in an either open or closed nucleus breeding system. Long-term experiments have the potential to provide unique data sets that may provide a huge resource for ongoing analysis and also provide a case of best practice. However, the value of long-term datasets can only be noticed when such data are utilised. One of the issues that was raised in the e-conference is that most of the institutions are not effectively utilised

Most countries in Sub-Saharan Africa have artificial insemination (AI) centres. Most of these produce and distribute semen to farmers. From the e-conference, however, AI centres were mostly considered as semen and service providers and not as included or put in the frame of a vital component of a robust R4D in animal breeding and genetics. Functioning AI and livestock breeding programs were noted to exit where there was a market oriented (commercial) livestock sector. An example that was given was that of South Africa where developed breeding programs and support infrastructure (e.g. stud breeders and breeders association for many species), national performance recording and breeding value estimation services are functioning and evident.

Human resources
Databases of animal breeding and geneticists exist at different levels of detail. For example there is a relatively comprehensive database in South Africa where there are about 45 Animal Breeders and Geneticists. Lack of proper databases and lists of animal breeders could mainly be attributed to the fact that is some countries there are very few animal breeders and hence co-workers know each other. It was estimated that there were 60 animal geneticists in Sub-Saharan Africa and 75% of them were in South Africa. Currently, most animal breeders work for universities and research institutions. The absence of breeders organizations (implementers of genetic improvements) in most countries on the continent has led to any advantages of using new improvements or technologies not be appreciated or proved under field conditions.

On-going development of human and technical capacity

In terms of training in Animal Breeding and Genetics, it was shown that most universities/colleges had programmes in Animal Science and teach Animal breeding and Genetics. Training is mostly at first degree level. Post-graduate training opportunities in animal breeding and genetics in Africa are very limited. Only a few universities have post graduate programs, and these universities have less than optimum capacity (expertise and facilities) to deliver high quality MSc or PhD training.

Even with those countries where training and educational programmes exist, there is a general deficit in the numbers of animal geneticists on the continent. Two problems exist in this field. One is the inability to maintain the trained personnel and the other is the failure to attract the numbers from young scientists to join the field and in some cases failure to retain the existing ones. Quite a good number of the human resources are now gainfully employed either in other countries or in other organizations that do not deal in animal breeding and genetics. There is outward migration of personnel to other fields such as relief and development, NGOs among others. Different reasons such as salaries, career development prospects and the need to have their work appreciated were given for this situation. There is a general decline in numbers of students in Animal breeding and genetics. The discipline of animal breeding and genetics seems not to attract high numbers of new students who would be the next generation of movers and shakers. Interestingly, the quantitative and numerate skills are highly appreciated when animal geneticists move into other fields.

As pointed out by Gibson et al. (2014) there is need and potential to innovative regional graduate programs that harness collective capacities of multiple universities. Such an initiative could be linked to advanced research institutes/universities in the developed world. A fundamental difference between successful livestock genetic professionals (researchers, industry, and extension) in the developed world versus Africa is that after receiving their MSc or PhD, the former generally receive strong mentoring and continuous 'learning-through-doing', while there is limited or no opportunity to gain deep experience and high-level mentoring for most African graduates of livestock genetics training.

Breeding programmes
The e-conference revealed that in most African countries R4D related to animal breeding is under the control and support of government institutions. These institutions were established with the aim of providing improved stock and technologies to the farmers. In the establishment of these institutions, there is little or no participation of the end users (farmers). As a result, these organizations are detached from the farming community. Therefore, their contribution to the nation as well as to the farming community is very low relative to the cost incurred in establishing or running these programs. In addition to the government institutions, in some countries there are private breeding companies and NGOs who sell germplasm (semen and embryo) and live animals imported from the Europe, America and to a limited extent from South Africa. This is mainly for dairy cattle and poultry.

It was noted that even in the commercially oriented operations, in the rest of Africa there is no strong breeding institution. As the result of this weakness, farmers are dependent on imported animals for the replacement stock. One of the consequences of the disjoined R4D activities is the lack of coherent breeding policies. This has resulted in a mismatch of genotypes with production systems. Private sector, farmer organizations and the emerging commercial farmers are totally disconnected to the research programmes. Most R4D initiatives seem to be developed with little attention paid to the production environment. The issue of identifying and matching the animal genetics and breeding R4D to the existing and appropriate farming systems was emphasised during the e-conference. This was identified to be a major problem in small-scale and communal farming systems. The paradox is that in most African countries, the dominant type of livestock

farming is either small scale or subsistence, where animals are managed under communal farming system with no controlled mating. There is currently no breeding institution established to serve this community. Further, the subsistence farmer keeps his/her livestock for multiple purpose use– food, power, cash, etc. The animals numbers per farm in this sector are small (one or two) and sometimes mixed species and with no controlled mating. How do you define the breeding objectives for the subsistence farmer? How do you implement the improvement program? Answering these questions will help inform the debate on making animal breeding and genetics relevant and appropriate on the continent with farmers as part of this institutional framework.

Together with R4D organizations, breeding organisations and performance recording organizations take the new developments forward to the users and feedback to the R4D organizations. The existence of institutional herds able to act as experimental herds or nuclei for spreading genetic improvement across commercial herds is important. However, if breeder's organizations are not available the advantages of using the new improvements and technologies can not be proved at farm level.

Low profile

Participants in the e-conference expressed concerns over the low profile of animal breeding and genetics in the different SSA countries. Despite the fact that this is one of the few disciplines that brings about permanent change and improvement in livestock it is very often undersold especially to the policy makers. In the large multinational animal products and service companies investment in animal genetics is growing faster than in animal nutrition and animal health (KPGM, 2013). It was noted that the production sector and society do not appreciate research as a part of their activity and hence researchers are not rewarded with reasonable remuneration. However, it was also noted that animal scientists and more specifically animal geneticists have not themselves demonstrated the value of animal breeding to society. In summary, it was pointed out that, animal breeding and genetics should not only be done but should be seen to be done. Some of the points that were put forward as possible ways to raise the profile of animal breeding and genetics were:

1. Animal Breeding and Genetics should be made more attractive while maintaining its relevance and robustness
2. Teaching and research facilities and equipment should be established in order to make the course more practical than theoretical.
3. The importance of within-country collaboration that would enable students to do practical work or placement in research institutions. This could be extended to formal scientific exchange programme between institutions.
4. The need for clear information on career path and expected returns from the career are crucial in creating not only a clear demand for and place of animal breeding on the market but also helping to develop the area.
5. Use of already existing resources and forums such as, All Africa Conference of Animal Agriculture (AACAA), World Congress (WCGALP), pedigree of animal breeders should be utilised more to increase the profile and visibility of the activities that animal breeders undertake in Africa.

Sociological and ecological differences

The need to recognise regional social, economic and environmental differences and similarities was highlighted and acknowledged. This line of discussion was extended to sociological and ecological differences in different countries. This may mean that it will be more efficient to promote regional collaboration. However, care should be taken not to breakdown the regions too much as from the discussions; it transpired that there are serious capacity deficiencies within country, and regions. Also, similarities are worth exploiting within as similarities may outweigh differences. It was noted that strong national human capacity yields strong regional human capacity. As Animal Geneticists, we need to work to improve each others weaknesses and build each others strengths. The issue of mentoring young scientists was also highlighted.

Harnessing available collaborative opportunities

Collaboration both within Africa and with those in the Diaspora remains an untapped potential source of capacity. There are some initiatives that require regional collaboration in order to achieve sustained impact. Some useful observations in this regard were made by Wollny *et al.* (2002). Even with some within-country initiatives, there is need to break-down the traditional boundaries among research, extension and training. In most of the countries, NGOs have contributed substantially to changing the gene pool through the importation of different genotypes especially in dairy cattle, pigs and goats. Animal geneticists need to integrate their activities with those by the NGOs thorough taking the work forward and adding the genetic improvement dimension to the work. This can be, for example, through setting up systematic animal performance recording, conducting genetic evaluation, and sire selection.

Collaboration both within Africa and with those in the Diaspora remains an untapped potential source of capacity. Initiatives such as pooling data from across institutions/ across countries and analysing such data with appropriate statistical models that account for regional and country differences would not only provide some fundamental information but also work as a training ground for students and young scientists. Not every country would have the human resources with such skills. Skill sharing and knowledge exchange would help Africa best use the scarce human and institutional capacity it has in the area of animal genetics and breeding. Some models of collaboration exist between African institutions and other parts of the world. Most of these could be explored further for longer term benefits on institutional capacity. This is because most of the collaboration efforts that go a long way start as researcher-to-researcher initiatives. Although this is the case, other formidable collaboration initiatives have been those that have been initiated through bilateral agreements. Clearly articulating the research and development needs helps to identify relevant projects and work-areas. Forming project consortia and responding to specific research calls has been other very successful strategy for collaboration. Involving both Africa-based scientists and those in the Diaspora has a synergistic effect to the collaboration effort. Simpler networks and approaches that are affordable in Africa must also be encouraged and funded; for example strengthening the African Animal Production Association, initiating e-forums and discussions. Formal scientific exchange programs for researchers between institutes should be considered as a catalyst for further long-term collaboration. Sub-Saharan Africa is in a unique position for potential joint and regional postgraduate training programmes. As noted by Gibson *et al.* (2014), there are vast regions that share language, cultural and political diversity.

Generating technologies and increasing efficiency

Research in animal breeding should be attractive to the private sector in order to attract investment and innovation. It should also give political mileage to Governments so that they can justify spending scarce financial resources in supporting the research. There is need to rethink breeding and genetics as part of a bigger dynamic system of innovation in agriculture and rural development. What does 'innovation systems' thinking require of breeders and geneticists in Africa? Following are some points on innovation systems:

1. We must focus on innovations not merely research or science and technology. Innovation is defined as 'the application of knowledge to achieve social and economic outcomes'
2. We must develop working styles and practices, both as individuals and as organizations and the incentives, support structures and policy environments that encourage innovation.
3. Breeders and geneticists in Africa must be responsive to stakeholder demands and agendas, not their own religiously guarded pet projects or academic interests. In other words, think beyond the 'lab' or 'experimental field' to find out what clients really need out there.
4. Breeders and geneticists in Africa need to be dynamic – new challenges require new partners and new ways of working. Institutional learning is central to this process and will ensure successes and failures of the past are used to inspire future solutions. If you can't change you will soon become irrelevant.

Institutions such as AU-IBAR and ILRI should continue to take the lead and create opportunities to motivate scientists on the continent to come up with solutions to the numerous challenges of Animal Genetics on the continent. They need to support capacity building and also a fair balance of projects on Animal Genetic Resources across the continent.

Catalyzing the evolution of sustainable R4D platforms

Fundamental to any breeding programme is the accurate and appropriate estimation of genetic parameters and the consequent formulation of breeding goals. Currently, there are no such breeding programmes at both national and regional level in most of Sub-Saharan Africa. Mostly, this is due to lack of infrastructure and functioning animal recording systems. The inevitable consequence of the lack of breeding programmes is the importation of foreign genotypes especially in the dairy sector based on evaluations which do not account for the genotype by environmental interaction. The questions are: Is it possible that several institutions to initiate a joint animal recording system? Is it possible to pool together any existing data from across institutions and countries and analyse such data with appropriate statistical models that will account for regional and country differences? Affirmative responses to these questions would create the needed platform that would provide the footing for fundamental information in terms of genetic parameters, breeding values and the basis for the formulation of national and regional breeding programmes. Collaborative efforts would provide the technical expertise needed for such an analysis.

Conclusion

The participants to the e-discussion expressed gratitude to have had a chance to discuss one of the fundamental issues in livestock development in Sub-Saharan Africa. It was noted that the e-discussion was a very useful exercise that brought out a lot of issues and also constructive suggestions that would inform the development of a framework for enhancing the efficiency and effectiveness for delivering livestock genetics R4D to address high priority constraints for sub-Saharan Africa. General consensus was towards developing fundamental soft infrastructure and capacity that would form the basis of vital R4D with minimal bureaucratic constraints.

The need for capacity building, organization of data collection and utilization, improved communication and coordination of efforts within and across countries was emphasized. It was highlighted that animal breeders and geneticists within Sub-Saharan Africa should be the ones to 'kick-start' the process and raise the profile of the profession. This is because they are the ones that have the political contacts and local knowledge to obtain the buy-in on different R4D initiatives from the key people within Governments and the farming community. Colleagues in the Diaspora should be involved in transferable-skills initiatives and to help identify new project opportunities.

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Thanks to all the participants in the e-discussion. Many thanks to the organisers and hosts, animalgenetics forum, for the space and time that they dedicated to the e-discussion.

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Agricultural Education and Skills Improvement in Africa North-South-South training model embedded in programs/projects and harnessing

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Summary

Sub-Saharan Africa will contribute significantly to the growth of the world's population, which is expected to top 9 billion by 2050. The supply of animal-sourced foods apparently needs to more than double in order to meet the demands of the increasingly urbanized and newly affluent in Africa. Thus, livestock production obviously holds substantial potential for poverty reduction in Africa. However, this potential can only be realized if Africa is able to develop technological innovations to transform current near-subsistence livestock production systems into market-oriented sustainable production systems. It is well-known that Africa today does not have the technical and institutional capabilities to test and adapt past animal production technologies that allowed the other continents to advance the productivity of their livestock. Current trends in human and institutional capacity development in Africa will be woefully inadequate to bring about the needed intensification, especially for areas where livestock systems require attention to climatic adaptability and disease resiliency. We are facing significant deficits in animal science training compared to countries such as India and Brazil, and no single country is likely to be able to individually support the level of investment required to change the current trend.

Africa urgently needs new collaborative approaches to human and institutional capacity development and sharing that will tap and leverage core competencies from different countries. We hope that this meeting will be the starting point for conversations on how Africa could adopt a new regional model for human and institutional capacity development and sharing in animal agriculture.

Agricultural education and skills improvement in Africa

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Summary

The improvement of human capital in African agriculture through better education and technical training are key factors for the agricultural sector's ability to contribute to the economic development in Africa. Success stories in some emerging economies like South Korea, India and Brazil show that enhanced learning and knowledge management in education and skills improvement greatly accelerate national development, poverty alleviation and facilitation of wealth creation. Unfortunately, institutional learning regimes in African Tertiary Agricultural Education (TAE) training systems are not in synchrony with present and most probably future labour market demands. Therefore the TAE training systems and need innovative approaches that focus more on job creation and wealth creation competences. Furthermore, the poor linkages between teaching and research and in general the isolation of teaching from knowledge sources outside the universities, which then aggravates an already bad situation.

In 2003, the leaders of the African Union (AU) underscored their vision to improve agriculture through the Comprehensive African Agriculture Development Program (CAADP) which aimed to achieve 6% of annual agricultural growth and to increase investments in agriculture to at least 10% of national public expenditure. Ten years later, a review of the CAADP framework and processes led to a new commitment, dubbed 'Sustaining CAADP Momentum (SCM). The review aimed to get political buy-in, as well as help mobilize the technical and financial resources for the rapid enhancement and expansion of capacity building in agriculture. SCM calls for an overarching Agricultural Education and Skills Improvement Framework (AESIF) at a continental-level, in order to stimulate and coordinate a common agenda that will drive agricultural education and skills development. In connection with these reform initiatives, NPCA (NEPAD Partnership and Coordination Agency) has supported the establishment of the Tertiary Education for Agriculture Mechanism (TEAM-Africa) and the Agricultural Technical and Vocational Education and Training (ATVET) which are committed to a joint effort to strengthen the capacity of actors in implementing the SCM results framework actions, particularly component 6 dealing with 'enhancing knowledge support and skills development for agriculture at the Regional Economic Councils (RECs) and countries levels.

A notable training initiative was a program on Capacity Building for sustainable use of Animal Genetic Resources (AnGR), built on the concept "Training the Trainers", that aimed to address weaknesses in the area of animal genetics and breeding in developing countries. This was a ten year collaborative program between ILRI (International Livestock Research Institute) and SLU (Swedish Agricultural University), with support provided by Sida. Through the program, 138 trainers in 46 countries in Africa and Asia were trained in multiple related skills, and were linked through regional and continental networks. As the landscape in developing countries is rapidly changing, continuous learning and adaptation is required. The model implemented by the ILRI-SLU project has been recommended as a basis for adoption and further development in other relevant subject areas.

The concept of pan-African centres of excellence: an example of the Nelson Mandela institute of science and technology

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Summary
Africa is at the cusp of transfiguration many ways. With a youthful and growing population, and changing demographics particularly rapid urbanisation present bright opportunities and inherent challenges, not least is the need to provide abundant highly nutritious food from a limited resource base, and to compete effectively in a knowledge dominated global economy. Many of the challenges are trans-boundary, and so require a pan African effort for example through centres of excellence. The African Union has promoted creation of centres of excellence to address biosciences capacity as exemplified by the Biosciences eastern and central Africa (BecA-ILRI) hub. President Nelson Mandela, proposed the creation of Centres of Excellence in Science Technology and Innovation in Africa to address the human capital development gap that limits transformation and effective use of Africa's resources. The proposal is now embodied in a network African Institutions of Science & Technology (AISTs) whose essence is value-addition to Human Capital and natural resources for the sustainable development of SSA. We present here once such centre; "The Nelson Mandela African Institute of Science and Technology (NM-AIST) in Arusha, Tanzania. NM-AIST is a graduate only, research intensive institution, with a mission to transform education and research in Africa, and to contribute a cadre of highly competent, scientists, engineers and technoprenuers that will lead the transformation of Africa to competitive global player.

Delivery of biosciences capacity to African NARS through shared facilities: Experiences from the Biosciences eastern and central Africa (BecA)

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Summary
The Biosciences eastern and central Africa – International Livestock Research Institute (BecA-ILRI) Hub was established as a joint partnership between ILRI and AU/NEPAD, under the African Bioscience initiative – ABI, to provide access to affordable and world-class bioscience research facilities, empower and strengthen human resources in biosciences in Africa. The BecA-ILRI Hub is located at ILRI and managed as a shared research, capacity building, high-end biosciences technologies platform to support African scientists and institutions to address key agricultural productivity, food and nutritional security challenges.
In Africa, building the capacity in national agricultural research systems (NARS) for effective, efficient and sustainable delivery of their mandate remains a key challenge and determinant of agricultural productivity gains. The BecA-ILRI Hub is demand driven program and responds to this challenge by focusing on agricultural improvement primarily in 18 countries in Eastern and Central Africa. Capacity building and research coupled with capacity building and technology development and application at the BecA-ILRI Hub focuses on five key themes: a) livestock productivity, b) crop improvement, c) climate change, d) food safety and improved nutrition, and e) harnessing the potential of orphan crops and livestock species for improved nutrition and income generation.
The objective of the BecA-ILRI Hub's capacity building program is to support and strengthen the capacity of African NARS scientists and institutions to deliver their mandate. The main delivery mechanism is the Africa Bioscience Challenge Fund (ABCF), which largely focuses on a competitive fellowship program (The ABCF fellowship), annual training workshops and institutional capacity building. The ABCF fellowship program targets, supports and hosts a wide range of scientists from African NARS for up to twelve months at the BecA-ILRI Hub. While at the BecA-ILRI Hub, NARS scientists access available resources (a broad mentoring faculty of world class scientists from within and out of Africa, technologies platform, research support services and other opportunities for new partnerships development, collaborations and resource mobilization) to help accelerate their research agenda and in the long term ensure sustainable activities at home institutions. The BecA-ILRI Hub ABCF program also includes annual short training /enhancement

courses (hands on molecular biology, bioinformatics, genomics, lab management, technical and scientific writing etc), Institutional capacity building and creating connections and sub networks between scientists. Since 2010, the ABCF program has contributed to hosting over 150 African research scientists, trained over 450 through short term courses, published over 100 peer reviewed manuscripts and conference proceedings. Other outputs of the ABCF program include the translation of research output into product development (including novel diagnostics tools for crop and livestock diseases), seminal discoveries (identification of new viruses of significance to animal and human health, established of wide crosses for expanding crops genetic repertoire and accelerated breeding) and other research-based evidence to engage with policy makers.

To provide further respond to the needs and ensure broader support to African NARS, and at the same time lead the implementation of cutting edge biosciences research in support of African agricultural productivity, food and nutritional security, the BecA-ILRI Hub has established the following technologies platforms: Genomics, Bioinformatics, Diagnostics, plant tissue culture and transformation, mycotoxin and nutrition analysis, and molecular breeding. Their applications to a wide range of research topics and capacity building provides an ideal environment to build a critical mass of well trained and well equipped African bio-scientists to effectively address national, regional and continental agricultural productivity, food and nutritional security issues.

Since full operation in 2007, the BecA-ILRI Hub is now a key research for development in Africa through ensuring that high quality, responsive and impact driven agricultural biosciences research is conducted in Africa. It also works to ensure that African bio-scientists are equipped to play key and leading biosciences research roles and effectively contribute to the global scientific knowledge.

Rural veterinary service delivery in Kenya - Challenges and prospects

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Summary

Animal health service delivery has been liberalized in Kenya transferring most of the roles from the public veterinary department to the private sector consisting of private commercial animal health service and product providers and non-profit nongovernmental organizations. This transition is yet to be regulated. A significant proportion of livestock in Kenya is in rural areas and is kept by small-scale producers or pastoralist areas. The provision of animal health products and services to these areas is fraught with many challenges: poor infrastructure rendering areas virtually inaccessible, few or no qualified extension staff, periodic disease outbreaks and droughts, feed scarcity, poor access to markets, poor quality and counterfeit products, ill-timed deworming and vaccination campaigns and generally poorly developed service delivery systems all of which ultimately result in great losses of livestock.

These problems are compounded by lack of proper disease control strategies. In most cases, interventions are by veterinary departments and non-governmental organizations and are characterized by free product issuance, ill-timed vaccinations, deworming exercises, and belated drought response strategies leading to a culture of over-dependency on aid. Insecurity of investment, uncertainty in policy direction and weak private sector involvement has denied the sector of the benefits of sustainable business models. In response to these challenges, innovative stakeholders are embracing progressive approaches to animal health product and service delivery to encourage a more pluralistic, business-oriented and demand-driven approach to providing support, products and services to livestock farmers in rural areas.

GALVmed has been working with partners to promote sustainable veterinary practices and service delivery. ECF vaccination has been a very successful example of how well planned disease control strategies can be adopted by farmers as routine practice. This presentation shares insights on the GALVmed-Sidai Africa Limited partnership and more specifically, on the veterinary franchise model as a practical example of rural veterinary product and service delivery. It highlights the workings of a fee-based system where farmers are trained on the value of disease control and

pay the full cost of vaccines and other products. The use of qualified professionals to manage the commercial outlets ensures quality advice, service and products are provided to farmers. This model ensures that resource constrained livestock farmers, even those in the most inaccessible areas, obtain quality products and services thus assuring sustainable access to animal health services for improved livelihoods.

Who offers veterinary services to smallholder dairy farmers in Western Kenya? Lessons from Kakamega County

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Abstract
Liberalization of both clinical and artificial insemination services in Kenya allowed many players into the livestock service sector. This study seeks to examine the key providers of veterinary services and the factors that influence the delivery of veterinary services among smallholder dairy farmers in Kakamega County. Socio-economic data was collected through a household survey of 128 randomly selected households and 30 purposively selected service providers. The descriptive statistics revealed that 59% of all cases were attended to by animal health assistants, with private animal health assistants attending to 38% of all the cases. The results of Multinomial logit econometric model estimated with self-treatment as the base category revealed a negative influence of distance on the choice of government service providers but a positive relationship with tropical livestock unit, treatment cost and education level of the farmer.

Keywords: Animal health, Service delivery, Smallholder dairy, Kakamega.

Introduction

Livestock production plays a very critical role in the livelihood of the rural populations in Kenya. Privatization of clinical veterinary services in the early 1990s resulted in emergence of different livestock health service delivery systems and players (Oruko *et al*., 2000). Some of the players included private and government veterinary surgeons, private and government animal health assistants (AHAs), community based animal health workers (CAHWs) and non-formally trained Para-vets (Irungu *et al*., 2006). However, the key players of the livestock service delivery system among the smallholder dairy farmers in medium potential areas are still not clearly understood, notwithstanding that this cadre of farmers contribute about 60 to 80% of Kenya's milk output (Oruko *et al.*, 2000). This study aims to critically examine the key providers of veterinary service and the factors that influence demand and delivery of veterinary services among smallholder dairy farmers in Kenya, taking the case of Kakamega County as an example.

Materials and Methods

The study was conducted in Kakamega North District, Kakamega County in Western Kenya. A total of 128 randomly selected households and 30 purposively selected livestock service providers were interviewed. Both descriptive statistics and econometric methods were employed in the data analysis. Multinomial logit model was used to analyse the data due to its ability to analyse a number of response categories at the same time, taking into account the interactions between various categories of the variables (Hailpern and Visintainer, 2003).

Model specifications
The choice of the service provider, (Spp) is a nominal outcome variable with categories 1=Government for government veterinary service providers, 2=Private for private veterinary service providers and 3=Self for those who treated their livestock. The independent variables include the distance to the government veterinary office (dist), the value of the herd

size (tlu), the cost of accessing veterinary service (tr_cost1), education level of the household head (Educ2) and the nature of the disease (Endemic) whether it is endemic in the area or not.

$$\ln \Omega_{m|b}(x) = ln\frac{\Pr(y=m|X)}{\Pr(y=b|X)} = x\beta_{m|b} \quad \text{for } m = 1 \text{ to } J \qquad (E1)$$

Where b = the base category or the comparison group; m = the other categories in the comparison group; Ω = the multinomial logit function ; β = the column vector for the parameters to be estimated; Since $ln\Omega_{b|b}(x) = \ln 1 = 0,$ it must hold that $\beta_{b|b} = 0$ (Long and Freese, 2006).

Results

The results indicate that East coast fever (ECF) is the most prevalent disease in the area accounting for 32% of all the reported cases as shown in Figure 1. This is followed by Anaplasmosis which account for 16% of all reported cases. Tick-borne diseases account for 65% of all reported cases.

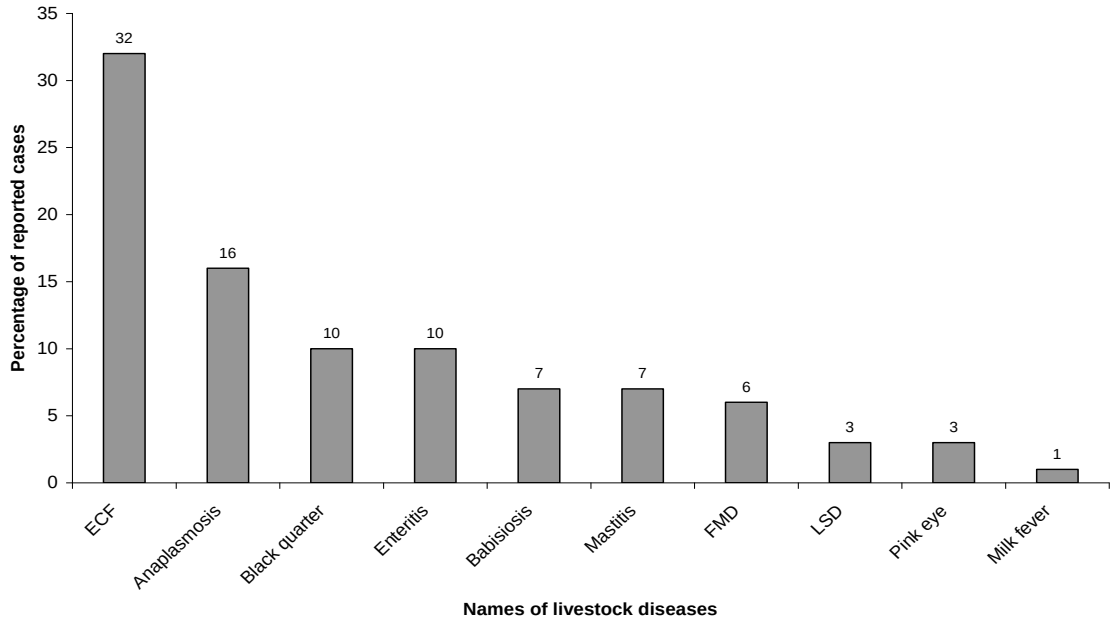

Figure 7. Prevalence of livestock diseases in Kakamega North District. ECF = East Coast Fever, FMD = Foot and mouth disease and LSD = Lumpy skin disease

Private animal health assistants (Private AHAs) are the key providers of clinical veterinary services to the farmer, attending to 38% of all the cases as shown in Table 1. The government animal health assistants (Govt AHAs) only attend to 21% of all the cases. About 63% of the service providers in the district are animal health assistants who have certificate or diploma level of education and only 10% were veterinary surgeons.

Table 6. The proportion of cases attended to by various service providers

N=71	Category	Frequency	Percent
Valid	Private AHAs	27	38
	Non-trained Para-vets	19	27
	Government AHAs	15	21
	Treatment with local medicine	7	10
	Private Vet. Surgeon	2	3
	Drug seller	1	1

Total	71	100

Empirical multinomial logit estimates revealed a negative influence of distance variable (dist) on the choice of the government service provider but a positive influence on the choice of private veterinary service providers. This is significant at ($p<0.05$ and $p<0.10$) for government veterinary service providers. The tropical livestock unit variable (tlu) has a positive effect and is significant ($p<0.10$) for government service providers but not significant for private vets. Those with secondary education and above (Educ2) had a positive effect and was significant at $p<0.10$ for government veterinary service but not significant for private veterinary service (Table 2).

The treatment costs variable (tr_cost1) is significant at ($p<0.01$) with a positive coefficient in the choice of both government and private veterinary service providers. The variable (Endemic) is only significant at ($p<0.05$) for private veterinary service providers.

Table 7. The estimates of the multinomial logit model analysis

	Estimation coefficients- Multinomial Logit model		
Variable	Government	Private	Self-treated
Dist	-0.1829*	-0.0180	This is the
Tlu	0.4387*	0.1847	Base
tr_cost1	0.0099***	0.0046***	Outcome
Educ2	2.2262*	0.9633	
Endemic	0.9600	2.3241**	
Constant	-10.8987***	-4.6134***	

* ,** , ***= Significant at 10%, 5% and 1%, respectively

Discussion

Prevalence of tick-borne diseases is one of the major constraints to livestock production in Kakamega County as is the case in many parts of Kenya and many tropical countries especially in Sub Saharan Africa, confirming the findings of Thornton (2010). The most prevalent disease is East Coast Fever (ECF), a situation similar to the observations made by Oruko *et al.* (2000) among dairy farmers in Kilifi District and also by Bebe *et al.* (2003) among smallholder dairy farmers in the Kenya highlands. Liberalisation was a deliberate policy to enhance private players' participation in delivery of livestock related services to the farmers (GoK, 1996 cited in Oruko *et al.,* 2000). This study has revealed that private practicing animal health assistants are the key providers of veterinary services in the County with very low participation of veterinary surgeons. In a related study, Musalia *et al.* (2010) observed that most smallholder dairy farmers preferred to hire services of less experienced animal production and animal health technicians because they charged less compared to the more qualified veterinary surgeons. This confirms that a great majority of the rural poor still don't enjoy the range and quality of services required to support the growing livestock industry as observed by Cheneau *et al.* (2004).

In a recent study on access to breeding services by smallholder farmers, Murage and Ilatsia (2011) reported increased access to AI services as a result of close proximity to the technicians. Long distances coupled with poor infrastructure can be very instrumental in determining demand and delivery of veterinary services (Owango *et al.,* 1998; Kathiravan *et al.,* 2009). More often, smallholder dairy farmers would prefer non-trained paraprofessionals because they are readily available and flexible in service charges (Irungu *et al*., 2006; Musalia *et al.,* 2010).

The tropical livestock unit (tlu) had a positive relationship with the demand for government service providers. These results are consistent with the findings of Tambi *et al.* (1999) which showed that farmers with large herd sizes are more likely to respond to herd health service needs. The results predicted a marginal increase in the probability of choosing both government and private service providers despite the increase in treatment cost. These findings corroborate the findings of Ahuja and Redmond (2004) which found a high willingness of the farmers to pay for livestock services, cost notwithstanding. Education increases the farmer's management capacity and his/her ability to tackle complicated information related to modern livestock production techniques, hence influencing the management decisions taken at the

farm. The significant potential increase in the probability of choosing government veterinary service is a clear indication that better educated farmers seek services of government veterinary services which is consistent with the observations by Irungu *et al*. (2006) who noted that a shift from informal to formal education would have a significant effect on the choice of the service provider. However, the case of endemic diseases predicted a high increase in probability of farmers going for private veterinary service, which is understandable because they are closer to the livestock keepers. Any complications would then be referred to providers in the higher cadre. This type of arrangement is similar to that observed by Rubyogo *et al.* (2005) among the community animal health workers and the AHAs in Mwingi District.

Conclusion

At the title of the paper, we posed a question on 'who provides veterinary services to rural livestock keeper?' Results show that private animal health assistants are the key service providers, which can be an indication that privatization is taking root. The role of the government should focus more on disease surveillance and supervision of the private service providers to ensure quality in the livestock service delivery.

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Dissemination of information and technology to improve agricultural productivity

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Abstract
Adoption of technologies and productivity is still low in many agricultural commodities in Kenya. This may be associated to the use of inappropriate information packaging, the method of communication and language used in technologies and information dissemination to clients. A survey was carried out using a questionnaire targeting participants during the Nairobi Trade Fair from 30th September to 3rd October 2013. One hundred and four respondents from 26 counties participated in the survey. Men accounted for 73% while women were 23%. The study collected data on gender, education, occupation, previous interaction with KARI technologies, agricultural forums, packaging of information, media agricultural documentaries and preferred language. The objectives of the study were to identify appropriate forums for technology dissemination, information packaging and language that can be used to increase adoption of technologies. Analysis of data was carried out using SPSS for descriptive statistics. The respondents interviewed had attained post primary level of education 87%. Farmers were the majority (41%). Less than half of the participants had interacted with at least one of KARI generated technologies. Technologies where participants had interacted most were in food crops (40%), dairy (30%), horticultural crops (25%), dairy goats (20%) and indigenous chicken 17%. Most common technology dissemination forums were through exhibitions (57%) and field days (32%) while leaflets were the most common package (45%). Radio/TV documentaries were ranked the most appropriate dissemination channel (67%). Books and manuals (23%) and journal papers (13%) were ranked lower and least appropriate for information packaging respectively. Radio/TV documentaries and exhibitions were most preferred modes of dissemination while YouTube was the least preferred (15%) among social media. English language was most preferred language (52%) of communicating technical information. The study recommends increased female participation in agricultural trade fairs for improved access to technologies. Use of Radio and TV, forums like trade fairs and field days in dissemination of technologies is recommended.

Keywords: Technologies, Dissemination, Trade fair.

Introduction

For most of the world's poorest countries, and especially those in Africa, agriculture continues to offer the leading source of employment and contributes large fractions of national income. In many of these countries, however, agricultural productivity is extremely low. Clearly, increasing agricultural productivity is critical to economic growth and development. One important way to increase agricultural productivity is through the introduction of improved agricultural technologies and technical information to farming communities and other stakeholders.

Kenya Agricultural Research Institute (KARI) contributes to agricultural development through development of technologies, innovations and new knowledge for agricultural enterprises. It therefore provides solutions on demand by farmers and other agricultural stakeholders. Through research and dissemination of findings, KARI has tried to keep pace with the increasing technology demands and has been instrumental in providing scientific solutions for agricultural development. There are many pathways that are used to disseminate the developed technologies. The pathways used may be influenced by different variables such as education, age, preference, gender and cultural issues. The institute therefore seeks to establish how best to disseminate technologies and information to their clients. A study was carried out during the September/October 2013 Nairobi Trade Fair where respondents were the trade Fair clientele. This study had the objectives of; identifying appropriate forums for technology dissemination, determining the preferred packaging of technology to clients and identifying the preferred language in technology dissemination.

Methodology

Data collection and analysis
The data was collected from randomly selected people who attended the Nairobi Trade Fair in September/October 2013. A semi-structured questionnaire was used in data collection. Descriptive statistics were done using Statistical program for Social Science (SPSS).

Results

Gender and Resident County of respondents

One hundred and four respondents participated in the survey. Females comprised 27% while males were 73% indicating more male visit the Trade Fair and participated in the survey. Participants were drawn from 26 Counties mostly from Nairobi, Kiambu and Nakuru Counties. Nairobi and Kiambu Counties had the highest number of respondents indicating that close proximity to the venue of the agricultural show could be an incentive to attend the shows.

Primary occupation of respondents

Occupation of respondents from Kiambu comprised 40% farmers, 10% extension and 45% business while Nairobi comprised of 43% farmers, 19% extension and 14% business. Occupation of respondents from Nakuru County comprised 50% farmers, 30% extension and 10% business. This indicates that farmers in peri-urban areas consider Nairobi trade Fair as an important venue for business ventures. In general, most respondents (41%) were farmers followed by Public servants and Business people (17%), extension staff (14%), Students (4%) while the other respondents combined were less than 3%.

Education level of respondents

About 87% of the respondents had post primary education with 59% indicating tertiary education. This indicates that the more educated respondents were the more likely they were to obtain new technologies and information from agricultural shows and trade Fairs. Of the respondents, one percent had no education, 12% had primary, 28% secondary and 59% tertiary or college. Very low participation by the academia (1%) in agricultural show indicates that for this cadre, agricultural trade fairs may not be appropriate forum for learning and technology dissemination.

Interaction with KARI technologies

Sixty five per cent of respondents had interacted with KARI technologies while 35% had not. Figure 1 below indicates respondent's interaction with KARI technologies.

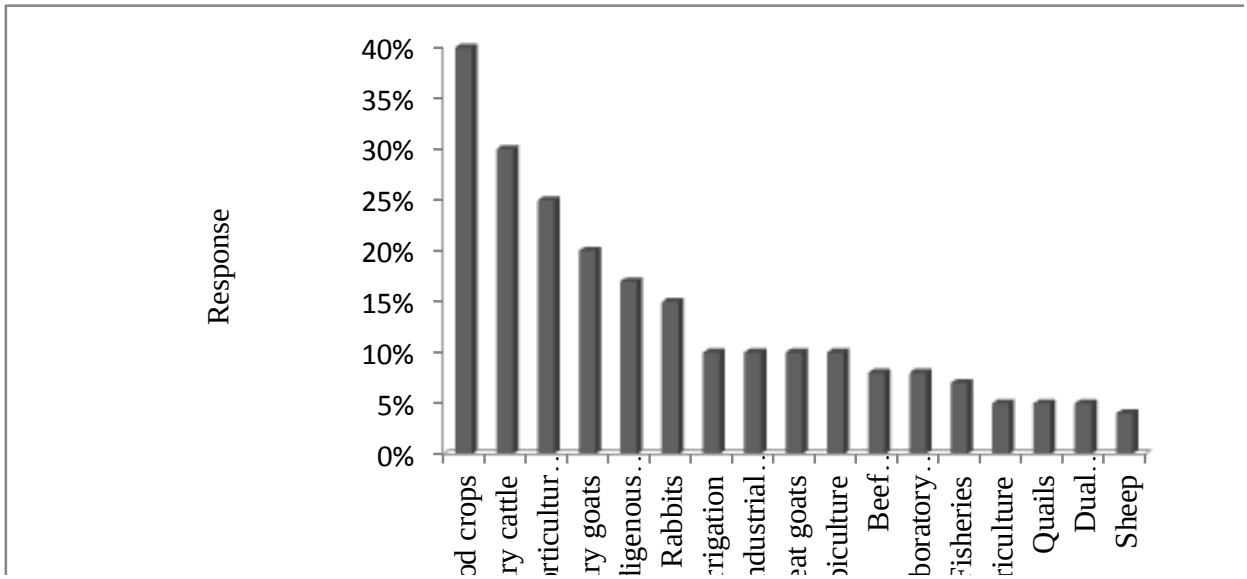

Figure 1. Level of interaction with KARI technologies

Dissemination Forums and packaging of KARI technologies

The study evaluated forums through which KARI technologies were transferred. Shows and exhibitions (57%) were most popular followed by field days (32%), on-station visits (29%), extension (25%), farmer groups (17%), farmer field schools (13%), county barazas and through friends (11%), internet and scientific conferences (8%), Priority setting meetings (7%) and Mass media (6%). In dissemination of information, KARI uses a number of packages. The most commonly used packages were leaflets (45%), followed by radio and TV documentaries (34%), posters (32%), Books and manuals (23%), both Technical bulletins and Journal papers (13%) while personal interaction, internet and seminars were rarely used (5%).

Preferred packaging and forums

Respondents were asked about their preference for information dissemination through the social and conventional media. Results in figure 2 below show the preferential ratings where radio/TV documentaries (67%) and Field days (62%) in conventional media and Facebook (37%). Social media was the most preferred while You Tube (15%) was the least preferred.

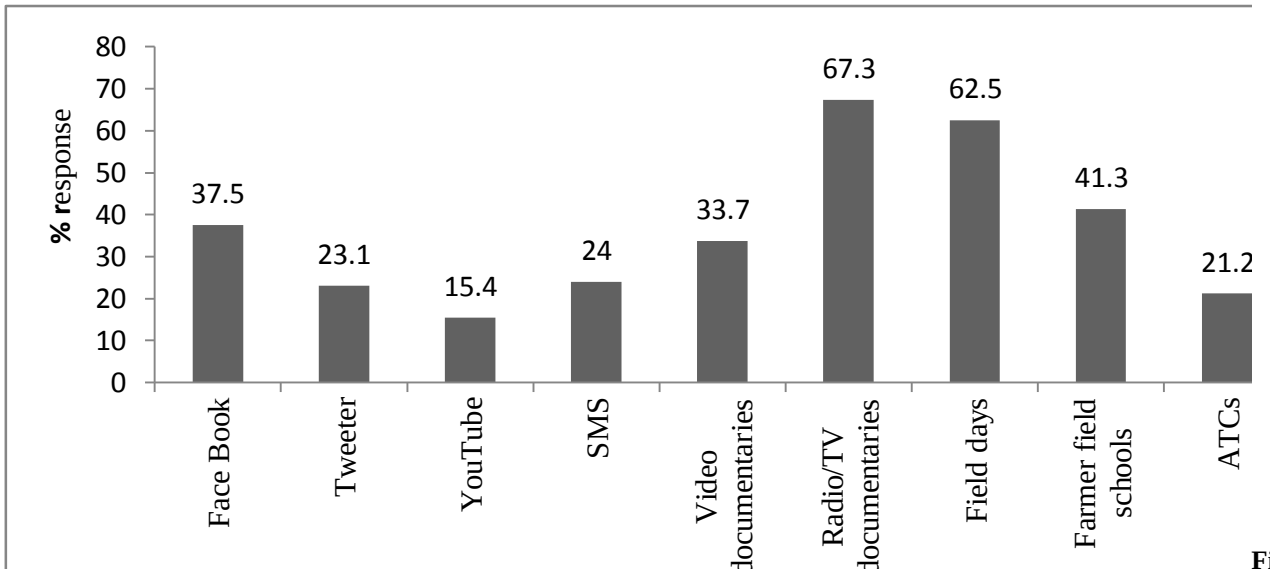

Figure 2 . Preference rating for various dissemination media

Ranking of language for communicating technical information

In communicating technical information, the language used can enhance or discourage learning and adoption of technologies. The study established that English language was the most preferred (52%) followed by Kiswahili (31%) while vernacular were the least preferred (20%) in information packaging for dissemination of technologies.

Discussion

More males participated in the survey compared to females. This may mean that men are more likely to have time and resources to attend agricultural trade fairs compared to females. There may be a higher likelihood for men to adopt new technologies as a result of training received in these forums.

Most farmers participating in the show had post primary education with majority having achieved tertiary education. More educated farmers are typically assumed to be able to process information and search for appropriate technologies to alleviate their production constraints. The belief is that education gives farmers the ability to perceive, interpret and respond to new information much faster than their counterparts without education. Studies in Mozambique (Uaiene *et al.*, 2009) on adoption of improved seed by smallholder farmers found a positive effect of education on the probability of adoption of improved maize seeds.

Agricultural shows and trade fairs offer opportunities for farmers to interact with technology developers, extension and other actors along the agricultural product value chain. Sensitization of farmers by technical staff through visits and discussions has been shown to promote adoption of technologies (Nsabimana and Masabo, 2005). During trade fairs, farmers have opportunity to learn about advantages of new technologies, raise questions and gain knowledge useful in application of these technologies for increased agricultural productivity.

The purpose of the KARI strategic plan (KARI, 2009) is to enhance generation and promotion of agricultural knowledge, information and technologies that respond to clients' demands and opportunities. The plan seeks to enhance availability of knowledge, information and technologies on agricultural product value chain. Results of the survey showed that most

participants have interacted with KARI in technology transfer during field days, shows and exhibition forums. Use of mass media in technology transfer was very low. Similarly, less than 10% of respondents attributed technology transfer to fora such as priority setting, internet and scientific conferences organized and used by KARI. This finding suggests change in strategy in technology transfer with emphasis on shows and exhibitions, field days and extension in Counties.

Studies in five African countries indicate that farmers demonstrated increased knowledge of agricultural innovations as a result of listening to radio programs and most scoring at least 60% on follow up knowledge quiz about promoted farm practices (Perkins *et al.*, 2011). Considering staff challenges where the ratio of frontline extension worker to farmers is about 1:1000 in Kenya (GoK, 2012) compared to the desired level of 1:400, use of radio and TV is a viable option especially in awareness creation and mobilization. Increased use of radio and TV documentaries should be considered by extension agents to reach farmers who otherwise may not find time to attend field days or farmer field schools. Radio/TV documentaries and field days were most preferred in dissemination of technical information. Access to radio and TV may not be limiting to most show attending clientele. Speed of uptake of technology depends on the dissemination pathway used (Murage *et al.*, 2011). Field days and farmer field schools are preferred due to advantages of interaction and interrogation on the specific technologies exhibited (Mbugua *et al.*, 2010). This suggests need for increased use of this media to promote technology adoption in agriculture. Increasingly, the mobile phone is becoming an important tool of communication but also for extension and technology dissemination. Studies involving farmer trainers in Uganda showed that over 80% used mobile phones in mobilizing farmers (Karuhanga *et al.*, 2012). Studies in use of mobile phone in India involving cotton farmers (Cole and Fernando, 2012) showed that demand for agricultural advice was high, with more than half of farmers calling in during the first seven months of the service introduction.

This study established that the least appropriate KARI technology packaging was in books and manuals as well as journal papers. This finding was unexpected considering the level of education of respondents. However it reinforces long held perception about poor reading culture of Kenyans. The study however established that posters and leaflets were considered more appropriate compared to journal papers, books and manuals. Packaging of printed information on KARI technologies should therefore be in posters and leaflets with readability features considered to attract various audiences.

Conclusion and recommendation

Most of the respondents were males. There is need to increase female participation in forums such as agricultural trade fairs for improved access to technologies adoption which would facilitate increased agricultural productivity and improve post-harvest processes such as market access. Technologies generated by KARI were mostly transferred through field days, trade and exhibitions while leaflets and posters mostly used in information packaging. Most preferred information packaging was in radio and TV documentaries. Information dissemination should target these media for enhanced adoption of new technologies while use of mobile phone as a tool of communication up-scaled. English was the most preferred language of communicating technical information while vernacular was least preferred. Use of English language should be emphasized in technology packaging and dissemination. However, though Kiswahili and Vernacular were ranked lower, they have audiences that prefer them. Programs made in English should also be prepared in these languages.

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Delivery of Animal Health Services in Northern Ghana: Are Community Animal Health Workers the Solution?

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Abstract

The recent trends toward agricultural intensification and biophysical changes have resulted in increased risk of zoonotic diseases. Yet, access to quality animal health services still remains a fundamental problem in developing countries partly due to limited human capacity. This paper uses the concepts of accessibility, affordability and transaction costs to examine the perceptions of livestock keepers on the various animal health service providers. The empirical analysis is based on a survey of 120 livestock-keeping households and 18 service providers in the Northern Region of Ghana. A multinomial logit model was used to determine the factors that influence households' choice of alternative animal health service providers. The results show government para-vets to be the most preferred type of animal health service providers, while Community animal health workers the least preferred. Reasons for this preference include high costs of transaction and low performance resulting from limited training. In areas with few or no government para-vets, farmers resorted to self-treatment or to selling sick animals for consumption, which has undesirable health implications. This paper finds that Community animal health workers system is insufficient for providing quality animal health services to the rural poor in marginal areas. Therefore, 'market-smart' alternative solutions requiring strong public sector engagement to support livestock farmers in marginal areas and setting minimum training standards for animal health service providers merit policy consideration.

Keywords: Animal health services, Marginal areas, Market smart alternatives, Para-professionals

Introduction

Livestock keeping supports the financial, human and social capital needs of about 70% of the world's poor in developing countries through direct income provision for: farming activities, medical care, finance and education, as well as serving as a social safety-net (FAO, 2011). Yet, poor livestock keepers in marginal areas often lack access to affordable clinical and preventive animal health services (Awa and Achukwi, 2010). Diseases such as Contagious Bovine Pleurapneumonia (CBPP) and Peste des petits Ruminants (PPR) among others continue to affect livestock production and inflict losses to livestock keepers (Awa and Achukwi, 2010; FAO, 2011). Providing quality and sustainable animal health services to livestock dependent communities is a key to reducing economic losses and human health risks associated with animal diseases.

To provide quality and sustainable animal health services, most governments in developing countries promoted private practices and discontinued the automatic employment of veterinarians (service providers with a university degree in animal health training) and of para-vets (service providers with a diploma or certificate in animal health training). However, private practice is limited to some urban areas and in the intensive production systems, but not in livestock dependent marginal areas. As a result, the Community Animal Health Workers (CAHWs, community members with limited training) have been promoted to fill the gap in providing animal health services to the poor (Randolph *et al*., 2007; Awa and Achukwi, 2010). Although the CAHWs succeeded in improving access to animal health services in some marginal areas, there are growing concerns that their qualifications and the quality of the services that they provide are subpar (Lamichhane and Shrestha, 2011).

The privatization policy interventions in developing countries have created a livestock service delivery environment in which a limited number of government employed para-vets are working alongside CAHWs and private para-vets. This study examines livestock keepers' perceptions of the various service providers in Ghana. The multinomial logit model (MNLM) was used to determine the factors that influence households' choice of alternate service providers. The MNLM has been widely used in human health research (Zhu *et al.*, 2010; Kuunibe and Dary, 2012) but to the best of our knowledge no studies have applied it to animal health. This could be attributed to the fact that several studies in animal health decisions have been focused on binary choices, rather than nominal choices, for which the MNLM is very useful. Although our interest was in the use of CAHWs, which would permit the use of a binary model, Cheng and Long (2007) argue that restriction of choices when they exist is unacceptable in applied research.

Materials and methods

The study was conducted in the Tolon-Kumbungu and Savelugu-Nanton districts of the Northern Region of Ghana. The region and districts were purposively selected because of the importance of livestock to livelihoods there. A two-stage cluster sampling technique was employed to select a total of 128 livestock farmers and 18 livestock service providers. The questionnaire was designed to generate information on household perception about livestock health service delivery indicators such as affordability, access to service providers, access to drugs and transaction cost of service delivery. Information on households' demographics and farming activities were also generated.

Data analysis

Farmers were presented with six livestock service delivery indicators: physical access to service providers, access to drugs from service providers, access to animal health information, cost of drugs from service providers, cost of livestock services and overall performance. For each indicator, farmers were asked to rank (1= highest to 4 = lowest) the government para-vets, private para-vets, CAHWS and self-treatment (STS). The indicators follow the components of the scoring framework used by Mcleod and Wilsmore (2002). A multinomial logit model (MNLM) was applied to identify the factors that influence the farmers' choices among the three different types of service provider.

Results

Government para-vets were the most used service providers by livestock keepers. The proportion of farmers who self-treated livestock was higher than those who used the services of CAHWs. The government para-vets were perceived as the best performing animal health service providers relative to the other service providers (Table 1). The CAHWs' system was ranked as the least accessible. The government para-vets had the highest rank in terms of accessibility to service providers and access to animal health information. For cost of drugs, the private para-vets had the highest rank. For treatment cost, self-treatment was ranked highest. The government and private para-vets have similar training, while the CAHWs only have three to four weeks of training (Table 2). The GPVs are provided with fuel allowance, motor cycle on hire purchase, and monthly salary but the private para-vets and CAHWs do not have such incentives.

Results shows that compared to GPV use, the likelihood of PPV use was lower for farmers who had: some level of education, cash objective for keeping livestock, income from livestock production, large land sizes and higher treatment cost (Table 3). Farmers who had off-farm income were likely to use PPV compared to GPV use. Compared to GPV use, the likelihood of CAHW use was lower for farmers' older in age and who had: higher treatment cost, cash objective for keeping livestock and large land sizes. High treatment cost decreases likelihood of farmers self-treating livestock compared to GPV use but availability of off-farm income increases likelihood of self-treatment compared to GPV use.

Results show that compared to GPV use, likelihood of self-treatment of livestock was lower for farmers who had cash motives, some level of education and large land sizes.

Table 1. Perception of animal health service delivery systems (Rank analysis)

Perception Indicators	Government para-vets	Private para-vets	Community Animal Health Workers	Self-treatment System	Kendall 'sW[a]
Physical access	1	2	3	-	0.56
Access to drugs	1	2	4	3	0.35
Access to information	1	2	3	-	0.33
Cost of drugs	2	1	4	3	0.22
Cost of services	2	3	4	1	0.55
Performance	1	2	4	3	0.47

Note: 1= Highest rank to 4= Lowest rank, W= 0.54 & p-value= 0.00 for all livestock service delivery. W value represents the degree of agreement.

Table 2. Training and incentive for service providers

Indicators	Government para-vets	Private para-vets	Community Animal Health Workers
Education	Three years diploma program in animal health training	Three years diploma program in animal health training	Three to four weeks certificate program in animal health training
Transport	Provision of motor cycle by government on hire purchase	Personal purchase of motor cycle	Bicycle from Non-governmental Organization
Incentives	Salary and fuel allowance from government	Private income	Toolkit from NGO and private income

Table 3. Determinants of animal health service providers (Multinomial logit model)

	Ppv Service Provider		Cahw Service Provider		Self-Treatment Of Livestock	
	Coef	Z	Coef	Z	Coef	Z
Age	0.031	1.29	-0.061**	-2.02	- 0.041	-1.39
Objective	-2.144**	-2.30	-2.419**	2.20	-1.833*	-1.74
Educ	-0.197**	-2.35	-1.657	0.01	-0.183*	-1.84
Land	-0.076***	-2.81	-0.102**	-2.32	-0.107**	-2.50
Income	-0.001**	-2.51	-0.000	-1.47	-0.000	-0.81
Distance	0.060	0.52	0.198	1.46	0.015	0.11
Care	-0.729**	-2.35	-0.247	-0.67	-0.432	-1.21
Cost	-0.130**	-2.49	-0.197***	-2.89	-0.241***	-3.44
Tlu	0.061	1.03	0.106	1.51	0.041	0.57
Offincome	2.134**	2.29	1.411	1.18	2.129**	2.03
Cons	5.482	2.81	1.656	0.69	3.536	1.58

Number of obs = 119 LR Chi^2 (33) = 60.25 Prob>Chi = 0.0009 Pseudo R^2 = 0.2201
Note: GPV is the reference category. *, **, *** refers to significance level at 10%, 5% and 1%, respectively

Discussion

The government para-vets (GPVs) are the most preferred and more widely used animal health service providers by livestock keepers than CAHWs and private para-vets (PPVs). This is consistent with Leonard *et al.* (2013) review which shows that, clients demand for service providers with superior competence. The better performance of GPVs (as indicated by farmers' rankings) compared with CAHWs and private para-vets could be associated with the fact that government para-vets easily consult veterinarians who supervise them. Also, PPVs were perceived to be more cost effective than GPVs and CAHWs in terms of drugs, because most of the PPVs operate animal drug shops, thus retailing to other service providers. The CAHWs were ranked as having the highest operating costs and being the least accessible. This is attributed to the fact that CAHWs do not often have drugs available and livestock keepers have to pay the transportation cost of CAHWs to buy drugs from the nearest town and also pay for treatment charges. Yet, livestock keepers could call GPVs on their mobile phones, and have them come with drugs to treat sick animals or take advantage of their presence in the community when they visit other farmers. These results contradict the popular view that the presence of CAHWs will necessarily translate into better access and affordable service delivery. Catley *et al.* (2004) expressed this view in the past and recently by Lamichhane and Shrestha (2011).

The higher a livestock keeper's age and education level, the less likely they are to use CAHWs and PPVs, and the more likely they are to use government para-vets. This finding suggests that, all things being equal, advancing in either age, and increasing years of education decrease CAHWs and PPVs use compared to GPV use. This observation agrees with findings by Lamichhane and Shrestha (2011) in the Kaski District of Nepal. Their results show that an increase in age and higher education level increases demand for qualified service providers. CAHWs will need to acquire superior knowledge through adequate training in animal health care and refresher courses to remain valuable and active in the community. Livestock keepers that own more land and have higher incomes are also less likely to use CAHWs and PPVs compared to GPVs use. Land and income are measures of wealth, therefore farmers with more land and income could have the capacity to seek more qualified services. This concurs with findings of Irungu *et al.* (2006) in Kenya and Lamichhane and Shrestha (2011) in Nepal.

Findings from this study show that, there is a trend toward government para-vets use compared to other service providers. The government animal health workers are better trained and have access to incentives which improves their capacity and performance. While the CAHWs may be useful in implementing disease control programs such as vaccination exercises, they are insufficient in meeting the animal health needs of farmers in marginal areas. This is could be attributed to the limited training of the CAHWs and lack of incentives. The limited number of government para-vets due to privatization policy of the government, inability of the private sector to fill the gap and low demand of CAHWs services is affecting the animal health sector.

The current trends toward agricultural intensification and the associated risk of zoonotic disease emergences in developing countries, and other human health implications, it is imperative to boost the human capacity needs of the animal health sector. Therefore, 'market smart' alternative solutions involving strong public sector engagement in training more para-vets are essential to solve the human capacity challenge in animal health service delivery, while at the same time synergies between the private and public sectors must be harnessed. Training more qualified para-vets and establishing them in strategic communities could reduce costs and provide sustainable services to livestock dependent communities. These trained staff should be linked to private input dealers so they can get inputs at affordable prices. Alternatively, the poor could be targeted through a livestock service delivery voucher system. Government regulation in setting minimum standards for training of para-professionals and regular supervision by veterinary staff should also be enforced.

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Application of the decent work concept in labour and employment conditions on smallholder dairy farms in Nakuru county, Kenya

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Abstract

Smallholder dairy farms constitute the overwhelming bulk of all dairy enterprises in Kenya. The concept of decent work involves four interlocking elements: employment, rights at work, social protection and social dialogue. Although employment relations are governed by labour laws which have a basis on the decent work concept, a fundamental gap in knowledge exists about the employment situation of smallholder dairy farm workers. Consequently, a study on small farms and individual rights is very timely and highly significant for sound policy formulation. Data was collected with the use of a questionnaire through a survey in Nakuru County of Kenya in four divisions selected purposively. Respondents were identified through snowballing, resulting to 123 respondents. SPSS version 17 software was used for data analysis to obtain descriptive and inferential statistics. Results indicate that labour management was highly informal, with many smallholder dairy farms unable to match the terms or benefits envisioned in the decent work concept such as minimum wage, health insurance and social security for their workers. Workers also seemed to lack a collective voice or have no choice. Social and economic factor caused shifts in the extent to which various indicators were taken up, thereby, playing a role in compliance. Some that were identified include factors like the farmer's principal occupation, size of land and the number of animals kept, whether one was a domestic migrant or not, education level of worker and milk marketing channel. Adoption also seems to be constrained in part by lack of linkages between trade union, employers and employees. While some factors may be amenable to policy change, others require attitude change. It is recommended that education, institutional or legal assistance be instituted to drive compliance with the decent work concept. There is need to provide incentives to encourage the formalization of jobs and, *inter alia*, support the enforcement of rules and regulations by allocating greater resources to labour inspectorates. Additionally, there is need for consciousness, progressive and supportive system that should include but not limited to farm labour unions, community groups, and advocacy organizations to provide support for basic social services and social security institutions whilst at the same incorporate extension and marketing agencies to make farmers more productive. The study contributes to the literature of decent work for smallholder dairy farms by providing empirical evidence on the practice.

Keywords: Decent Work standards, Working conditions, Smallholder dairy farmers, Kenya

Introduction

The employment relationship is the key point of reference for determining the nature and extent of employers' rights and obligations towards their workers (ILO, 2006). Employment status influences quality of work. In today's labour market, growth in employment has taken place more in the informal market (ILO, 2002). Informal sector work has often been considered of low quality and precarious in nature (ILO, 2013). Workers in informal employment earned less, had volatile incomes, lacked access to basic public services and protections, and faced higher risks of poverty compared to workers in formal employment, lacked access to modern capital markets, to formal training and to official social security systems, among other employment challenges (Chan, 2013). Labour relations where they exist in informal situations are based mostly on casual employment, kinship or personal and social relations rather than contractual arrangements with formal guarantees (ILO, 1993). Over the last decade, concerns on the nature of employment in informal sector, has led to a focus to improve the informal nature of employment to formality. The International Labour Organization (ILO), being uniquely placed through its tripartite structure and mandate, has taken up this challenge through the concept of decent work (ILO, 2003).

Decent work refers to opportunities to work in conditions of freedom, equity, security and human dignity (ILO, 1999). The decent work agenda focuses on four inseparable, interrelated and mutually supportive objectives: *employment* – this considers employment opportunities, stability and security at work; *rights* – encompasses adequate earnings, decent hours, combining work and family life, work that should be abolished, equality, freedom from discrimination, freedom from forced labour, child labour, and s*ocial protection* – social security safeguards income and underpins health (ILO, 2011). It includes aspects such as security of income, access to minimum health, means to meet emergencies and need include ill-health, maternity needs, accidents, unemployment and safe work environment. Finally is *dialogue* – which entails social dialogue, voice and representation, employers' and workers' representation, participation in workplace decision-making and collective bargaining, and participation by workers in employers' and civil society organizations. Individual countries ratify ILO conventions while taking into consideration their own social economic political and legal considerations. Tripartism ensure ownership of strategies, stability of national policies and fairness at home and in relation with donors and international organizations (ILO, 2003). Decent work, therefore, applies not just to workers in the formal economy but also to unregulated wage workers, the self-employed and home workers (Ghai, 2003, ILO, 2010). The Government of Kenya has enacted new labour laws that domesticated ILO conventions on decent work, thereby, providing a clearer legislative framework on issues such as employment contract, hours of work (GoK, 2007a, b, c, d, e).

As far as informal employment is concerned in Kenya, farm workers comprise the largest single category of wage jobs because farming is the dominant way of life for much of the population (World Bank, 2012). A key subsector of livestock sector where farmworkers play a critical role in the country is dairy farming. Small- and medium-scale dairy farms dominate the industry and contribute 75% of milk produced (Ouma *et al.*, 2007; FAO, 2011). Farmers account for most (87%) of employment at the farm-level (Ouma *et al.*, 2007). According to FAO (2011) farm level dairy activities are estimated to generate a total of about 841,000 full-time jobs (585,000 for full-time hired workers and 256,000 for self-employed/farm owners) up from 365,000. It has not been established whether the enactment of legal laws on decent work basis has given impetus to decent work practices on farms. Besides, there have been relatively few attempts to systematically unravel the relationship between smallholder livestock farms and employment, and labour practices from a decent work perspective. It is not clear whether the employment status in small-scale dairy farms is found in common experience as created or developed contrary to regulation. Often, there exists a weakness in our knowledge of employers' willingness to adhere to both established and new areas of regulation. The current study investigated individual employment rights (IERs) in smallholder dairy enterprises in Nakuru County of Kenya.

Methodology

Through a cross-sectional survey, data was collected from smallholder dairy farms during the period 2013, covering 5 sub-Counties of in Nakuru County, namely; Njoro, Mau Narok, Elburgon, Mauche and Bahati. Due to lack of a sampling frame within the area of interest, snowballing was used to identify farmers with workers. Farms initially contacted were interviewed and asked for the names of other farms with workers who were then interviewed. A total sample of 123 farms was reached. Structured interview questionnaires were used to collect data, which was administered on the farm workers and their employers. The questionnaire was designed to collect information on farm, farmers, workers' characteristics and decent work indicators, and the decent work indicators; employment opportunities, rights at work, social dialogue and social security. For the first indicator, the variables of interest were employment opportunities, stability and security at work. On rights at work, the questionnaire captured adequate earnings, decent hours, combining equality, discrimination,

and forced and child labour. Regarding to social protection, affiliation to insurance and pension scheme was captured. Finally on social dialogue, voice and representation, employers' and workers' representation, participation by workers in employers' and civil society organizations workplace decision-making and collective bargaining was collected. Interviews were conducted by trained enumerators. The data was subjected to both descriptive and inferential statistical analyses. In this study The Statistical Package for Social Scientists (SPSSv17) software was used for data analysis to obtain descriptive statistics so as to describe the attributes of the study population.

Results and discussion

Demographic and social characteristics of farm workers

Seventy eight per cent of the farms had one employee, 17.1 % had 2 and 3.4%, representing 3 and 4 workers. Majority of the workers (85.4%) were male. Most (58.2%) of them were married and, together with singles (39.3%), formed the bulk of farm workers. The average age of the workers was 31.7 years. There was a distinctive concentration of farm workers in the age band of 19-35 years (69.1%) representing the youth.

Full and productive employment

Less than 13.0% of the employees had a written contract while most (85.4%) had an oral contract. Majority of the workers stated that contracts at the point of discussion were not detailed as they seemed to address only workers' personal details and wages but avoided most other facts. A small number of workers (1.6%) were employed on a seasonal or casual basis.

Rights at work

Wages: The current minimum wage was Kenya Shillings (KES) 4,918 per month equivalent to KES 208 per day for a farm employee in the rural areas. The most commonly reported wage was KES 3,000 per month as reported by 24.8% of the workers. Based on the current minimum wage, 65% of the respondents were being paid below the recommended minimum. Using the median paid and comparing this to the absolute poverty line, employees earned two times the level of the rural poverty line. Therefore, while employment in dairy farming may not provide adequate income, it can help to some extent in cushioning the employee from economic challenges. There was a difference between workers level of education and amount the worker was paid. The effect of education was significant, ($F4, 112 = 2.26$, $P = .067$). Results indicated that the workers with university level of education were paid an average of KES 8,750 (SD = 7,805); secondary level of education, KES 5,039 (SD = 3747); vocational level KES 4500 (SD = 4,822); primary level KES 4,276 (SD = 2,238): no schooling KES 4,063 (SD = 2528). Domestic migrants reported statistically lower wages (M = 3,983, SD = 1488) than did non-migrants (M = 4979, SD =3633), $t(111.32) = 2.08$, $p = 0.04$. There was marginal differences on average wages between workers taking part in decision making over those who did not F (3,110) = 2.197, $p = 0.94$. Essentially, this pointed out that employment relation may play a significant role with regards to whether salary was paid below or above the statutory minimum. Generally, amount of wages paid out increased with increasing income from the dairy enterprise. This was difference at F (3,113) = 3.375, $p = .021$ with respect to income from livestock. Low income group may not be able to retain good and highly educated workers since they may be unable to match their terms. Large farms paid higher wages (M=6100, SD=4508) than smaller farms (M=3763, SD=1326), $t(46.7)=-3.316$, $p<.002$). Farmers who had slightly more animals (M = 5, SD = 3) were also able to pay better wages than those with fewer animals (M = 1, SD = .7). These wages were (M = 6159, SD = 4899) and (M = 3911, SD =1324), t (test<0.01).

Working hours: Working time, combining work, family and personal time, annual leave and working on holidays

On average, employees worked for slightly over 8.7 hours a day. Only 37.3% farms exceeded the threshold of 45 hours per week by between one to six hours. It is noted that for married farmers, workers spent significantly more hours (M=8.81, SD=1.62) than either worker who worked for widowed (M=8.25, SD=0.45) or single (M=7.67, SD=0.5). Married farmers were likely to be under pressure to produce more, not only for family consumption but also for sale. The desire to produce more could lead to longer working hours. Employees working hours differed by the market channel ($t(22.94) = 7.98$, $P= 0.01$), with those in the informal channel spending more hours than formal. This is likely as marketing in formal channel is done through established collection points unlike informal. There was significant effect for herd composition, with crosses requiring more labour hours (M = 8.41, SD = 1.33) than exotics (M = 8.87, SD = 1.62; $t(118)$, $P = 0.098$). Working beyond the statutory minimum could, therefore, be as a result of the imperatives of the dairy enterprise. The proportion of workers with weekly rest periods was high at about 79.0%, with only 21.6% working beyond the recommended 6 days. Only 74.3% farm workers had leave facilities.

Employees and days worked and work that should be abolished;

Respondents aged 19 to 35 worked fewer days, averaging (M = 5.97, SD = 0.07) compared to above 6 for all other age groups of workers ($F3, 103 = 4.19$, $p = 0.08$). Females reported working on average more days ($M = 6.56$, $SD = 0.51$) than men ($M = 5.98$, $SD = 0.58$), ($t105 = -3.67$, $P < 0.001$). Only three workers were below the minimum age for hazardous work representing 2.4% of the farm workers interviewed.

Occupational safety and health and social security protection

Most workers (82%) made own provisions to protective equipment. Only 30.1% of the workers had attended training to ensure health and safety at work. About 46% of farm workers alluded to a health related issue sustained in the course of their work. The nature of injuries was not fatal, and related to cuts and wounds. None of the farm owners made any contribution to a social security scheme on behalf of their workers. Only 32.5% had affordable health insurance coverage. Many workers related non-contribution to uncertainty in employment.

Social dialogue and employers' and workers' representation

None of the respondents belonged to any union. All of them were unable to identify the union that represented agriculture workers, KPAWU (Kenya Plantation and Agriculture Workers Union). Membership to KPAWU was not limited to permanent workers but could extend to non-permanent workers (Dolan, 2004).

Conclusions

The analysis in this study was built upon a decent work conceptual approach. The findings suggest that smallholder farms made a contribution to creating employment. Formal employment contracts are rare in the sector, and where work agreements do exist, key provisions in standard employment agreements are often absent. Low pay was a systemic problem across the sector, and workers rarely received employment benefits like health insurance or social security. It was evident that salaries provided workers with economic relief. Farm work can also be hazardous, and workers faced risks of exposure to chemicals as well as workplace injuries. Generally, aspects of decent work concept with the lowest uptake included social dialogue (100%), social security (health 67.5% + pension 100%) and wages (65.0%). Educational level of the worker, and whether a worker was a migrant or not also had an effect on the worker's terms of employment. Further, economic conditions seemed to play a major role in the uptake of the decent work concept. Overall, farmer's uptake of decent working codes followed a stepwise approach. This inferred that education or awareness campaigns were relevant to drive compliance.

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POSTER PRESENTATION

Dairy information topics and their importance to smallholder dairy farmers in Limuru and South Kinangop sub-counties, Kenya

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Abstract

Dairy cattle farming is important in providing milk, meat, manure and as farmer assets in Kenya. It creates employment for smallholder farmers, traders, processors and input suppliers. However, milk production is below the cattle's expected potential. Among the factors attributed to this low production is farmer's insufficient access to technical information. The study objectives, therefore, were to determine the number of dairy management topics farmers accessed and rating of these topics. Cross-sectional survey design was used where systematic and purposeful sampling procedures were applied. Data analysis were by the use of descriptive (frequencies, percentages and mean) and inferential statistical tools. Dairy farming in Limuru was characterized by more female managed enterprises while South Kinangop had more male managers. Male farmers had more education than females in both study areas. There was a difference in number of topics accessed among gender. However, farmer education positively correlated with number of dairy information topics accessed. Most accessed information were pest and disease control, fodder production and conservation and making feed rations. The least accessed information to farmers were milk marketing, accessing credit, seasonal production control and cattle recording with the official dairy recording services. There was no difference in rating importance of breeding management, milk hygiene and recording cattle which showed concurrence on importance attached to these management practices in the sub-counties. With varying education level, there were no differences in rating of some of the topics although younger farmers appreciated importance of home based value addition, breeding, record keeping and hygiene. Extension efforts should be geared towards farmer education on control of breeding, production control, record keeping and livestock feed management with emphasis placed on female farmers who had least access.

Keywords: Dairy, Information topics, Access, Smallholder dairy

Introduction

Dairy cattle farming is important in providing milk, meat, manure and capital asset to farmers in Central Kenya. It is a significant source of employment to small holder farmers, traders, processors and input suppliers. However, milk production, even in high potential areas, is below lactating cows expected potential (Wambugu, 2000). One of the factors attributed to this low production is the farmer's insufficient access to technical information which has shown to reduce efficiency in resource use for dairy farming (Makokha *et al.*, 2004). In agriculture, the role of extension has traditionally been vested in public extension predominantly within the ministry of Agriculture, Livestock Development and Fisheries. The extension services have an important role in sharing knowledge, technologies and agricultural information in order to transform subsistence farming to modern and commercial agriculture (GoK, 2012).

Insufficient technical information flow has remained the main hindrance to the dairy sector. In particular, information on dairy cattle management that includes appropriate feeding practices, required milk quality standards, management of livestock diseases, appropriate breeding methods, value addition, access to credit and market requirements are key constraints to enhancement of productivity. This study focused on Limuru and South Kinangop Sub-counties where dairy farming is intensive and extensive systems respectively. There is lack of information about specific dairy farming information required by dairy farmers practicing intensive farming in Limuru and extensive farming in South Kinangop Sub-counties. The study's objectives were to asses the number of dairy management topics that farmers accessed and to determine the farmers rating on important dairy farming information in the two sub- counties.

Methodology

The study used cross-sectional survey design using systematic and purposeful sampling procedures where transects were drawn in each location and every 5th household on either side of the road visited in Limuru and South Kinangop sub-counties. The household owner, spouse or other senior member of the household was interviewed using a semi-structured questionnaire. Where none of these were present, or the household did not have dairy cattle, then the next household was picked. Responses were based on farmer recall for a period of one year preceding the study.

The sampling frames were the locations in the two sub-counties. Ngecha, Rironi and Limuru locations were sampled in Limuru sub-county based on different exposure levels of government extension service (Wambugu, 2000) while in South Kinangop sub-county, three locations (Nyakio, Njabini and Magumu) were sampled. The sample size was a proportion of the dairy households that were 63 and 281 households in Limuru and south Kinangop respectively. Data was analyzed using Statistical Package for Social Sciences (SPSS) software version 20.

Results and discussion

Farmer characteristics

Limuru dairy farmers practiced intensive dairy farming South Kinangop mainly practiced extensive farming. Proportionally, Limuru sub-county had more female dairy farmers while South Kinangop had more male dairy farmers (Table 1). This implies that labour in dairy farming is provided mainly by women in Limuru and men in South Kinangop. Men were more involved in off-farm employment activities in Limuru, being peri-urban compared to South Kinangop which mainly is a rural setting. Males had more education than females in both study areas. Farmers with post primary education were more in Limuru (49%) than in South Kinangop (33%) sub- counties. In both sub-counties, most farmers had attained at least primary level of education.

Table 1. Gender and education level of smallholder farmers in Limuru and South Kinangop sub-counties

Farmer characteristics	Category	Limuru		South Kinangop		Total	
		n	%	n	%	n	%
Gender	Male	27	43	151	54	178	52
	Female	36	57	130	46	166	48
	Non formal	10	16	34	12	44	13
	Adult education	0	0	7	2	7	2
Education level	Primary	22	35	149	53	171	50
	Secondary	21	33	81	29	102	30
	Tertiary	10	16	10	4	20	6

Source: Survey data (2010)

Farmer education level and access to dairy topics

Farmer education level was positively correlated with the number of dairy topics accessed. However, using Mann-Whitney test for independent samples, there was a difference in number of topics accessed, ($p=0.258$) in the two sub-counties. There was significant ($p=0.000$) and positive correlation (+0.249) in number of topics accessed and education level. Mburu (2013) reported that significant relationship between age and education of smallholder farmers and access to agricultural information using different channels.

Gender and information topics accessed

Women role in agricultural labour has continually grown (World Bank, 2012) and therefore their role, responsibilities, access to resources including agricultural information is required. Men accessed more dairy

information topics compared to their female counterparts. Using Mann- Whitney test for independent samples, there was significant difference (p=0.003) among gender in number of dairy information topics accessed. This asymmetry showed that training should focus on female dairy farmers more than to male farmers. The national extension policy (GoK, 2012) has identified the challenge of developing comprehensive and dynamic extension packages that consider client socio-economic conditions and gender among other issues. The information packaging should address this information asymmetry among gender.

The least accessed dairy information by farmers in the two study sites were milk marketing, accessing credit, production control in wet and dry seasons and recording of dairy cattle with the dairy recording services of Kenya (DRSK) (Tables 2 and 3). In both study sites, female farmers had least access to information on production control in wet and dry seasons and recording of cattle. More female farmers seemed to have accessed information on calf rearing compared to male famers.

Sensitization on new technologies through visits by technical staff and discussions during sector meetings has been shown to promote adoption of technologies (Nsabimana and Masabo, 2005). To control the perennial production of milk production fluctuation between dry and wet seasons, extension efforts should be geared towards farmer education on control of breeding, record keeping and livestock feed management. Utilizing inclusive dairy value chain platforms, credit provision should complement technical training in feeding, breeding and marketing.

Table 2. Gender responses on dairy topics accessed (%)

Dairy farming topics			Sub-county	
Accessed	Limuru (N=63)		South Kinangop (N=281)	
	Male	Femal e	Male	Female
Pest and disease control	8.7	11.7	12.2	9.9
Fodder production and conservation	9.6	14.8	11.6	10.8
Making feed rations	5.7	7.4	11.3	9.8
Livestock housing	3.0	3.5	5.2	3.8
Calf rearing	1.7	4.8	2.6	2.8
Feeding management	5.2	4.8	5.5	3.6
Milk hygiene and quality control	2.2	5.2	2.4	0.9
Production control in wet and dry seasons	0.4	0.0	0.3	0.1
Accessing credit	0.0	0.4	0.2	0.0
Marketing milk	-	-	0.6	0.4
Record keeping	0.4	0.4	0.5	0.3
Recording dairy cattle	0.9	0.0	0.1	0.0
General husbandry	4.8	4.3	2.6	2.5
Total	42.6	57.4	55.0	45.0

Source: Survey results, 2010

Most accessed dairy topics were pest and disease control, fodder production and conservation and making feed rations.

Table 3. Dairy topics accessed and farmer level of education

Dairy topic assesed	Adult literacy									
	Non Formal				Primary		Secondary			
	Limuru	South Kinangop	Limuru	Kinangop	Limuru	South Kinangop	Limuru	South Kinangop	Limuru	South Kinangop
Pest and disease control	18.2	19.4	-	21.9	19	23.4	22.1	20.4	22.2	25
Fodder production	24.2	25	-	21.9	26.2	22.7	22.1	21	25	22.7
Making feed	15.2	16.7	-	21.9	14.3	22.7	9.1	19.7	16.7	22.7
Livestock housing	9.1	7.4	-	3.1	6	9.6	7.8	9.1	2.8	9.1
Calf rearing	6.1	4.6	-	9.4	6	4.7	3.9	6.8	13.9	4.5
Feed management	9.1	6.5	-	6.3	13.1	8.8	9.1	10.7	5.6	9.1
Milk hygiene	6.1	3.7	-	0	4.8	2.4	11.7	4.9	5.6	4.5
Seasonal Production	0	0.9	-	0	0	0.2	0	0.6	2.8	0
Accessing credit	3	0	-	0	0	0.2	0	0.3	0	0
Record keeping	0	0	-	3.1	0	0.4	2.6	1.3	0	2.3
Recording dairy	0	0	-	0	0	0	2.6	0.3	0	0
General husbandry	9.1	13	-	9.4	10.7	4.3	9.1	4.2	5.6	0

Farmer rating of information topics

In the current study, farmers were asked to rate the most important to the least important topics that they felt could assist in improving milk production and sales. In both sub-counties, there was no significant difference in rating for breeding management, milk hygiene and recording cattle (Table 4). This indicated concurrence on importance attached to these management practices in dairy farming regardless of level of intensification in production. There was significant difference in rating for pest and disease control, fodder production and conservation, feed ration formulation, livestock housing, calf rearing, home based milk value addition, production control in wet and dry seasons and record keeping. Under the extensive system in south Kinangop sub-county, farmers had more experience in livestock diseases especially tickborne diseases compared to Limuru where intensive production was practiced. Due to limitation in land for grazing in Limuru, farmers attached a lot of importance to feed production and conservation compared to south Kinangop farmers who had more land allocated to grazing. Due to the same reason, livestock housing was considered more important in Limuru. Milk marketing challenges were more evident in south Kinangop where gluts affected farm income more than Limuru. Marketing was therefore rated more highly in south Kinangop compared to Limuru where due to proximity to urban markets and strong co-operatives, milk marketing was less challenging.

With varying education level, there were significant differences in rating of feed formulation, livestock housing, breeding management, milk hygiene, record keeping and recording of cattle. Similarly, with varying age of the farmers, there was significant difference in rating for breeding management, milk hygiene and quality control, homebased milk value addition and record keeping. Younger farmers were more likely to appreciate importance of home based value addition, breeding management, record keeping and hygiene.

Table 4. Farmer rating in importance of dairy management topics

Dairy topics	Variable that influence rating of topics					
	Years of experience	Education level	Gender	Age group	Sub-county	Primary occupation
Pest and disease control	0.238	0.708	0.987	0.670	0.000*	0.426
Fodder production and conservation	0.147	0.308	0.097	0.801	0.038*	0.034*
Feed ration formulation	0.864	0.007*	0.216	0.276	0.015*	0.380
Livestock housing	0.038*	0.003*	0.582	0.203	0.000*	0.023*
Calf rearing	0.275	0.439	0.625	0.791	0.000*	0.622
Breeding management	0.038*	0.034*	0.062	0.003*	0.144	0.349
Milk hygiene and quality control	0.087	0.007*	0.148	0.002*	0.091	0.647
Home based milk value addition	0.318	0.342	0.761	0.001*	0.009*	0.319
Production control in wet and dry seasons	0.113	0.058	0.018*	0.113	0.000*	0.459
Record keeping	0.016*	0.049*	0.062	0.000*	0.000*	0.071
Recording cattle	0.014*	0.000*	0.015*	0.935	0.310	0.024*

Figures with* are statistically significant ($p<0.05$). Analytical test used was Kruskal-Wallis Test for independent samples which unlike ANOVA, does not place restriction of normal distribution of observations.

Conclusions and recommendations

In both sub-counties, male farmers had attained more education than their female counterparts. Proportionally, more Limuru farmers had attained secondary and post secondary education compared to those in South Kinangop. Farmer education level was positively correlated with number of information topics accessed. Female farmers accessed less number of information topics compared to male farmers indicating that training should focus more on female farmers. A further study is required to understand why female farmers accessed less dairy information for extension intervention to reduce the asymmetry. Least accessed dairy information to farmers in the two study sites were milk marketing, accessing credit, production control in wet and dry seasons and recording of dairy cattle with the dairy recording services of Kenya (DRSK). To control the perennial production of milk production fluctuation between dry and wet seasons, extension efforts should be geared towards farmer education on control of breeding , production

control, record keeping and livestock feed management with emphasis placed on female farmers who had least access.

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Application of the decent work concept in labour and employment conditions on smallholder dairy farms in Nakuru County, Kenya

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Abstract

The decent work concept is based on four pillars, namely; employment, employment rights, social dialogue and social security. However, the uptake of decent work practices in smallholder dairy farms in Kenya at the moment is poorly understood. This study explores the linkage between socio-economic status of smallholder farmers and compliance with decent work standards. Data was obtained using purposive and snowballing sampling, which resulted in 123 farmers being interviewed. Three index scales were constructed to measure decent work based on a composite index founded on the four pillars of decent work. Ordinal logistic regression was used as a tool to model the composite index with respect to age, marital status, literacy level, gender, income source and level of income of the farmer, and dairy animal breed owned. The analysis revealed that there was a relationship between decent work level, breed of dairy animal and education level of the respondent. Consequently, policies that would address inadequate genetic capacity of dairy animals and ensure improved literacy levels for the general populace could enhance decent work interventions. For education, this can be partnerships between labour organizations with adult literacy or extension institutions and programmes to incorporate general awareness campaigns.

Keywords: Socio-economic characteristics, Decent work, Smallholder dairy farmers, Ordinal logistic model

Introduction

During the last decade, extensive labour market reforms have been undertaken by policy makers in Kenya in an effort to improve the performance of the country's labour markets. Essentially, the laws were to lead to improved labour standards for all workers and, consequently, contribute towards formalization of informal employment and achievement of decent work. These laws are set out through the Employment Act (GoK, 2007a), Labour Institutions Act (GoK, 2007b), Labour Relations Act (2007c), Occupational Safety and Health Act (GoK, 2007d), and Work

Injury Benefits Act (2007e). An aspect of these reforms has been to ensure that labour laws are in consonance to the decent work concept. The concept entails four main pillars, namely; employment rights, social security and social dialogue (ILO, 1999). Related to these four pillars are several elements as criteria for quality employment, which include equal opportunity and treatment in employment, adequate earnings and productive work, decent work hours, stability and security of work, a safe work environment, social benefits, and combining work and family life (Anker *et al*., 2002; Bescond *et al*., 2003; Bonnet *et al*., 2003; Ghai 2003). Dairy production in Kenya plays an important role in economic growth and employment. According to Ouma *et al*. (2007), close to 1.8 million small-scale farmers are involved in dairy farming. Farmers also account for most (87%) employment opportunities at the farm-level.

Labour laws in Kenya under the decent work framework represent opportunities for workers in the dairy sector and, at the same time, exciting challenges for smallholder dairy farmers in the country. Better labour practices can be achieved by proper implementation or adherence to labour laws. Factors which can affect the employment relationship and/ or dairy operations include characteristics of the employer, employee, external product market and of the job itself (Chantalakhana, 1999; Bewley and Forth, 2010). Research on determinants of non-compliance to labour regulation is scarce (Marshall, 2007). The current study evaluated the relationship between socio-economic characteristics of the dairy farmers and compliance with labour codes associated with decent work conditions, and borrows heavily from adoption studies. Current economic theory of adoption is based on the assumption that the potential adopter makes a choice based on maximization of expected utility, subject to prices, policies, personal characteristics and natural resource assets (Just and Zilberman, 1983; Caswell *et al*., 2001). With the decision to comply or to not to comply, the producer is choosing the alternative that maximizes utility.

Methodology

The study was undertaken in Nakuru County, Kenya. A purposive and snowball sampling technique was employed in the selection of respondent farmers, resulting in 123 smallholder dairy farmers being interviewed. Descriptive statistics was used to analyze the socio-economic features of the farmers and the ordinal logistic model used to capture the degree of association between farm and farmer's characteristic influencing compliance with labour standards governing the employment relationship. To operationalize the model, the dependent variable, the Cumulative Decent Work Index (CDWI), was constructed using the four key decent work pillars; employment, employment rights, social security and social dialogue. Each indicator had a number of sub-indicators. These corresponded to employment contract, adequate wages, working hours, working days, provision of leave, social security in terms of health insurance and pension, and membership to a workers' union. Each sub-indicator was assigned a quantitative rank of 1 or 0 based on the field survey. The total score for a respondent was obtained by summing up the scores obtained on the sub-indicator. Depending on the extent of compliance of improved technologies, the respondents were categorized as low, medium or high adopters.

Given the dependent variable (was of ordinal categorical nature derived through summing up all sub-indicators of decent work pillars) an ordered logit model was employed to estimate the influence of independent variables (farm socio-economic and farm factors) on decent work practices categories. The ordered logit model is built around a latent regression in the same manner as the binomial logit model. This was presented as $y^* = ß'x + Ɛi$, where y^* is the underlying latent variable that indexes the level of compliance of decent work practices making, x a vector of parameters to be estimated and Ɛ the stochastic error term. The latent variable exhibits itself in ordinal categories, which could be coded as 0, 1, 2, 3, …, j. The response of category j is, therefore, observed when the underlying continuous response falls in the jth interval as shown below:

$y = 0$ if $y^* \leq 0$
$= 1$ if $0 > y^* \leq \partial 1$
$= 2$ if $\partial 1 > y^* \leq \partial 2$
$= 3$ if $\partial 2 > y^* \leq \partial 3$
$= j$ if $\partial j\text{-}1 \leq y^*$

The foregoing is a form of censoring, with the ∂'s being unknown parameters to be estimated with ß (Green 2000). The independent variables presented in Table 1 below were selected for the study.

Table 1 . Description of variables and their hypothesized signs

Variable	Description
Age	Age of farmer

Sizeland	Farm area (acres)
[genFar=1.00]	Gender of farmer (1= Male, 2=Female)
[A9b=1.00]	Breed of animal (1= exotic, 2 = cross or indigenous)
[iwincome=1.00]	Income from livestock (1=<5000, 2=5001-10000, 3=10001-30000, 4=>30000
[hgrdelc=1.00]	Level of education (1=Illiterate, 2= Primary, 3= Secondary, 4= University, 5= Vocational
[wymsourc1=1.00]	Source of income (1=farming, 2= farming and other)
[forinf=1.00]	Milk selling channel (I=formal, 2=informal)

Results and discussion

Factors affecting tier level of decent work practices

The ordinal logistic model (OLM) fitted established that systematic effects on tier level of decent work practices was related to the animal breed and education level. In relation to dairy animal breed, the *B* coefficient was 0.99. This indicates that farmers with exotic animals were 2.8 times more inclined than farmers with crosses or indigenous animals to employ more decent work practices. This implied that inadequacy of genetic capacity (genetic differences may indirectly play a role in farmers' uptake of decent work practices). Crossbreeds may deny farmers optimum income through lower productivity because breed group affects lactation (Kiwuwa *et al*., 1983). Ownership of dairy cows can result in positive outcomes for smallholder households, notably higher incomes associated with increased milk production and sales (Nicholson *et al*., 2004). Therefore, selection might contribute to improved economic net merits of dairy cattle and contribute to achieving decent work. By having exotic pure breed dairy cows may imply that the marginal cost of implementing certain labour practices decreases and, therefore, producers may be more likely to take up more decent work practices.

There was a strong association between level of education and decent work index. This was particularly true for farmers who were either illiterate or had not proceeded beyond secondary school level of education. The positive coefficient for farmers who had not received formal education and primary school level of education was 3.95 and 2.26, respectively. Illiterate farmers and those with primary school level of education were 52 and 9.73 times more likely to employ more decent work practices, respectively. This suggests that decent work programmes specifically designed to reach this unique group has potential. The extent of post-primary education did not seem important, probably due to farmers being of similar magnitude in the three computed compliance levels on decent work practices of high, low and medium. Consequently, there is need to improve on awareness campaigns for this group of producers.

There appeared to be relatively little relationship between income levels and compliance with voluntary adoption of decent work practices. However, with respect to compliance to voluntary uptake of labour practices, producers deriving income in the range of 10001-30000 were 0.19 times more likely while those with 5001-10000 and <5000 were, correspondingly, 15 times and 0.10 times more likely. Generally, as income increases, producers are likely to employ more decent work practices. Although similarly insignificant, those selling milk through the formal channel were more likely than those selling informally to employ more decent work practices.

Table 2. Relationship between farmer and farm attributes, and extent of compliance with labour practices by smallholder dairy farmers from the ordinal regression model

Attribute							95% Confidence Interval	
		Estimate	Std. Error	Wald	df	Sig.	Lower Bound	Upper Bound
Threshold	[comp1 = 1.00]	-0.65	1.91	0.12	1	0.74	-4.39	3.10
	[comp1 = 2.00]	3.60	1.98	3.31	1	0.07	-0.28	7.48
Location	Hmdcinco	-0.140	0.14	1.08	1	0.30	-0.41	0.12
	Age	0.01	0.02	0.31	1	0.58	-0.03	0.05
	Sizeland	0.12	0.10	1.29	1	0.26	-0.09	0.32

[genFar=1.00]	0.17	0.48	0.13	1	0.72	-0.77	1.12
[genFar=2.00]	0.00[a]	.	.	0	.	.	.
[A9b=1.00]*	0.99	0.58	2.87	1	0.09	-0.15	2.12
[A9b=2.00]	0.00[a]	.	.	0	.	.	.
[iwincome=1.00]	-2.23	1.40	2.55	1	0.11	-4.96	0.51
[iwincome=2.00]	-1.87	1.28	2.15	1	0.14	-4.37	0.63
[iwincome=3.00]	-1.61	1.24	1.69	1	0.19	-4.05	0.82
[iwincome=4.00]	0.00[a]	.	.	0	.	.	.
[hgrdelc=1.00]**	3.95	1.82	4.71	1	0.03	0.38	7.51
[hgrdelc=2.00]	2.69	1.14	5.53	1	0.02	0.45	4.93
[hgrdelc=3.00]	0.68	0.73	0.85	1	0.36	-0.76	2.11
[hgrdelc=4.00]	.718	1.070	.451	1	.502	-1.378	2.814
[hgrdelc=5.00]	0[a]	.	.	0	.	.	.
[wymsourc1=1.00]	-.040	.480	.007	1	.934	-.981	.901
[wymsourc1=2.00]	0[a]	.	.	0	.	.	.
[forinf=1.00]	.165	.527	.098	1	.754	-.868	1.198
[forinf=2.00]	0[a]	.	.	0	.	.	.

[a]This parameter was set to zero because it was redundant.
*Significant at 10%; **significant at 5%; ***significant at 1%.

Conclusion

The major factor that influenced farmers' level of compliance to decent work practices related to the breed of the dairy animal and literacy level. Therefore, policies that would address inadequate genetic capacity of dairy animals and ensure improved literacy levels for the general populace could enhance decent work interventions. With regard to education, partnering with adult literacy classes, agriculture programmes and labour organizations to incorporate more information and exposure on decent work practices could be an important contact point. This will strengthen capacity of the farmers and facilitate integration into decent work practices. However, further theoretical and empirical research is needed to develop a deeper understanding of the detailed determinants of the compliance decision.

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Smallholder dairy farming in Tanzania: farming practices, animal and public health challenges and opportunities

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Abstract

Smallholder dairy farming is seen as a viable and promising activity to support the livelihoods of cattle keepers in low income countries. This farming system, characterized by small herds of improved cattle raised under zero-grazing, is proven to lead to better milk yields, but also to require more constant and demanding inputs and resources to sustain production. Moreover, endemic diseases and the poor knowledge on disease control by farmers, along with the limited availability of veterinary services presents challenges for effective farming. We conducted a cross sectional survey among smallholder dairy farmers in Tanzania to understand the farm management practices, animal health, access to veterinary services and knowledge and attitudes towards public health of farmers. We aimed to understand the challenges being faced by farmers and the opportunities to overcome these. In addition, we collected blood samples from sick animals for screening for a range of cattle diseases. Milk production was found to be suboptimal, with only few lactating animals in each herd and average milk yields of 9 liters per day. Cattle diseases were an important threat to farmers, but they lacked knowledge and capacity on disease prevention and

control. Farming and milk harvesting practices were in general acceptable, but farmers had very poor knowledge on zoonosis and on practices that can mitigate milk contamination. Improvements on farming practices could be made to limit public risk of direct and milk-borne disease transmission to farmers and consumers.

Keywords: Milk, Smallholder dairy farmers, Farm management, Animal disease, Zoonosis.

Introduction

Livestock is an essential source of nutriment and wealth for humans worldwide. Despite controversial opinions such as the environmental impact of intensive livestock farming and the negative health effects of excessive meat consumption, animal derived food products remain not only the most efficient source of micronutrients to sustain life, but represent a basic source of income and basis of livelihoods for many farming communities around the world.

Livestock farming must be effective in producing the biggest yields with the lowest inputs. The high mechanization levels and production effectiveness achieved in richest countries contrast with the inefficiencies in livestock production in low income countries, where the scarce environmental resources and limited access to inputs and markets conditions the capacity of farmers to maximize outputs (Tebug *et al*., 2012; Onomo *et al.,* 2013). Nevertheless, in these countries farmers depend on livestock as a main basis of the family diet and income. In East Africa, the predominantly large extensively raised herds are proving challenging to achieve appropriate yields and smallholding zero-grazing farming is looked up as an alternative that can provide greater yields and more sustained incomes. In this type of farming system, farmers keep small numbers of improved (crossbreeds) animals that have the potential to produce better yields, but are also more demanding in terms of environment and nutritional requirements, among others (Zvinorova *et al*., 2013). In addition, the system presents many challenges, and the appropriate context and infrastructure need to be available to ensure farmers are supported with the necessary services and inputs that will help maximize the benefits and outcomes of this type of farming.

This study aimed at assessing animal farming practices among smallholder dairy farmers and the animal health situation and management in the herds. We also explored the knowledge and practices towards public health protection. We finally conducted a critical analysis of the animal health and public health challenges faced in this type of farming system and discuss opportunities for improvement.

Materials and methods

We conducted a cross sectional survey among smallholder dairy cattle farmers in three districts in two regions (Morogoro and Tanga) in Tanzania between October and December 2013. A structured questionnaire was administered to participating farmers collecting information on farm management practices, animal health, access to veterinary services and knowledge and attitudes towards public health. In addition, a blood sample was collected from 1-3 animals in each farm and was subjected to laboratory screening for presence of antibodies against a range of major animal diseases known to be affecting cattle in East Africa along with common cattle diseases whose presence in Tanzania is unknown.

Results

A total of 53 farmers participated in the study, most of which (75.5%) were located in Tanga region, predominantly in Lushoto district. Smallholder dairy farmers kept between 1-12 animals (mean = 4) but only an average of 1.1 lactating cows (range 1-4) at the time of visit. Almost 80% of the farmers practiced mixed farming (crop and livestock keeping), which is in fact a common feature among livestock keepers practicing zero-grazing. Farming was the most important economic activity in the family and 64% of the farmers kept other livestock, primarily small ruminants and poultry. Farming practices were quite standard across participants, and farmers proved knowledgeable about basic concepts on livestock farming.

Farmers declared animal diseases as a common problem, and East Coast Fever was often mentioned as the most prevalent disease. However, many farmers were unable to name a cattle disease. Lack of knowledge on animal diseases compromises the farmers' ability to fight livestock diseases. In fact, most farmers do not apply health checks or require health certificates when buying animals, and only rely on external appearance when selecting animals to purchase. Only half of the farmers declared conducting tick control (mainly spraying), but not frequently enough. This emphasizes an important lack of knowledge and awareness among farmers on how to recognize, deal and prevent common cattle diseases (Tebug *et al*., 2012).

Farmers produce and market milk. Hygiene practices during milking were appropriate but the standards could be increased, especially considering that most of the lactating cows in the farms had evidence of subclinical mastitis. Over half of the interviewed farmers declared being unable to recognize an udder with mastitis. This means milk from mastitic cows is regularly harvested, marketed and consumed. Farmers showed limited knowledge on zoonotic disease, suggesting that practices to limit arrival of zoonotic pathogens in the milk and to protect farmers of directly transmitted zoonosis are not commonly used.

Discussion

Smallholder cattle production has the potential to provide a constant and sustained source of income and meat and milk to farming communities in Africa. This farming system requires an appropriate context that ensures constant availability of feeds and water avoiding the need to move herds in search of pasture and water and it may therefore not be a suitable and effective system in all ecosystems. Moreover, high yielding breeds require appropriate herd management to maximize production. Farming management can be boosted and farmers need to be equipped with the necessary knowledge and tools for animal disease prevention and control. Raising awareness on milk safety and quality would be essential to ensure health protection among milk consumers and farming families.

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ABSTRACTS

Market-based drivers for stimulating human capacity and the adoption of productivity enhancing technologies and techniques

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An approach of 'if you train them, they will do' is commonly taken in development efforts worldwide, especially within the crop and livestock sectors. Development practitioners lament that low or short-term adoption rates of improved technologies and techniques prevent increased production, improved productivity and hinder market efficiency. Not limited to low adoption rates by producers, use of best practices or techniques is also lacking within processors and service providers alike. Models for delivery of extension services remain, for the most part, unsustainable. In some cases, information about the improved technology or technique is lacking. However, often information is available and new practices are not being adopted. The drivers of why technologies and techniques are not adopted needs to be better understood. Building sector capacity is much more than dissemination of knowledge (human capital) and establishing infrastructure (built capital). In Land O'Lakes experiences, building human capacity, and thus the adoption of best practices and technologies and sustained demand for goods and services, must have a market incentive driving the process. Focused on the dairy sector, this presentation highlights Land O'Lakes' experiences in increasing the capacity of improved breeding services, mainly artificial insemination, in East and Southern Africa. Establishing a network of AI service providers requires technical training and a steady supply of inputs (semen and liquid nitrogen). But even if these issues are addressed, the desired impacts of increased production of milk and improved farm productivity are not reaching scale. The AI technicians have little incentive to offer consistent quality services if demand for services by dairy farmers is low and thus AI services delivery is not seen as a profitable endeavor. Conversely, farmers complain that AI technicians are absent and/or their animals are not becoming pregnant through AI, perpetuating the lack of demand for more costly private AI services. Through the lens of AI service delivery, the presenter will outline the positive and negative feedback loops that perpetuate low human capacity, in the form of adoption of improved technologies and techniques, within the sector.

Models of Farmer Field Schools targeting livestock farmers in semi-arid/arid regions of Kenya: Case of Kenya Semi-Arid Livestock Enhancement Support (K-SALES) Program

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Farmer Field Schools (FFS) is an approach to farmer training developed in the late 1980's to address a common problem of pest management on rural farms in Indonesia. Without quality extension services, farmers were applying highly toxic pesticides; causing harm to themselves, the environment and developing pesticide-resistant pests. A system of large-scale decentralized education of farmers was called for to the remedy the situation. Farmers, through hands-on training and peer-to-peer learning, were expected to become "experts" in managing their production systems and increasing overall production. Since these first steps, the FFS model has been replicated and adapted throughout the world. Seen as an entry point into rural communities for training on improved production technologies and techniques, the model often serves as link to public and private sector training and peer-to-peer learning. Although FFS has been widely used in farmers training (Arnould and Deborah, 2011), it has greatly evolved and adapted and undergone various innovations and developments. FFS's may not always be the panacea they have been made out to be. Often driven by the international development community, the life of a FFS often mirrors the lifecycle of the project supporting the initiative. The success of a FFS can be influenced by the production system it is targeting. Efforts to include fee-based extension services

have had varying success. Focusing on the use of FFS's in Kenya, this study profiled and reviewed available FFS models, analyzed their structure and identified their strengths and weaknesses. In addition the study elaborated on their appropriateness and applicability in training beef, sheep and goat farmers in the semi-arid areas and suggest appropriate models with specific reference the value chains being supported.

The in-depth analysis showed that FFSs have not gained as much popularity in the livestock agriculture as in crops. Moreover, where the concept has been applied in livestock enterprises, it has been largely for dairy and village chicken production. These productions systems follow a cyclic/seasonal calendar unlike beef cattle and shoats which have longer production cycles spanning across seasons / years. Based on these observations, the study proposed a non- cyclic 3 model with a modular curriculum that allows the producers freedom to choose topics they have knowledge and skills deficiency.

YOUTH: THE FUTURE HOPE?

Agriculture transformation Agenda: Unlocking Agri-business opportunities for Youth

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Summary

Two out of three inhabitants of sub Saharan Africa are under the age of 25. It has been estimated that about forty percent (40%) of the total unemployed are youth and majority of them, 70%, live in rural areas. For those that are employed, low productivity, underemployment and meagre earnings characterise their agricultural profile.

Agriculture remains a key driving force for economic development in the SADC region in which most inhabitants rely on agriculture directly or indirectly as their main source of livelihood. It remains the primary source of subsistence, employment and income for 61%, or 142 million of the region's total population of 232 million. Agriculture accounts for close to 8% of the region's gross domestic product (GDP). Despite the importance of the sector in SADC's economy, agricultural growth rates have been both low and highly variable across the region, averaging only 2.6% per annum in the last decade. Between 1960 and 2005, net per capita agricultural production decreased by about 40%. This suggests that agricultural production has not kept pace with population growth in the region. Youth unemployment is one of the major problems countries of the SADC are facing. Very limited gains have been achieved in addressing this challenge. The number of unemployed youths that are also out of school and not in any formal training or skills development programmes continues to rise. In response to this growing challenge, governments of SADC and civil society organizations have put in place programmes and projects that have to date achieved limited progress in sustainably addressing the challenge. Unlocking business opportunities in Agriculture will provide an opportunity for addressing this challenge.

Youth and animal farming –Is landless monogastric farming the rescue?

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Summary

The narrative regarding the farming community in Africa, and indeed all over the world, is that the average age of the farmer is getting higher and higher. The major cause is seen to be that young people are turning their backs on both farming and the rural community. The age-old questions that arise are what the barriers to entry are, and what could be done to encourage and incentivise the youth into animal farming in Africa. Some of the causes that have been identified and postulated are such as the prohibitive financial and land resources needed to make entry and the small financial reward to the inevitable hard work. Another is the lack of markets or access to markets. We offer that one of the solutions that could help on this journey of harnessing the youth in livestock farming in Africa is the concept of land-less monogastric system of livestock production. While not new it is less practised in Africa compared to the other regions. It's effective use and success must be accompanied by the use of appropriate breeds and strains, feed quantity and quality, housing and disease control, as well as assured markets both at home and abroad. The need for resources can be less compared to large ruminant production in that one can start small and expand over time as circumstances permit. Monogastric farming tends to have quicker cash flow and hence gives opportunity for one to sustain themselves while pursuing expansion of the enterprise.

Improving Opportunities for Decent Youth Employment in Animal Agriculture in Africa

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Summary

With over 200 million people aged between 15-24 years, Africa has the youngest global population. Sixty-two percent of its population are under 25 years of age and estimated 11 million young Africans will join labour force every year for the next decade. Over 50-70% of them rely on agriculture for food, nutrition and employment. Youth unemployment and underemployment are major concerns facing Africa. Only 15% of youth have access to wage employment in most African countries. Agriculture remains the principal employer and producer in Africa. A profitable agriculture sector can create significant employment opportunities for the youth. Eight-five percent of rural households in Africa depend on Animal Agriculture. The subsector offers real opportunity as it contributes 40% of agricultural GDP in most African countries. Estimates of milk production (in tons) in 2000 and 2012 has increased from 14.5 to 25.8 million, egg from 1 .2 to 1 .9 million, meat from 7.8 to 11 .6 million, respectively. Respectively, estimated consumption increase by 2030 for milk, egg and meat will be 107, 155, and 170 percent. Creating opportunities for decent employment for African youth along the whole livestock value chain – feed, breeding, veterinary services, fattening, marketing, product processing – by making young women and men as explicit target groups in policies, strategies, and programmes. Addressing key constraints such as access to productive assets, land, markets, capital and skills would be essential. Research should be conducted to advise policy makers by generating evidence on youth employment in the sector. Actions should target adapting existing education, training, and extension services to the needs of the young men and women. Proven methodologies such as farmer field schools, community-based animal health workers, etc. can be used for on-the-ground capacity building and outreach approaches. Support should be provided for youth focusing on inclusive SME's by creating an enabling environment for small business in the sub-sector. Increasing information and knowledge sharing, and networking among and within countries in shared production systems with high potential for transferability of experiences are paramount importance.

Can we use animal agriculture transformation to solve youth unemployment in Africa?

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Summary

The UN estimates that Africa's population is about 1.1 billion representing 15% of the world's population and continues to grow rapidly, doubling in the period 1982–2009, and quadrupling from 1955–2009. The challenge of feeding and employing this population is further exacerbated by a large youth bulge. About 44% of the total population of sub-saharan Africa is below the age of 16 years, making it the youngest region in the world, and by 2050, it is estimated that 60% of Africans will be living in cities. All of these combined with rising incomes and globalization will drive demand for livestock products. With the high unemployment among African youth, animal agriculture can plan an important role and provide a promising platform to develop jobs and careers to meet the rising demand for livestock products through carefully calibrated policy prescriptions and smart approaches to supply expanding markets that takes into account the realities of globalization, access to land, affordable credit, technical training, new technologies, environmental concerns and climate change. Plans must include finding appropriate financing models, providing vocational technical training, building sound small and medium scale businesses through innovative policy interventions by government, private sector and international donors using

partnership models that will assisting the development of efficient value chains in animal agriculture to reduce youth employment. The long term negative implications for failing to harness the energy and entrepreneurial spirit of this large segment of Africa's population means that efforts must begin right away to deliberately craft and implement policies to address this challenge by stakeholders in the public, private and civil society sectors.

Innovative application of mobile based technologies geared towards improving information exchange between researchers, extension services and farmers: A case of mobile based extension services and a farmer centric recording and feedback platform

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Summary

The small holder farmer faces a myriad of challenges in their day to day activities. The challenges range from lack of suitable breeds for their farming system to trouble accessing markets for their produce. A common aspect of these challenges is access to relevant and actionable information. Access to accurate, timely and actionable information can make a big difference in the livelihoods of farmers. For example, reports indicate that farmers who use the iCow ITC platform recorded a 56% increase in milk production while Kilimo Salama another platform has enabled smallholder farmers to significantly increase their farm incomes.

Mobile telephony, with a penetration above 80% is currently the most accessible technology in Africa, and this is rising. The price of smart phones has plummeted in the last 5 years making the smart phone and the mobile phone in general increasingly accessible to all including the low income population. It is therefore a need to develop innovative mobile phone-based platforms for the small scale farmer to remit and access valuable information to and from the research community on a near real time basis. The Virtual Agricultural Community (VAC) is an intelligent platform which aims at providing agricultural extension services through the mobile phone. Using an interactive voice response (IVR), the VAC platform aims at delivering research content and general information to the farmers by using a dial in service. The farmer would dial a specific number and will be automatically guided to different information using a prompt menu. This way the VAC is used as a medium to offer refresher tips to the farmers and possible solutions to their everyday questions. Most importantly, it can be used as a linkage platform where farmers can be referred to a practicing extension officer who can offer more advice and help if need be.

High quality data is paramount in any research setting and the effects of working with wrong data is catastrophic. The International livestock research Institute (ILRI) has developed a real time recording and feedback system-the Ng'ombe Planner, which rides on the high penetration of mobile phones. Besides its other noble objectives, this project ensures accurate data capture. Ng'ombe Planner is a platform where farmers can record their day to day activities that take place in the farm, eg. milk records, calving events, deaths, diseases, preventive and curative activities. Ng'ombe planner is accessible from any mobile phone by dialing a short code *384*4# or *384*4564# or by using an android or java application which can run on mid to high end devices. It is an interactive platform where the farmers choose the information to record or access. In addition, the farmers receive alerts and notifications on livestock keeping best practices. In cases of sickness reports, a practicing vet is notified to attend to the sick animal. Ngo'mbe planner is currently being pilot tested in Kenya's western and Rift Valley regions.

ORALLY PRESENTED

Women workload and role in livestock production in pastoral and agro-pastoral communities of Ethiopia: The case of Afar

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Abstract

This study looked at three pastoral and agro pastoral communities of Afar, Ethiopia. By surveying women and men in households that were headed by women (WHH) and that were headed by men (MHH), we were able to go beyond simply how labor is allocated between genders. Women do close to 100% of the household chores, but men share more of these in MHHs. MHHs appear to have advantages from more labor. Women in these households spend half as much time fetching wood and water and more time on rearing livestock than women in WHHs. Women in WHHs are less educated, but take more advantage of technical trainings and involvement in associations. The result of the multiple regression analysis showed that male labor was the most important factor influencing output. Labor from women was found to be used less efficiently in both households, implying that the spare time gained by women in MHHs was productive but still less so than men. Perhaps the most important findings here is that households without men are more likely to be limited to a subsistence lifestyle, and that one important reason is the time it takes for simple tasks such as fetching wood and water.

Keywords: Labour, livestock, Elasticity, Gender, Pastoralist.

Introduction

Women make up about 65% of Ethiopia's agricultural work force, thus shouldering the base of the Ethiopian economy. And with a push to increase productivity of the pastoral sector and incomes of rural producers, labor has intensified within pastoral households. Social definitions of which tasks should be carried out by men or women vary from one society, region, class or ethnic group to another. This variability indicates that the division of labor is determined not by the physical differences between sexes, but by the social definitions of proper relationship between women and men. As a result of the drive to increase pastoral productivity, women's workloads have increased substantially without any measure to alleviate their already heavy domestic burden. In order to develop intervention strategies that may alleviate these burdens, researchers had to first identify how much time was spent on different daily tasks. Through this information, researchers could determine what technologies, adaptation strategies and trainings could be implemented that would increase efficiency and therefore productivity.

There is ample evidence that most efforts towards increasing the productivity of the pastoral sector and the real incomes of rural producers have been accompanied by an intensification of labor within the pastoral household (EIAR, 2012). This has increased women's workloads in the absence of any measures to alleviate their already extremely heavy domestic burden. It, therefore, stands to reason that very little can be achieved in terms of increasing rural women's labor productivity without taking into account the exact modalities of their participation in livestock production and the intrinsic limitations imposed on such work by other time-consuming household tasks (MoA, 2012).

The purpose of this study was to assess women's performance, labor allocation patterns and level of burden compared to men in livestock and crop production. While the relatively higher labor burden on women has been documented time and again, little is known about how household livelihoods would be changed if women took a more active role in livestock production, or even whether they would allocate more time to livestock production if more time became available. More time could be made available if, for example, investments were made in infrastructure or technologies to reduce the time it takes to secure fuel and water.

To better understand how household duties compete with livestock production, a survey was undertaken to men and women in women-headed households (WHH) and to men and women in male-headed households (MHH). We then compared the time spent on household activities to those related to livestock for both men and women in each type of household. The survey strategy of this survey is innovative because the division of labor between households headed by women and those headed by men provides insights on how women use their time when dominated by their male partners and when not. We completed our study by estimating a production function to determine the marginal productivity of women and men in each type of household.

Methodology

Description of the Study Area

Afar is one of nine regional states situated in the north-eastern part of Ethiopia. It borders the Oromiya region in the south, Tigray region and Eritrea in the north, Djibouti and the Somalia region in the east, and the Amhara region in the west. The altitude of the region ranges from 1500 meters in the western highlands to 120 meters below sea level in the Danakil/Dallol depression. It has an estimated population of 1.2 million, of which 90% are pastoralists (56% male and 44% female) and 10% are agro-pastoralists. The livestock population is estimated to be about 4 Million.

Administratively, the region is divided into five zones and further sub-divided in to 29 woredas. The regional capital, Semera, is located in the Dubti Woreda, some 600 Kilometres north-east of Addis Ababa on the main Addis–Djibouti tarmac road. There are 323 rural farmers associations and 32 urban kebeles. Three sample woredas, Amibara, Afambo and Ewa, were chosen for this study. They are characterized by an arid and semi-arid climate with low and erratic rainfall. Temperatures vary from 20^0c in higher elevations to 48^0c in lower elevations. Rainfall is bi-modal throughout the region with a mean annual rainfall below 500 mm in the semi-arid western escarpments, decreasing to 150 mm in the arid zones to the east. The region receives three rainy seasons. The main rain, *karma*, accounts for 60% of annual rainfall and is from mid-June to mid-September. This is followed by rainy showers in mid-December called *dadaa* and a minor rainy season during March to April called *sugum*. Disruptions on the performance of any rainy season will impact the availability of pasture and water as well as the overall food security situation of the pastoral and agro-pastoral communities.

Analysis of Data

Simple analytical tools such as percentages and averages were employed to descriptive analyses. To find out if there is a significant mean difference between WHH and MHH t-test was used in the analysis. Cobb-Douglas production function was also estimated in order to capture the difference in labor productivities in agricultural activities between the two sample household type i.e. the MHH and WHH (Dillon and Heady, 1998).

$P = \omega M^{\alpha} W^{\beta} Y^{\lambda}$

Where: P = production level of livestock

ω = a constant

M= male labor hour in activities

W= women labor hour in activities

Y= livestock ownership

α, β, and λ are the elasticity tests

To define the labor force of different age groups the labor power unit (lpu) was used. The LPU is defined as a physically and mentally healthy, average person. A person defined as a full labor power unit works eight labor power hours (lph) per day (Wudnesh, 1991).

Table 8. labor power unit of different age groups

Age group in years	7-9	10-12	13-14	15-64	65-69	70-75
Labor power unit (lpu)	0.3	0.5	0.9	1.0	0.4	0.2

Source: Wudnesh, 1991

According to Wudnesh (1991) the labor input of household members in each activity will calculated as follows:

LHY=T*N*F

Where: LHY= labor/hour/household/year
T= time taken to do the job
N= number of people engaged
F= frequency per year

Results and Discussion

Descriptive Analysis

Characteristic of household: The women headed household was found to have about 32% of the total family members in the sample while women were 17%. The men headed household had 26% and 18% men and women members in their families respectively. The average household size was 5.6 and 4.2 persons with a range of 2 to 10 and 1 to 9 for men and women headed households, respectively. As the t-test shows the mean difference was significant (t=4.7, p=0.01). This implies that men headed households have larger family size than women headed households. In addition to the un-scaled family size, adult equivalent (AE) that takes care of age and sex of individuals was also computed (Table 2). Accordingly, the mean family size was 4.4 and 3.2 in MHH and WHH, respectively, which is statistically different (t=4.6). Saito *et al.* (1994) also indicated that WHH had relatively lower family size compared to MHH in their study conducted in Kenya and Nigeria. The result is also consistent with that of Dejene (1994) and Addis *et al.* (2000).

Table 9. Average family size of the households in AE

Sex	MHH	WHH	Total	t-value
Men family member	2.6	1.5	2.1	5.2***
Women family member	1.8	1.7	1.8	0.7
Total	4.4	3.2	3.8	4.6***

***, ** and * indicate significance at 1 %, 5% and 10% respectively Source: Own survey 2013

The difference in family members was statistically significant (t=-0.5, p=0.6) at 10%. Regarding economically active family members (15 to 65 years), the MHH had larger economically active members (2.4) than WHH (1.7), significantly different at 1% probability level (t=4.0). The age distribution in both groups shows that the economically active age groups constitute the largest share of the family members (Table 3).

Table 10. Average family size by age group

Age group	MHH	WHH	Total	t-value
<5 year	0.5	0.3	0.4	2.5**
5-14	1.3	1.2	1.2	0.7*
15-65	2.4	1.7	2.1	4.0***
>65	0.1	0.1	0.1	1.2*
Total	4.4	3.2	3.8	4.6***

***, ** and * indicate significance at 1 %, 5% and 10% respectively

The educational status indicates that about 66% of the WHH were illiterate; about 13.8% attended literacy classes while around 20.2% had primary education. In contrast, about 45.3% of MHH were illiterate, 12% attended literacy classes while 22.6% had primary education. On the average, head of men households attended 2.7 years of schooling while that of women heads attended 0.8 years. This shows that there is a significant difference (t=4.6, p=0.01) in terms of access to formal education between MHH and WHH (Table 4). In most sub-Saharan Africa, the adult literacy rate of men is almost twice that of women and the enrolment of boys is almost twice as that of girls in secondary school. Gender based educational discrepancies tend to be greater in countries where incomes are lower (Saito and Surpling, 1992; Saito *et al*., 1994). Studies conducted by Addis *et al.* (2000), Tiruwork (1998) and Dejene (1994) in Ethiopia also show that WHH have less access to formal education in rural Ethiopia.

Table 11. Literacy rate of household head

Literacy	MHH	WHH	Total
Illiterate	45.3	66	55
Read and write	12	13.8	12.9

Grade 1-6	22.6	20.2	21.4
Grade 7-8	10.6	-	5.7
Grade 9 and above	9.5	-	5
χ^2=15.9 p=0.003			
Mean years of schooling	2.7	0.8	1.7

χ^2 is the Chi-square
Source: Own survey 2013

Household activities: Household activities include bread baking, injera baking, preparing wet, grain grinding, water fetching, fuel-wood collecting, washing clothes, house making and cleaning barns. Out of all these, the ones, which are performed daily, are baking, wet making (soles for traditional food) and water fetching, whereas fuel wood collection and barn cleaning are performed daily or once in two days depending on the livestock owned and availability of fuel wood. The others, injera baking, grain grinding, washing clothes are done weekly, once or twice a month according to the habit of each household.

As the figures in both sites show bread baking, injera bakes, wet cooking, grain grinding and house cleaning were entirely women activities in the area, while the other activities were shared between the two genders and still the proportion is high for women. From all the activities, fire wood collection consumed much of women's time due to the fact that the distance traveled was too long and the frequency of collecting was between once a day to once in two days (Table 5) .

Table 12. Average Labour-hour in percent spent on household activities

Activities	MHH		WHH	
	Men	Women	Men	Women
Bread baking	0	100	0	100
Injera baking	0	100	0	100
Preparing wet	0	100	0	100
Grain grinding	0	100	0	100
Water fetching	25	75	18	82
Fire wood collecting	33	67	22	78
Washing clothes	20	80	0	100
House cleaning	0	100	0	100
cleaning barns	10	90	0	100

Source: Own survey 2013

The Gender Division of Labor in Livestock Production: Water Fetching: Information gathered from observation and interviews showed that water is used for drinking (for household and livestock at home), cooking, washing clothes and bathing. Households fetched water from rivers and springs that were far away. In comparing the difference in labor hour between the selected households, the labor-hour has been used as a common unit. The length of time taken was nine months to avoid the effect that the presence of rain and using the formula**:**

ALH=T*N*F*270
Where: ALH=average labor-hour per 270 days per household
T=time (hr) required for fetching water/day
N=number of people involved (lh)
F=the frequency of fetching water

After the average man-hour requirement was calculated, t-test was used to see if there was a significance difference. Using the surveyed data, the t value for fetching water and the average man-hour requirement was calculated. The results are given in (Table 6). The calculated t-value shows that labor-hour requirement in the WMHH for fetching water was significantly different from the WHH at 1% significance level. This means that women in WHH spent more than double the time spent by those living in WMHH.

Table 13. Mean difference in water fetching

	WMHH	WHH

Average labor-hour per house hold per 270 days	422.15	936.44
t-value	7.16***	

***, ** and * indicate significance at 1 %, 5% and 10%, respectively
Source: Own survey 2013

Wood collection: Woods were commonly used for baking, cooking, house and barn making etc. The households ground the different wood for baking injera and bread, making wet and other purposes. In both of the study sample, it was learnt that, they carry in frequently in small amounts. The average man hour per household per year was calculated as a unit of comparison between the household. The average labor-hour per household in a year was calculated using the following formula:

ALH=T*N*F*12
Where: ALH = average labor-hour per 12 months per household
T = time (hr) required for collecting wood/day
N = number of people involved (lh)
F = the frequency of collecting wood

The average labor-hour requirement and the t-value for collecting wood for the household were calculated, and are presented in Table 7. The resulting value of t value 6.4 was compared with theoretical value with degrees of freedom. The computed value was found to be significant at 1% level of significance which shows that more women in the WHH spent much time in collecting wood for different purposes and they spent 599.33 hours per year.

Table 14. Mean difference of collecting wood

	WMHH	WHH
Average labor-hour per house hold per 12 months	219.23	599.33
t-value	6.35***	

***, ** and * indicate significance at 1 %, 5% and 10% respectively
Source: Own survey 2013

Livestock management

With respect to livestock management which includes herding, barn cleaning, taken caring sick animals, etc. The households used traditional way of managing livestock while in all MHH and WHH. It was also found that there was a difference in man-hour requirements in the study sampled household. This was analyzed using the average man-hour requirement for the task per household per year. The average was obtained as:

ALH=T*N*E
Where: ALH = Average labor-hour per household per a year
T= Time (hr) needed to livestock management
N = Number of people involved in the activity
E = Number of livestock

From data of the survey, the following information was generated. As shown in Table 8, the average man hour per household per year was 813.7 for WMHH and 1454 for the WHH.

Table 15. Mean difference in livestock management

	WMHH	WHH
Average labor-hour per house hold per 12 months	813.7	1454
t-value	7.21***	

***, ** and * indicate significance at 1 %, 5% and 10% respectively
Source: Own survey 2013

From the value of t, it could be inferred that there is a difference between the two households in the time used for livestock management processing at 1% level of significance which indicates that women headed households spent more time in different types of livestock management in the pastoral community of the sample districts.

From the information gathered from formal survey, focus group interview and observation, there is a strong justification that showed the extra time gained in WMHH had been used for producing forages and milk sales the nearby. The average production of forage and milk selling purpose per household per year was used to compare the difference between mean productions in WMHH and WHH. Summarized information on backyard production is given in Table 9.

Table 16. Mean differences in forage production at the backyard

	WMHH	WHH
Average labor-hour per house hold per 12 months	363.2	122.9
t-value	4.44**	

***, ** and * indicate significance at 1 %, 5% and 10% respectively
Source: Own survey 2013

The above t-value, can be inferred that a significant difference existed in the production levels of forage at 0.05 level of significance. In fact, discussion made with women in MHH confirmed the above result. One woman said "previously, let alone producing forage much in our backyards for feed, we did not even have enough time to manage sick livestock but at moment my daughters are involved in other responsibilities in helping so that we are trying to manage the forage production for animal feed".

Production Functions

Production function is the mathematical relationship between the quantity of output and the quantities of inputs required in the production process. It is represented as $Y= f(x_1, x_2 \ldots x_n)$, where Y is the output and the X_i is the inputs (Heady and Dillon, 1998). Results of this study depicts that MHH have access to labor and time saving technologies as shown in descriptive statistical analysis. And it is also found that these technologies have helped them to get spare time and energy as compared to the WHH. Fitting production functions in the two sample categories was shown the marginal productivities and which in turn explain difference between them if there is any, which could be a result of the freed labor citrus paribus. The production function was estimated for MHH and WHH, respectively as follows.

$$PMHH= 0.74M^{0.57}\ W^{0.11}L^{0.04}Y^{-0.05}F^{0.38}$$
(0.07) (0.14) (0.08) (0.11) (0.12) (0.16)

$$PWHH= 3.57M^{0.46}\ W^{0.32}L^{-0.04}Y^{-0.09}F^{0.25}$$
(0.88) (0.16) (0.12) (0.09) (0.07) (0.11)

Where: M=Male labor hour in production activities (Mlpu)
W=women labor hour in production activities (Wlpu)
L=Number of livestock in the year
Y=Livestock ownership (Tlu)
F=Farm land ownership (Ha)
P=Production level of livestock

Table 17. Estimated parameters for production of livestock in WHH

	Cobb-Douglas	
Variables	MHH elasticity	WHH elasticity
Intercept	0.74(0.07)**	3.57 (0.88)***
Male labor hour	0.57(0.14)***	0.46 (0.16)***
Women labor hour	0.11(0.08)**	0.32(0.12)***
Number of livestock	0.04(0.11)***	-0.04(0.09)**
Livestock ownership	-0.05(0.12)***	-0.09(0.07)**
Farm land ownership	0.38(0.16)***	0.09(0.11)***
N	150	150
R-square	87.3	80.3
Adjusted R^2	78.4	75.1
Std. Error	0.13	0.24
F-statistics	52.09	58.02

F-probability	0.000	0.000

Note: results of parenthesis = robust standard errors; ***, **, * indicate significance 1 %, 5%, 10%, respectively
Source: survey data computed, 2013

From the estimated function for MHH, it could be observed that labor hour was the most important factor as it affected gross output ($p<0.01$). The other important factor was land size, which affected output positively and significantly. The remaining variables, women labor, livestock ownership, and number livestock in a year, were found to be marginal in influencing output.

The estimated production function for MHH showed that the most important factor which affected output level significantly was male labor. Women labor and farm land size also affected output respectively. The other factors specified in the model had minimal effect in influencing output. The adjusted coefficient of multiple determinations is a statistic which gives the proportion of the variation in the output observations explained by the fitted function. Correction has been made for the size of the sample studied. The values were 87.3 and 80.3% for MHH and WHH, respectively, with standard errors of 0.13and 0.24. In both cases, the estimates were more than three times of their standard errors. Therefore, the values were significant at 1% level. One can argue that the majority of the variability is captured by the regressed function (Table 10).

For each input resource, the estimated coefficients (elasticity) indicate the expected percentage increase or decrease in production that would occur if the amount of the input resource was increased or decreased by 1% other input factors being held constant. And because of the models' nature, the estimates of the elasticity remain unchanged over the range of input levels to which the function is fitted and to which it might be applied.

On the other hand, the sum of the elasticity is an indication of the returns to scale under the assumption that no relevant input factors have been excluded. The sums of the estimates were 1.05 and 0.91 for MHH and WHH areas, respectively. These results imply the existence of constant returns to scale in the operation of the farms. This shows that a proportional change (increase or decrease) in the levels of all of the inputs together will bring a proportional change (increase or decrease) in the level of the output. Each of the elasticity for the two areas, except for livestock, was less than one indicating that diminishing returns hold true for the particular resource. That is, a 1% increase in input or use of the particular resource results in an increase in the level of production by less than 1%. Whereas decreasing returns (an increase in input level resulting in a decrease in the level of output) was shown in livestock estimates in both samples.

Conclusion and Recommendations

Skewed and unequal gender divisions of labor often characterize pastoral livelihoods, disadvantaging women in terms of heavy workloads. This study confirms that household activities are time consuming and limit the role of women raising livestock. However, it is difficult to tell how much time women would devote to livestock if time were freed up from these responsibilities, and whether the reasons for their choices are being excluded from many livestock rearing activities or stems from a lack of interest. We surveyed women in male-headed households and in female headed households to help shed light on these questions. Women in women-headed households are not directly controlled by a spouse; however they are in a sense constrained by less time because they have fewer family members to work the farm. We found that WHHs had a 25% smaller family of eligible workers than MHHs.
We found that the additional labor in MHHs was linked to many advantages for the MHHs compared to WHHs, which women in MHHs also enjoyed. Women in both types of households did almost all of the household chores, but men helped a little more in MHHs. Therefore, women in WHHs spent a much larger fraction of their time on household activities, since they had less help. Women in WHHs spent over 1500 hours per year, more than 4 hours per day, collecting wood and water alone. Women in MHHs spent less than half that. Women in MHHs were able to use this advantage of time to apply 75% more hours to livestock activities, giving the entire MHH another advantage. In addition, they were able to spend three times more raising supplemental feed.

We are unable, of course, to detect any equity issues or other negative social consequences for women in either type of home. However, we can show some interesting contrasts. Women in MHHs spend more time on livestock activities and less time on household chores than women in WHHs. However, women in WHHs take more advantage of training opportunities and participating in farm groups like cooperatives. This appears to show either

that women have less interest in working with livestock or that they are partially excluded from these activities in male-dominated homes. Women in WHHs don't spend as much time on livestock, but given the time it takes to do household activities, they probably can't. There is no question that freeing up some of this burden would result in an increase in family livelihood in both types of households, but there is some question about how much of that time would be applied to rearing livestock.

In comparison to pastoral men, women in the case study areas are at the margins of development interventions and their voices and needs remain unheard. They continue to have limited access to development resources, trainings, extension services, credit, and inputs. Hence, development efforts aimed at supporting pastoralist are less able to have meaningful and equitable impact. Perhaps the most important finding here is that households without men are more likely to be limited to a subsistence livelihood, and that one important reason is the time it takes for simple tasks such as fetching wood and water. Cultural limitations may also be important, but time seems to be a pressing issue.

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Climate change and the choice of poultry production for youth entrepreneurship and food security in Tropical Africa

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Abstract

Facts on climate change and the choice of poultry production for youth entrepreneurship and food security in tropical Africa were reviewed. Climate change and animal production have always had a negative impact on each other, with livestock production accounting for about 18% anthropogenic greenhouse gases (GHG) emission in form of carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4) which is emitted when animals respire. On the other hand, the effect of climate change and global warming on livestock and crop production is on the increase and will continue to increase with the high rate of man's industrial activity if not checked. In tropical Africa, there is an increasing demand for animal protein because of high increase in population and this is projected to double by the year 2050. To meet up with this increase in demand, various grass root or rural agricultural and youth entrepreneurship involvement is needed to ensure food security come 2050. However, this agricultural revolution will have great challenge on the environment because of the high rate of climate change that goes with industrialization and agriculture. Because poultry has low global warming potential, it has an advantage over other

livestock. Poultry has lower GHG emission due to its low enteric methane production rates compared to the ruminant livestock species. Poultry is cheap, readily marketable and nutritious; it can generate investment opportunity for teeming tropical African youths and rural populace. It is therefore concluded that to meet up with the ever increasing demand for animal protein and the need to achieve food security, various government agencies, banks, private sectors, civil society, rural co-operative societies, youth agencies in tropical Africa with the assistance of various international donor agencies can collaborate and play a more facilitating role through giving of loans, grants and adequate extension services to ensure that food security and youth empowerment is achieved within a friendly environment through profitable commercial poultry production.

Keywords: Climate change, Entrepreneurship, Food security, Poultry production, Youth.

Introduction

The issues of climate change have become very threatening not only to sustainable development of socio – economic and agricultural activities in Tropical African countries but also to the totality of human existence (Adejuwon *et al.,* 2004). Climate change is considered to be the average pattern of weather in an area over a relative long period of time (IIPC, 2007). It is also defined as a change that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere in addition to natural climate variability observed over comparable period of time. United Nations framework report on climate change in 2007vividly elucidated that greenhouse gases (GHG) emission is increasing with negative impact on the environment and people. Many countries in Tropical Africa are expected to be more vulnerable to global warming (Mendesohn *et al.,* 2000). Several Agricultural activities as well as man's industrial activities have led to climate change and global warming which has seriously affected the land and the cultivation of various crops such as cereal grains and legumes resulting in food-feed competition between human and animals for available feed materials(Mendesohn *et al.,* 2000). According to FAO (2007) report, livestock accounts for about 18% GHG emission in form of carbon dioxide, nitrous oxide (N_2O) and methane (CH_4) which are emitted during respiration and manure production. The contribution of livestock to global greenhouse gas emission is quite significant with cattle, sheep, pig and poultry producing 180kg, 8kg, 1.5kg and 0.015kg methane emission per year respectively (WFC, 2014). Other agricultural activities such as deforestation bush clearing and machine intensive farming methods also contributes to the increase of carbon concentration with a corresponding increase in global warming (vermeulen, 2012). World metrological organization in 1997 reported that various industrial activities such as burning of coal, oil and gas flaring are altering the composition of the atmosphere and contributing to climate change. Carbon dioxide is produced when coal, oil, and natural gas (fossil fuels) are burned to produce energy used for transportation, manufacturing, heating, cooling, electricity generation, and other applications. The use of fossil fuel currently accounts for 80 to 85% of the carbon dioxide being added to the atmosphere (WMO, 1997).

It becomes imperative to source for human activities that will cause minimal negative effect on the Tropical African environment. Poultry production is one of such human activity. Poultry due to its low global warming potential has advantages over other livestock and most industrial activities (WFC, 2014). Poultry can be reared intensively thereby devoiding any environmental stimuli and tend to produce more manure that can be used as fertilizer on nearby cropland (FAO, 2010). Poultry Production remains the backbone of most tropical African economies (Hussein *et al.,* 2008). However, by-product from intensive poultry production if not properly handled, will be the concern and exacerbate the environmental problem (FAO, 2011). Poultry product is cheap, nutritious, readily marketable, and can generate Job/investment opportunity for many teeming African youths and rural populace in Tropical Africa (UNECA, 2011). Therefore the objective of this review is to briefly discuss Climate change and the choice of Poultry Production for youth entrepreneurship and food security in Tropical Africa.

Impact of climate change in Tropical Africa

Climate change is a change in variables (Rosenzweig *et al.*, 1993) that is a threat to the sustainable growth and development of the world, particularly for Tropical Africa (APF, 2007). Africa is one of the most vulnerable continents to climate variability and change because of multiple existing stresses and low adaptive capacity (Salvador *et al.*, 2004). Existing stresses include poverty, political conflicts, and ecosystem degradation. By 2050, between 350 million and 600 million people are projected to experience increased water stress due to climate change (Adejuwon *et al.,* 2004). Climate variability and change is projected to severely compromise agricultural production, including access to food, in many African countries and regions. Toward the end of the 21st century, projected sea level rise will likely affect low-lying coastal areas with large populations (Adejuwon *et al.,* 2004). Climate

variability and change can negatively impact human health in Tropical Africa (Salvador *et al.*, 2004). Climate change expressed as increased global average temperature is very likely due to increased concentrations of GHG in the atmosphere with origin from human activities (anthropogenic) since the mid-20th century. Correspondingly, continued or increased GHG emissions will cause further warming and it is very likely that larger changes in the global climate system than the ones observed until now will occur. FAO (2007) reports that extreme weather events such as droughts and floods are expected, increasing sea levels are likely, as well as higher average temperatures, deforestation, desertification, reduced animal and crop performance as well as coastal erosion. One of the main pathways taken to reduce the problem with climate change is to reduce GHG emission (FAO, 2007).

Interrelationship between climate change and livestock production

There is a negative relationship between climate change and livestock production (Olanrewaju *et al*., 2010). According to report by (Mendelsohn, 2009), livestock are adversely affected by climate change through the following ways:

Low livestock productivity and high production cost: Climate change will affect livestock productivity directly by influencing the balance between heat dissipation and heat production and indirectly through its effect on the availability of feed and fodder.

Climate change is likely to cause the manifestation of vector and vector borne diseases, where an increase in temperature and humidity will create ideal conditions for malaria, sleeping sickness and other infectious diseases.

An increase in temperature and a change in the climate throughout the continent are predicted to cause recurrent droughts in most of the region which will cause dehydration and death of livestock animals.

The FAO in 2007 projected that the number of livestock worldwide will double, so livestock-related GHG emissions would also approximately double with livestock production accounting for about 18% anthropogenic greenhouse gases (GHG) emission in form of carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4) which are emitted when animals respire (FAO, 2007). As a result, a significant reduction in livestock raised worldwide would reduce GHGs relatively quickly. However this is not possible because Agriculture and livestock rearing are source of livelihood to the majority of the population in Tropical Africa (Hussein *et al.*, 2008). The utmost concern should therefore be a better understanding of the potential impact of the current and projected climate changes on African agriculture and to identify ways and means to adapt and mitigate its detrimental impact (FAO, 2007).

Choice of Poultry Production

Income improvements, increase in population and protein demands will pose a challenge to the environment (FAO, 2011; Mitloehner, 2010; FAO, 2009). However, this demand will desire for future growth of the poultry industry (Daghir, 2009; Dave, 2007; Abedullah and Maqbool, 2007).Because poultry have lower greenhouse gas emissions due to their lower enteric methane production rates than ruminant livestock species, Poultry industry has advantage over other livestock industries because of its low global warming potential, ease to establish, fast rate of income return, no-taboos and high nutritive values (FAO, 2010; Costa, 2009; Daghir, 2009; FAO, 2009).

The involvement/entrepreneurship of youths in poultry production, the way forward

'Youths' are defined as those between 15-24 years of age (UNECA, 2009). For the purpose of this paper however, a 'youth' is defined as any person aged between 15-35 years of age. Sub-Saharan Africa has the fastest population growth projected between now and 2050 and the highest youth population in the world (UNECA, 2011). It is crucial that governments factor this 'youth bulge' into national and social development planning. Despite the potential benefits of entrepreneurship, especially youth entrepreneurship, many sectors, including some members of the education system and the private sector, have failed to recognize its importance (ILO, 2010). Available data show that in recent years self-employment has emerged as an important source of employment, livelihoods, empowerment and economic dynamism in both developed and developing countries (ILO, 2010). A sure way to help curb this youth unemployment issue that is threaten the peace and national security in various tropical African countries is adequate skill acquisition in poultry production (ILO, 2010). According to Kekeocha (1998), poultry render economic services to mankind. Poultry birds scientifically known as *Gallus gallus* reproduces freely under man's care (Smith, 1990). The economic services rendered to mankind by Poultry includes its low GHG emission which can reduce issues relating to climate change, it's use as source of meat and eggs as food; its droppings (faeces) for manure in crop-production and as feed for fish in aquaculture; the feathers and bones for ornamentals and decorative; the offal, meat and bones are also used in production of some animal-feeds and/foods (Elenwo and Okafor-Elenwo, 2013). Compared to a number of other livestock species like cattle, sheep, goats, pigs and rabbits, poultry is easier to rear, less-laborious to cater-for and financially less expensive to maintain(Elenwo and Okafor-Elenwo, 2013). Poultry has fast-growth and high financial-returns; with few social, health and religious taboos against its consumption, usage and production than the aforementioned animals (Job, 1992). Kekeocha (1998)

reported that poultry production is less-demanding for space as it can be done in relatively small spaces such as the backyard and wooden-cages (especially in vertical-tiers) making it suitable for youth involvement.

Involvement of government, civil society, banks, international bodies to ensure food security come 2050
In most African countries, youth restiveness is becoming a common experience and this is expected to worsen come 2050 (Oluwale, 2013). African youths are industrious and productive yet 65% of these youths are unemployed. It becomes imperative for government, banks and various stakeholders to engage most unemployed youths in gainful activities such as funding and training them in poultry production. In the past few years, various African countries through the backing of their government have organized programs such as Yes Youth Can (YYC),Agribusiness Development Program,(ADP), The smallholder poultry agribusiness Development (SPADE), African Development Bank (ADP), International fund for Agricultural Development(IFAD), Alliance for a green Revolution in Africa (AGRA), Bill and Melinda Gates foundation and various banks that have interest in giving low interest loans to various youths In tropical Africa. These governmental and non-governmental agencies are the reasons behind the commendable progress in these past few years. However a lot still has to be done to ensure that more jobs are created to match the ever increase youth population in Tropical Africa.

Meeting the food security target through poultry production
Around 60 developing countries worldwide have already met the hunger - reduction target outlined by millennium development goal number one, to halve the proportion of chronically hungry people between 1990 and 2015. In Africa, the countries include Angola, Benin, Cameroon, Egypt, Ghana, Libya, Malawi, Niger, Nigeria, South Africa, Togo and Tunisia (FAO, 2014). However a lot is still left to be done in other to achieve the ultimate goal for attaining food security come 2050 because in Tropical Africa, climate change will have negative impacts on the food security (Heather *et al.*, 2010) of the people. Youth involvement is a major route of attaining this set goal because getting more African youth involved in poultry production will be pivotal to improving food security and economic well – being in the years to come (FAO, 2014).

Conclusion

It is therefore concluded that poultry production can be a sure way to reduce greenhouse emission and thereby reduce the problem of climate change in Tropical Africa, poultry production can also be a vehicle that will aid reduce youth restiveness, produce youths that are job creators as well as ensure food security that will commensurate the ever increasing Tropical African population that is projected to double come 2050.

Recommendation

We therefore recommend that the government and private agencies in various Tropical African countries should adopt a more aggressive grass root approach in training, funding and setting up of monitoring committee for funds set aside for youth in setting up poultry farms. In the same vain honesty and patriotism on the part of our leaders in effectively disbursing these funds to well-trained deserving youths will lead to attaining this laudable crusade in various Tropical countries in Africa.

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Information and communication technologies (ICT) attracts youth into profitable agriculture in Kenya

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Abstract

Youth cherish technology, efficiency and innovations and accommodate entrepreneurial risks. The study documented examples of profitable use of Information and Communication Technologies (ICTs) in agriculture among youth in Kenya, assessed ICTs use and commonly used tools, documented challenges, benefits and impacts and suggested future ICTs use. Profitable ICTs were exemplified by 'Mkulima Young Champions' who lead in digital initiatives, drew youth into farming, helped them learn among themselves, traded and overcame agricultural challenges. Using radio, SMS and social media, they discussed agricultural topics and shared successes. Mkulima Young's Facebook, was vibrant where youth posted photos and videos, asked questions, discussed issues and interacted. Most youth obtained information from internet hence internet was best platform to market and promote agriculture to youth. They used Internet and social media to obtain production technologies, market information and information sharing. Most commonly used tools were MS Office and spread sheet in trading records keeping. Voice messages and SMS assisted timely accessing market prices, reaching clients, sharing production information and money transactions. The ICTs content should be relevant to targeted youth, valuable, localized and dependable. ICTs savvy youth operated intensive, efficient and profitable farms, producing diverse and branded products for niche markets. These youth transformed the community use and access to ICTs and influenced community economic status. Smart phone technology will revolutionise access and use of ICTs and fibre optic cable installation increased bandwidth and coverage, stimulating ICTs use among the youth. YouTube, Twitter and WhatsApp should be expanded and widely popularised among youths.

Introduction

There is pressing need to rebrand agriculture to address the long held belief that agriculture and rural areas are for those who cannot make livelihood anywhere else. Agriculture needs to be branded as the new unexploited frontier for growth in business opportunities (Njenga *et al*., 2012). The youth find agriculture unattractive mainly due to the low returns to time and inputs investment as the traditional staples are slow to mature, risky and often yield low returns. Agricultural incomes are seasonally related to rainfall and harvest cycles meaning that for long periods of time, the youth would have no income. There are insufficient innovations leading to reliance on traditional and arduous labour based production techniques and concentration on a narrow range of agricultural commodities mainly staple crops.

There is under-utilization of Information and Communication Technologies (ICTs) for agricultural production and marketing (Njenga *et al*., 2012; IICD, 2013). However, it is essential to digitize agricultural production and marketing information into web-based resources. This would enable wider outreach and use since the few available extension officers do not effectively reach majority of the farmers at different locations. The youth could greatly contribute to the agricultural industry through actively participating in generating, posting, management and utilization of this information.

The formal Kenyan economy is unable to create enough employment opportunities to absorb the constant supply of labour-seeking youth. Whatever the solution to this problem, a great deal of coordination and skilful thinking will be required to attract gadget loving and efficiency prone young people into the agricultural sector. However, youth participation in the agriculture sector in many developing countries is low, largely because the sector is highly unattractive due to risks, costs, inefficiency and its labour intensive nature. As such, motivating the youth to view agriculture as a career opportunity will require a multi-level intervention. Continuous initiatives to support youth in agricultural enterprises and widening the opportunities to showcase their successes in order to attract more young people are paramount. One of this should be the incorporation of information and communication technologies (ICTs) such as the Internet, mobile phones, computers and Global Positioning Systems (GPS) associated or not with traditional communication technologies such as radio, television, written press and video.

There is an emerging trend in Kenya where well educated and skilful youth are turning to agriculture to earn a living. These youth are not interested in growing the traditional crops or rearing the usual domestic animals. They target niche markets to start ventures whose produce moves quickly. Farming has become attractive, and despite their academic qualifications, they are not averse to soiling their hands to earn decent living where their less creative contemporaries see no money. A day for any of the youthful farmers is a busy one. Majority of them own modern phones and spend considerable time on the Internet, reading about the animals they keep or the crops they grow, following their markets and farming trends. Most have active Facebook accounts and websites and spend most mornings responding to queries from customers or fellow digital farmers. These digital youth advertise their

products through Facebook by posting their products photos, indicating their offer price, giving the location and product demand calls immediately start coming in.

Education certainly offers these youthful farmers alternative ways to skin a cat. When they do not get jobs, they turn to farming and, thereby, create jobs for less educated youths. When they do not get extension services, they turn to the Internet and radio for information. When the market is limited, they post their products on the Internet for a wider reach. And when the seasons are bad for certain crops, they get alternatives. A change of attitude and a little seed money could be the next big thing for jobless graduates. With this in mind, empowerment programmes must demonstrate clear understanding of the youth's affinity for technology, efficiency and strong voice in decision-making processes. The youth desire innovations and have high propensity for taking higher entrepreneurial risks.
Kenyans are famous ICTs platforms innovators. Some of the innovations include M-PESA ("Pesa" Swahili word for money) which allows users to deposit money into a credit account, withdraw money and send money to others. A revolution in banking is in the offing through Safaricom M-Shwari. M-Shwari, new banking product for M-PESA customers allows clients to save and borrow money through their phones while earning them interest. KilimoSalama, a microinsurance programme allows farmers to insure their crops using their phones.

The objectives of the study were to document current examples of profitable use of ICTs in agriculture among the youth in Kenya; assess the use of ICTs in Agriculture, accessing technical and marketing information; document the currently commonly used ICTs Tools; demonstrate the challenges, benefits and impacts to youth on ICTs use and suggest the future of ICT use in agriculture in Kenya.

Materials and methods

Five methods were used to collect data. They included literature review, focus group discussion, personal interviews, key informant interviews and internet search on case studies. Literature review mainly concentrated on studies on youth participation in agriculture in Kenya. Focus group discussion involved youth group representative comprising of 19 representatives in Baringo, Kiambu, Nairobi and Nakuru Counties. Key informant interviews included two Senior officers from Kenya Agricultural Research Institute (KARI), two professors from the University of Nairobi (UoN), two lecturers from Egerton University (EU), eleven senior officers from Ministry of Agriculture, Livestock and Fisheries (MoALF), Headquarters, three senior officers at Equity Bank, Headquarters, Nairobi and the Managing Director, Nutrimix Ltd, Nairobi. An interview guide was used during these discussions to pick out key youth participation.

Results and Discussion

Examples of Youth Profiting from ICTs
Until recently, many young Kenyans saw farming as an unskilled, unrewarding profession, suitable only for the retired or the uneducated. Now, however, a group of determined young farmers are challenging traditional prejudices and trying to explain the attractions of farming as a profession. They include the 'Mkulima Young Champions' and have become figureheads for a digital initiative to change the way farmers are viewed by young people. Using a range of technologies, they are proving that farming in Kenya really is a profitable 21st century career path. 'Mkulima Young Champions' aims to draw more young people into farming, help them learn from each other, trade, and overcome the challenges of agriculture together.

Since Mkulima Young started featuring champion farmers, an appreciable change in young people's attitudes towards agriculture has been noticed. By having Mkulima Young Champions who are educated and young, the attitude of the youth towards agriculture has changed, from viewing it as an activity for the old, to a profession where they can mint millions. Notably, it is not only the jobless who are turning to farming and the initiative is about far more than publicity. Using radio, SMS and social media, it engages young Kenyans to discuss agricultural topics and listeners to radio programmes can give feedback online, helping to shape the content and making it more relevant. Meanwhile, Mkulima Young's Facebook page, was opened in January 2013 and already has over 19,000 followers, has become a vibrant place where young people post links, photos and videos, ask questions, discuss issues and interact with other young people who are passionate about agriculture.

The following examples are detailed in a survey by Daily Nation (Muiruri, 2013). The survey showed that new graduates were not interested in growing the traditional crops or rearing the usual domestic animals. They targeted niche markets to start ventures whose produce moves quickly. A day for any of these youthful farmers is a busy one as majority of them spend considerable time on the Internet, reading about the animals they keep or the crops they grow. Most have active Facebook accounts and websites and spend most mornings responding to queries from customers or fellow digital farmers. They use gadgets such as iPad and tablets routinely and to reach markets beyond Kenya and these are considered most convenient marketing tools:

Mkulima Young website and Facebook accounts had posts that were simple and to the point: "Cucumber available (20-100 kilos); Red capsicum at KES 220 a kilo; Pork at KES 300, 650 kilos available; tomatoes available at Sh50 per kilo (120 kilos available, Eldoret); 1,000 all-male tilapia fingerlings available at Sh10 each (Maseno). Want nutritious feed for ua livestock? Get a hydroponic system at KES 95, 000 (Zambezi). Other posts showed numerous posts, such as enquiries on selling geese around Nairobi, red onions and about silk worms. Such were the interactive queries and information from youthful graduates in Kenya, hungry for information on agricultural produce or equipment.

Daniel Kimani, one of the Mkulima Young Champions, is a typical example of the new breed of Kenyan entrepreneurs who are starting to see the opportunities farming offers. A trained engineer, he set up an aquaponics system to rear fish and grow strawberries. Now he earns KES 300,000 (2,600€) a month from it. His system is resourceful and ingenious. Ammonia produced by the fish is filtered out of the ponds through stone-filled towers, providing free fertiliser and water for the strawberry plants. Daniel is one of those proving to a generation of Kenyans that technologically-enabled farming is clever, lucrative and not necessarily labour intensive.

Maryann Wairimu, 23, Kajiado County, Average monthly income: KES 80,000, Educational background: Bachelor's degree in technology, Technical University of Kenya. Maryann started her Gad Eden Green House and Nursery in Kiserian after working for two years for a KES 18,000-a-month-salary. The farmer is today contracted by farmers to grow seedlings. Half of her father's quarter-acre piece of land is taken up by her greenhouse, where she has a selection of horticultural seedlings such as traditional herbs and vegetables, capsicum, tomatoes, cabbages, spinach and cucumber. An iPad in hand, she rarely goes for half an hour without receiving a call. Her age-mates are baffled that she spends so much time on the farm in this generally urban set- up, yet most of them are hunting for jobs in various industries. Three months ago, she could grow only 100,000 seedlings but her second eight-by-15-metre greenhouse has doubled this capacity. "The right seeds contribute 60 per cent of a crop's yield." she says. "A farmer should be worried by the quality of seeds he or she has." Now saving for a master's degree, Wairimu also offers farmers after-sales service. "I sell seeds and train customers on how to take care of them. I consult with them via telephone," she explains. For those far away, she sends the seeds via courier services.

Mary Gitau-Makori, 29, Nairobi County, Average monthly income: KES 300, 000, Academic qualifications: Masters in Psychology, Daystar University. Fifty-two pigs, 50 rabbits, 200 runner beans and two greenhouses. That's what Mary, who holds a first degree in Human Resources from the Methodist University, boasts on her Doben Resources Farm in dry Ruai on the outskirts of Nairobi. Her venture is a remarkable, mixed-farming enterprise on a 150-by-100-metre plot. She bought it in 2009 and in the last one year, it has been earning her and her husband more than double what they earned as salaried employees. Last year she sold 40 pigs at a go and earned a KES 200,000 profit. She has four varieties of tomatoes, which earn her more than KES 90, 000 in three months, in addition to the KES 130,000 she gets from capsicum and strawberries. Her rabbits weigh between six and nine kilos; a mature one goes for KES 2,500. She now processes a blend of tomato and strawberry juice, which earns her a profit of at least KES 21,000 per month. Her proximity to the city has made it hard to satisfy the demand. "New customers keep coming. I never have enough," she says.

Wycliffe Fundi, 30s, Embu County, Estimated monthly income: KES 250,000, Academic qualifications: Civil Engineering graduate, Technical University of Kenya. Started with just KES 3,600 in 2008, Fundi's Kirata Poultry farm in Kagare has grown to host 1,600 chicken, 80 per cent of which are broilers. Apart from selling chicken, his hatchery can produce 2,000 chicks in a week or two. "I began with 30 chicks and today I have 1,600 chicken worth KES 960,000," he says. His two brooders hold 500 chicks at a time and, in addition, he has crossbred a variety of chicken, producing what he calls taste yangu (my taste) due to its special flavour. Fundi recently opened an outlet at Mwea town in Kirinyaga County, where he slaughters at least 40 chickens daily. A Facebook enthusiast, he sells most of his chicken via the medium. His wife, Anne Wawira, manages the farm when he occasionally lands

consultancy jobs with local road construction firms. “I would be earning KES 70,000 month. See where I am?” he challenges graduates who are still job-hunting.

Kenneth Kipkorir, 34, Uasin Gishu County, Average quarterly income: KES 700,000, Education background: Diplomas in Graphic Design and Interior Design. Kenneth almost died of alcoholism five years ago, but by the time he left Asumbi Rehabilitation Centre, he had decided to go back to the farm his parents had left to escape his nagging and wayward behaviour. Today, Kenneth Kipkorir proudly manages his father’s land, where he rears dairy cattle, goats and chicken and grows a variety of horticultural crops. Apart from 600 chicken, he has 3,000 runner bean plants from which he expects a 3,000kg harvest worth KES 900,000 in two months, yet it will not have cost him more than KES 200,000. With a KES 36,000 monthly profit from his dairy cows and another KES 50,000 from maize, the graphic designer acknowledges that he had chosen the wrong career. Kipkorir’s mixed farm has created four jobs for local youth, which has motivated him to work even harder. “I want to double production of each crop next year,” he says.

Martin Kiburi, 18, Nyeri County, Average monthly income: KES 40,000, Educational background: Student, Mt Kenya University. Even before he completes his first year at campus, Martin Kiburi is already earning more than a government-employed teacher. After witnessing his father’s woes as a dairy farmer, he decided to add value to it. After buying one cow from him on credit, he now makes yoghurt in his father’s home, which he sells at a milk bar in nearby Mukurwe-ini town. Fresh milk sells at about KES 35 per litre and he makes KES 50 per litre profit from the yoghurt. His grade cow produces 40-45 litres a day and he buys the rest from his father. “I no longer worry about marketing my milk. He buys more than 150 litres from me every day,” says Kiburi’s father, Charles Njoroge. Father and son enjoy a cordial business relationship. “We agreed that I would save for my university education. I paid my First Year fees for myself,” says Kiburi. The food science and technology student is planning to set up a cheese manufacturing unit as well as start making ice cream by the end of next year. “I have already enjoyed the fruits of one cow. I can only add more,” he says.

Use of ICTs in Agriculture

There is under-utilization of Information and Communication Technologies (ICTs) for agricultural production and marketing. It is essential to digitize agricultural production, processing and marketing information into web-based resources to increase outreach and use. The Extension Services emphasised the importance of involving the youth continuously. The technology requires training, investment in ICTs tools, tailor making to match niche markets and clients’ needs. Simpler software needed to be developed, tested and users trained before final commissioning.

The use of ICTs provided the required information to enable the youth to make objective choices on profitable enterprises, their niche markets, modern technology and model success stories. There was need to setup ICTs hubs near markets and agricultural commodities bulking centres. These hubs will enable easy access to farmers, the community, support organisations, trainers and information sources. Youth entrepreneurs were to be encouraged to invest in setting up such ICTs hubs as commercial enterprises. Possibilities of forming private-public partnerships in providing ICTs facilities was encouraged. There was need to integrate training and introduction of ICTs and its use in agriculture. Wide acceptance and application of ICTs in rural areas will increase retention of youth in agriculture, enhance access to new technology; widen access to modern production techniques, enables timely access to market information and agricultural financing opportunities.

The Youth Groups were enthusiastic on the use of ICTs in agriculture. They were particularly happy on the prospect of use of computer software in ration formulation, its application in feed formulation and the opportunity to provide feed formulae at a commission. It was felt that the demand was huge springing right from the individual households the youth came from, the existing groups, Cooperatives and the community. Nutrimix Ltd, Nairobi routinely provided backup on formulae to the feed industry in Kenya using several softwares. Various softwares were available and in use among the researchers in the Institutions visited including Excel Spreadsheet, PC dairy and Feed Formulator MOF-Dairy Edition (2010). However, there was no unified approach and choice of software as each type met the unique need for which it was developed. Majority of these softwares were complex in operation and information needs for functioning hence not friendly to farm level use. Simpler software needed to be developed, tested and users trained before final commissioning for farm level application.

Equity Bank ran loan packages to the youth and had accumulated a wealth of experience in financing the agricultural industry. The Bank ran training programmes to build capacity of the borrower right from the onset including 8 weeks training on financial management, leadership, record keeping and group dynamics. They ran wide

branch network at which preferably two officers had agriculture training and dedicated their time in handling agricultural credit and farmer capacity building. Equity Bank ran credit portfolio for individuals and groups.

Commonly used ICTs Tools

The ICTs savvy youth served as trainers and community consultants and transformed the community use and access to ICTs. Some of the youth widely used ICTs on their farms, for example, in Western Kenya, 90 percent of the youth emblazed ICTs in their farming (IICD, 2013). The most commonly used tools were MS Office for word processing and spread sheet in farming and trading records keeping. Frontline mobile phone SMS and voice messages was commonly used in accessing timely market prices, reaching clients, sharing accurate production information and money transactions. Examples included M-Farm, which gives you up-to-date market information, links farmers to buyers through their marketplace and current agri-trends (Macharia, 2013). M-Farm Ltd is a software solution and agribusiness company. Their main product M-Farm, is a transparency tool for Kenyan farmers where they simply SMS the number 20255 (Safaricom Users) to get information about the retail price of their products, buy their farm inputs directly from manufacturers at favourable prices and find buyers for their produce. They collect Wholesale Prices of the commodities from the 5 major markets in Kenya and post them on their price page.

iCow, the winning application in the Apps for Africa Competition 2010 allows small-scale dairy farmers to manage and trade livestock (Oafrica.com, 2012). The platform has allowed users to increase milk production by over 50% and income by 42%. iCow in one of its products helps beef farmers track their cows' gestation periods to increase livestock numbers. Farmers use an SMS code to register their cows and their insemination date. The service then sends SMS prompts to the registered farmer on the expected date of calving or the best days for new insemination. This service also sends weekly SMS messages to subscribers with tips on breeding, nutrition, milk production efficiency and other best dairy practices. iCow also posts the location of the nearest veterinarian or artificial insemination specialist on its website, or sends farmers an SMS with the information. Through its iCowSoko (market in Swahili) farmers can trade livestock and livestock by-products on their cellphones.

FrontlineSMS was created in 2005 to enable effective communications channels for communities in the developing world. FrontlineSMS leverages the ubiquity of mobile phones and familiarity of text messaging to turn an offline laptop into a communication hub. The simple innovation empowers villagers, aid agencies, and news services to exchange information among groups easily. FrontlineSMS was designed as a free SMS communications system for development projects and has been used effectively in very specific contexts such as pastoralists in northern Kenya to access local crop and livestock prices. www.nafis.go.ke/NAFIS, developed by the Ministry of Livestock Development, is a comprehensive information service, intended to serve farmers' needs throughout Kenya including the rural areas where internet access is limited. Kenya Plant Health Inspectorate Service (KEPHIS) operates Maize Variety SMS Service. To receive an SMS for the recommended maize varieties in your division: 1) Go to ' write message ' on your handset, 2) type MAIZE#DIVISION e.g. Maize#Lanet, 3) Send message to 20354, 4) You will receive details of Seed Varieties. The youth, also, viewed agricultural Videos, listened to Radio Programmes, viewed TV Programmes and surfed the internet using Google Search to obtain accurate production technologies.

With the widespread use of mobile phones, voice and SMS solutions should find more use. The voice solution is by far the most promising platform for the farmer as it can be customised for language, is readily accessible and very natural, as it entails using the mobile phone through direct responses to specific questions. Internet tools commonly used by the youth included M-Farm which is owned by M-Farm Ltd, a software solution and agribusiness company. Another site is kiwanja.net that helps social innovators, entrepreneurs, farm practitioners and non-profit organisations make better use of information and communication technologies in their work. kiwanja.net specialises in the application of mobile technology, with a particular emphasis on its role as a driver of innovation, entrepreneurship and social change around the world. Another web and mobile-based technology programme is KilimoSalama, which means "safe farming" in Swahili. Run by the Syngenta Foundation for Sustainable Agriculture (SFSA), part of a Swiss agribusiness operating in partnership with UAP Insurance of Kenya and Safaricom, It offers seeds and crop insurance against drought or excessive rains. Smallholders purchase cover through local agro-dealers while buying their seeds, fertiliser and insecticides. Using solar powered weather stations, KilimoSalama collects information about extreme weather that may reduce yields and sends farmers these reports via SMS. If the company's climate station registers extreme weather, it sends insured farmers a mobile money payment that covers the costs of their seeds, fertiliser and other inputs such as insecticide that have been insured. Even if the entire crop is lost, the insurer provides the farmer with the funds to buy next season's seeds.

Social media commonly used by the youth was facebook site 'Mkulima Young Champions' and have become figureheads for a digital initiative to change the way farmers are viewed by young people. Using a range of technologies, they are proving that farming in Kenya really is a profitable 21st century career path. Mkulima means "farmer" in Kiswahili – was founded to draw more young people into farming, help them learn from each other, trade and overcome the challenges of agriculture together. Mkulima Young Champions targets youth to inspire them to participate in agricultural activities through awareness creation and knowledge change by harnessing the power of multimedia including radio and other ICT tools. Mkulima Young Champions identifies outstanding agricultural entrepreneurial activities and disseminate it through radio, Facebook, Twitter and You Tube and SMS. They obtain feedback from their regular radio clienteles through an SMS and address them during subsequent radio programmes. Most youth got their information from the internet so the reality of the matter is that the internet would be one of the best platforms to market and promote agriculture if you want to reach the youth. Internet and social media were used to obtain farm production technologies, market information and for information sharing. Internet online was used to access production brochures, magazines and Newspapers. Seeking information from these and other platforms was an onerous task for the farmers as it entailed ploughing through many publications or surfing a large number of web-pages. Furthermore, for the illiterate farmer this becomes impossible right from the onset. Web-based solutions also bring challenges because internet infrastructure in Kenya is still very sparse. Nevertheless, these are very useful resources and all that is needed is to provide an easy way for the farmers to navigate them.

You Tube is one of the most visited website after Google and Facebook (Wambugu, 2014). You Tube is a user generated content website that allows every person, company and social entity to share their videos and voice. The poultry unit at KARI Naivasha uses YouTube to interact with farmers rearing indigenous chicken. Farmers receive training and provide feedback on areas such as housing, disease control, feeding and management. They have over 50,000 views from April 2013. Twitter is a social networking and microblogging service utilising instant messaging, SMS or a web interface that enables users to send and read "tweets", which are text messages limited to 140 characters. Registered users can read and post tweets, but unregistered users can only read them (https://twitter.com/). You Tube and Twitter were not commonly used by the sampled youth except those who accessed 'Mkulima Young Champions'.

Benefits and impacts to youth on ICTs use

The ICTs use was a gateway to better jobs and employment in farming or outside farming. The youth were more proficient using ICTs skills in farm planning, production and marketing. This improved productivity and profitability of farming activities through higher yields, higher prices and increased farm income. Use of ICTs provided reliable markets and modern production information on existing livestock and crops and provided better access to profitable markets. Youth status was transformed generally from idlers to more serious players in agricultural industry who can be engaged by both public and private sector in farming activities and information use and transmission. These youth were more entrepreneurial and eager to adopt innovations and modern agricultural technologies. The youth increased their recognition from parents, peers, farming organizations and other community members. They were more respected and approached as technical resource persons by other farmers on latest farming information and technologies and latest prices of agricultural commodities.

The public and private sectors valued them as the main entry point in introducing modern extension and agricultural technologies and in expanding extension coverage. In fact, the youth were able to effectively and profitably capitalize their linkages with private sector actors. Their effectiveness in obtaining current market information and modern farming technologies enhanced youth negotiation strength and market position, surpassing local traders, agribusinesses and other agricultural value chain players. The role of youth in agriculture stood-out more strongly internally towards their parents and externally to extension agents, private sector, chain stakeholders and community elders. The youth trained in ICTs were appointed to more responsible roles in producer groups and commodity bulking centres and also served as trainers to fellow youth. Their farms were more intensive, efficient and profitable, producing for niche markets and created employment to other youth. These youth transformed the community use and access to ICTs and influenced the community economic status and political power relationships.

In general, use of ICTs improves efficiency in agriculture. ICTs can provide weather forecasts, ease farm input purchases and pricing information, expand reach of extension services through phones, radio, video and their combined application. ICTs can provide mobile banking and timely payments for example using M-Pesa and M-Shwari and enable buyers manage transactions with thousands of smallholders.

Challenges in ICTs use

The use of ICTs required that the youth are well trained and conversant with these tools. It requires access to the computer and internet which may not be readily available. ICTs tools should be readily available and in close proximity to the users. The websites hosted by service providers should provide information that is well packaged, reputable and in the appropriate languages (vernacular, Kiswahili or English).

The future of ICTs use in agriculture

The smart phone technology will revolutionise the access and use ICTs particularly the social media including Facebook, You Tube, Twitter and WhatsApp among the youth in Kenya. This will enhance introduction of modern extension and agricultural technologies and will increase extension coverage. The outcome will be improved productivity and profitability of farming activities through higher yields, higher prices and increased farm income climaxing in more youth engaging in agriculture. The wide reticulation and commissioning of fibre optic cable in Kenya has increased the bandwidth and coverage among the majority of its citizens which will stimulate ICTs use among the youth. New innovations are likely to occur that will cause growth of the information and communication technologies sector in Kenya.

Conclusions and recommendations

The use of ICTs in agriculture increased opportunities, motivated and increased the capacity of the youth to engage in profitable agriculture targeting niche markets. Their use created an occupation worth investing in time, effort and financial resources. ICT tools availability should be expanded and organisations contributing to agricultural development require to package their technologies simply and post them at their websites for easy access. ICT tools need to be simple and affordable. Content should be relevant to targeted youth, valuable, treasured, localized and dependable. The use of You Tube, Twitter and WhatsApp in agricultural knowledge access by institutions and among the youth should be expanded and widely popularised.

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