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Faculty of Veterinary Medicine and Animal Science

Goat production in the tropics and mitigation to feed shortage in different production systems in Eastern, Tanzania

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Abstract

Seasonal feed fluctuation is the common problem among livestock keepers in the tropics. Even though there have been several intervention programs to the farm level little is known after these projects had phased out. This study was conducted to describe goat production systems, feed shortage mitigation in the dry period, versatility of previous feed shortage mitigation projects and identify other challenges in Eastern Tanzania. Stratified random sampling technique was employed whereby goat farmers under small scale intensive system (n = 21) in Tchenzema and Nyandira wards and extensive pastoralist system (n = 37) in Mangae and Dakawa wards were visited and interviewed on herd size, goat management, challenges they face and their suggested solutions. Informal discussion with the key informants namely Ward Livestock Officers (WLO) about issues facing the goat farmers was also conducted. Collected data were analyzed using Statistical Package for Social Science (SPSS IBM 22) to generate descriptive statistics, Mann-Whitney U test for the herd structure and size and Chi-square for proportions analysis.

There were significant differences between the intensive and pastoralists herd structure and size. Interviewed pastoralists (91.9%) and interviewed intensive farmers (76.2%) kept goat as the source of income. Goats were also kept as food source by 78.4% and 100% pastoralists and interviewed intensive farmers, respectively. Pastoralists (2.7%) and 95.2% intensive farmers benefited by goat manure, extra importance of goat production among pastoralists was insurance (43.2%) and traditional uses (10.8%). Intensive farmers tethered and fed concentrates to their goats alternatively pastoralists relied on grazing in the communal rangeland with little supplementation. Pastoralists mentioned dry period (July-October) as the time when goat feeds were scarce, intensive farmers experienced shortage during their farm fields' preparation for crop cultivation. To mitigate scarcity intensive farmers opted for cut and carry system (71.4%), tether their goats elsewhere (42.9%), feeding goat planted pasture (28.6%), leave a portion of prepared land for goat tethering (14.3%), feeding concentrates (14.3%), and use of alternative feed resources. In contrast pastoralists relied on migration (73%), alternative unconventional feed resources such as shrubs (27%), concentrates (16.2%) and changing of grazing system (2.7%).

Next to feed shortage, infectious diseases were major problems. Other challenges included marketing, as mentioned by 35.1% of pastoralists and 33.3% of intensive farmers. Goat theft (8.1%) and wildlife invasion (2.7%) were considered among pastoralists and intensive farmers complained about poor production (4.8%). Suggestions associated with the improvement of goat nutrition (farmers training and improve inputs) were shown not to associate with the production system. It was concluded that farmers in the two production systems had different period of feed shortage which was mitigated by changing management activities and feedstuffs among intensive farmers and migration among pastoralist. There was also widely adoption of the pasture establishment among intensive farmers as part of feed shortage mitigation probably from the previous projects. Marketing of goat products, wildlife invasion, theft and poor production had their own role in hindering goat farming as well.

Dedication

To my daughter Charity my nephews Shawn and Adam, my nieces Carolyne, Magreth and Modesta who have just started their journey in seeking knowledge.

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ABBREVIATIONS

CCPP	Contagious Caprine Pleuropneumonia
EPINAV	Enhancing Pro-Poor Innovation in Natural Resources and Agricultural Value Chains
FAO	Food and Agriculture Organisation
FMD	Foot and Mouth Disease
IFAD	International Fund for Agricultural Development
NBS	National Bureau of Statistics
SEAG	Small East African Goat
WLO	Ward Livestock Officer

1.0 INTRODUCTION

In most of the sub Saharan developing countries small ruminants, mainly goats, have been favored over cattle. This could be due to their small size, fast growth rate and adaptability on the seasonal changes as the result of their browsing behavior (Nyamangara & Ndlovu, 1995). Henceforth are considered as the cattle of the poor (Escareno et al., 2012). Most importantly their products such as meat are not subjected to the religious taboos unlike pork and beef to Muslims and Hindus respectively (Chenyambuga et al., 2012). Their milk is said to be better compare to other milk such as cows for people suffering from lactose intolerance which is common among adults in sub Saharan Africa (Haenlein, 2004). Besides goats' milk containing almost the same amount of lactose as cow's milk (Silanikove et al., 2015).

According to FAO statistics as per 2013 Tanzania had a total herd of about 16 million goats from which annual meat production was 37,800 tons and 110,600 tons of milk (FAOSTAT, 2015). This production is mainly due to large herd size rather than individual animal productivity (Alexandre et al., 2010). Moreover, these goats together with other animals are kept in different production systems within the country (Shija et al., 2013). Goat production systems in Tanzania could be categorized into intensive and extensive based on how resources are available and used (Escareno et al., 2012). Under intensive production system there is high to moderate input usage; such as use of supplements in animal ration and crossbreeds are reared to improve survival and increase production (Ketto et al., 2014). Alternatively, the extensive production system is defined as a little or none input system where indigenous breeds are mainly reared (Kosgey et al., 2008). These animals provide a method of utilizing grassland areas of arid and semi-arid parts of the country where other economic activities could be catastrophic (Baker and Rege, 1994; Kosgey et al., 2008).

Tanzania as a tropical country has two major rainy seasons, heavy precipitation between March and May then much less rainfall from October to December, in contrast it experiences dry season between June and beginning of October (Gamoyo et al., 2015). During this dry period there is a shortage of feed and water for animal consumption (Fleischer et al., 2000). Also during this season, even if forages are available they normally are of poor nutritional value. The digestible energy and protein contents of the forages are very low while lignin and indigestible fiber are of higher values than the recommended (Adjorlolo et al., 2014). Due to this nutrient supply fluctuation throughout the year there have been delays in goats' attaining mature weight (Mushi, 2004; Shija et al., 2013).

The prolonged period of goat attaining mature weight was shown to affect goat product quality such as meat tenderness (Shija et al., 2013). Conversely protein – energy imbalanced ratio during dry period influence both milk and blood urea concentration (Giaccone et al., 2007). The increase in animal urea excretion in the urine is of environmental concern and it has shown to have negative correlation with fertility (Nourozi et al., 2010). In order to address the seasonal goat feed fluctuation several studies have been conducted on the use of alternative feed resources and treatment of low quality straws by strong alkali to improve utilization (Fleischer et al., 2000).

Additionally, there have been several interventions programs to the farm level to assist farmers to cope with the feed shortage (Safari et al., 2005: Chenyambuga et al., 2012). Enhancing Pro-Poor Innovation in Natural Resources and Agricultural Value Chains (EPINAV) - dairy goat project which was in effect from 2011 to 2014 had a vision of promoting the use of multipurpose trees and conservation agricultural techniques in Mvomero district, Morogoro region (Disch et al., 2014). However, little is known about farmers' mitigation strategy to feed shortage after these projects had phased out. Hence this study was conducted to describe two existing goat production systems, and identify their major challenges. Similarly, an important aim was to explore the possible solutions by the farmers *i.e.* pastoralists and small scale intensive farmers to encounter these challenges especially feed shortage during the dry period. Another objective was to find out if there were traces of the previous implemented projects as part of feed mitigation strategy in Eastern Tanzania. It is further hypothesized that goat farmers used forage treatment and conservation techniques in the project areas even long after the projects are finished.

2.0 LITERATURE REVIEW

2.1 Nutrition and management

Most of the Tanzanian small scale intensive goat farmers feed their goats agricultural by-products from the milling industries, such as maize brans and sunflower seed cake, in addition to crop residues and green forages under cut and carry system (Jackson et al., 2014). On the contrary, pastoralists graze their goats in the communal owned land with little or no supplementation (Chenyambuga and Lekule, 2014). Hence during the dry season, the low input pastoralism system has a higher misfortune in terms of feed conversion and growth rate compared to the intensive high inputs goat farmers (Diogo et al., 2010).

During this period poor quality forages and agricultural residues such as rice and maize straws could be treated by different devised methods and used as the alternatives feeds resources. The treatment of rice straws by steam (Table 2.1) improved crude protein (CP) availability, amplified neutral detergent fiber and acid detergent fiber digestibility and increased dry matter and organic matter utilization among Xuhuai goats reared in China (Muhammad et al., 2014).

Table 2.1: Chemical composition of steam treated and untreated rice straws

	DM	OM	NDF	ADF	CP	DM	OM	NDF	ADF	CP
Steam-treated rice straw	61.06	59.45	52.36	59.98	52.25	65.94	66.07	58.86	62.40	63.44
Untreated rice straw	32.97	33.49	32.87	38.32	28.59	37.39	39.96	38.24	40.13	34.37

Adapted and modified from Muhammad et al., (2014)

Perhaps the most popular method of treating low quality forages and agricultural residues to be used in dry period is by using chemicals such as urea and strong alkali like sodium hydroxide (NaOH) (Fleischer et al., 2000). But unlike sodium hydroxide, urea supply non protein nitrogen (NPN) to the rumen microbes, simply available in the market and most important it is cheaper and easy to use (Alabi et al., 2013). Also urea could be regularly supplemented in the low quality forages to enhance nutrient intake, nutrient digestibility and nitrogen utilization efficiency (McGuire, 2013).

Alabi *et al.* (2013) noted that crude protein, digestibility and feed intake of total mixed ration (TMR) was improved in Yankasa rams with the rise in urea concentration level. The higher values were reported in 2.0% urea and lowest in 1.0% while 1.5% was intermediate (1.0%>1.5%>2.0%). This was probably the result of the NPN supply in sheep from urea. Also Shen *et al.* (1998) observed the increase in cellulose, hemicellulose, dry matter (DM) and organic matter (OM) losses in 48 hours' incubation *in sacco* prior to silica extraction when rice straw was treated by 5% urea. Conversely, the use of NaOH improves digestibility but not the protein content of the treated feedstuff. A comparison study between urea-treated and NaOH-treated rice straws by Fleischer *et al.,* (2000) reported that there were no significant differences in the in vitro dry matter digestibility of all treated straws (Table 2.2) but urea-treated straw had higher DM compare to NaOH-treated straws.

Table 2.2: In vitro digestibility and chemical composition analysis of treated rice straw used in an experiment

Feed	DM	CP	NDF	ADF	IVDMD
NaOH treated rice straw	79.17	7.08	73.05	54.55	50.98
Urea treated rice straw	84.7	10.45	62.40	56.80	52.98

Adapted and modified from Fleischer et al., (2000)

2.2 Breeds and breeding

Under intensive production system most of the farmers are keeping crossbreeds of local and exotic breeds such as Small East African goat and Norwegian crosses to improve performance and adaptability to local environment (Ketto et al., 2014). Also in some cases pure dairy breed goats such as Toggenburg are kept by farmers (Jackson et al., 2014). In contrast most of the pastoralists are keeping breeds such as Small East African goats which are indigenous breed of their localities (Kosgey et al., 2008). Small East African goats' breeds are attributed with distinctive physical features such as wither height of up to 50cm, mature live body weight of 18.6kg and heart girth of 57.9cm (Jimmy et al., 2010).

Moreover, the artificial insemination is rarely used among the Tanzanian goat farmers; natural mating is the dominant breeding practice among pastoralists and small scale farmers. Under this system a group of does are grazing together with one or more bucks and hence mate (Kosgey et al., 2008). Farmers prefer this method since it is cheaper and easy to practice compared to the structured mating but without breeding program there is no use of doing it (Chenyambuga and Lekule, 2014).

Alternatively, under the intensive system where effective dairy goats' projects are running, farmers have a breeding program and well defined breeding objectives. Farmers either have to keep their own bucks and mate it with the doe when in heat, or there is a common buck which is rotated among the participating farmers until its service time is terminated to avoid inbreeding among the herds (Jackson et al., 2014). Goats are normally individual housed or sorted in groups based on age and sex in order to avoid uncontrolled mating (Nonga et al., 2009).

Individual agro-pastoralists have different breeding objectives, but most of them prefer the Small East African goats (SEA). Traits of importance considered by farmers in this breed are easiness to feed probably attributed by their small body size and mature weight (Jimmy et al., 2010). Drought tolerant probably due to their survivor in the dry period, diseases tolerance, fast growth and low caretaking time are also included (Chenyambuga and Lekule, 2014). Similarly, other traits such as fertility, body size, meat quality, temperament and body shape are all put into consideration (Kosgey *et al.*, 2008).

Unlike their counterpart most of the intensive small scale goat farmers are concerned with the production efficiency. Age at first kidding, lactation yield and length, kidding interval, litter size and kid mortality rate are among the breeding objectives selected or set by the farmers and/or project decision makers (Jackson et al., 2014).

2.3 Goat production performance

Study by Jackson *et al.* (2014) on Toggenburg dairy goats kept in the semi-arid and sub-humid parts of Tanzania reported no differences in kidding interval and litter size between the two areas. Though goat kept in sub-humid area had more milk yield per day, higher kid mortality rate and they had their first kid a little later comparing to their counterpart kept under semi-arid condition.

Alternatively, Chenyambuga *et al.* (2012) report on reproductive performance of Small East African goat in the semi-arid part of Tanzania showed that on average goats first kidding age ranged between 14.2 – 16.8 months, with the kidding interval of 8 months. Most of the goats were not producing twins though the litter size was 1.2. Kids were weaned at the age of 5 months and reproductive life of dam was reported to be 7 years.

Under the traditional pastoralism system goats mature weight is delayed, they attain market weight of about 20 kilos at the age of 2 years (Mushi, 2004; Shija et al., 2013). Further study by Shija *et al*, (2013) in Small East African goats showed that goat meat tenderness is affected as the result of delayed body fat deposition under this production system. Hence make the meat tougher, though post mortem aging seemed to improve meat tenderness with gradual decrease in meat pH.

Moreover, Diogo *et al*. (2010) studied the resource use in urban and peri-urban and revealed significant differences in growth rate, seasonal feed given and daily Metabolisable energy intake between the high input and low input goat firm in Niamey, Niger. Nevertheless, goats under high input system had higher daily intake of nitrogen, phosphorus and potassium compare to the others in low input.

A study at village level on Norwegian goats and their crosses in Tanzania showed that increased exotic blood level (genotype) inclined weight gain. Also there was low weight gain during the wet seasons in the highlands and humid conditions but daily weight gain increased in transition from wet to dry season. This was explained as a result of tethering and/or confining goats during the wet season, and also the forages might be more succulent during this period (Safari et al., 2005).

2.4 Goat health and diseases

Environmental condition in the tropics support various form of lives, both macro and micro; the microorganisms are of special interest due to their role in causing different diseases. These diseases are adding production cost to the farmers, some of them are zoonotic and can be transferred to humans and, most importantly, they threaten food security not only in Tanzania but in the global scale (Kawooya, 2011).

Both endemic diseases and diseases outbreaks are said to be the setbacks for sustainable goat production in semi-arid part of Tanzania. The most notable ones are infectious diseases such as foot and mouth diseases (FMD), diarrhea, pneumonia, foot root and contagious caprine pleuropneumonia (CCPP). Other plundering diseases includes parasites both endoparasites and ectoparasites such as helminthesis and manges (Chenyambuga et al., 2012).

Disease occurrence in Tanzania is influenced by both spatial and temporal factors, Mbyuzi *et al*, (2014) reported the seroprevalence of CCPP in goats to be 52.1% in 2007 and 35.5% in 2009 and seroconversion of 28.7% (2009) for peste des petits ruminants in Southern Tanzania. Conversely there are significant differences in parasites occurrence among stall fed, tethered and pastoral production systems; ectoparasites had occurrence rate of up to 95% for fleas, 98% for ticks and 95% for lice while helminth eggs ranged 49 - 98% in Eastern Tanzania (Kusiluka et al., 1998).

Moreover, pastoralists have been selecting goats breed such as Small East African (SEA) which are said to be resistant to a number of diseases hence they have no regular diseases control routine. On the other hand, the small scale intensive goat farmers are dipping/spraying their goats, deworming and vaccinate as the part of routine control of ticks, helminthesis and CCPP (Chenyambuga and Lekule, 2014).

3.0 MATERIAL AND METHODS

3.1 Study area

The study was conducted in Morogoro region, Eastern Tanzania (Figure 3.1). Morogoro region is located in the $8^0$00'S $37^0$00'E coordinates and the altitude of 500 - 600 above the sea level. The region receives annual rainfall ranging 600 to 1000 mm; temperature ranges 20-27^o C during the coolest period (April to September) and 30-37^o C in the hottest period of the year (October to March). Morogoro region was selected due to its diversity in the goat production systems; Mvomero and surrounding districts being prominent with the intensive small scale goat farmers located on the slope of mount Uluguru and traditional Maasai people keeping goats on the flat rangelands of the district.

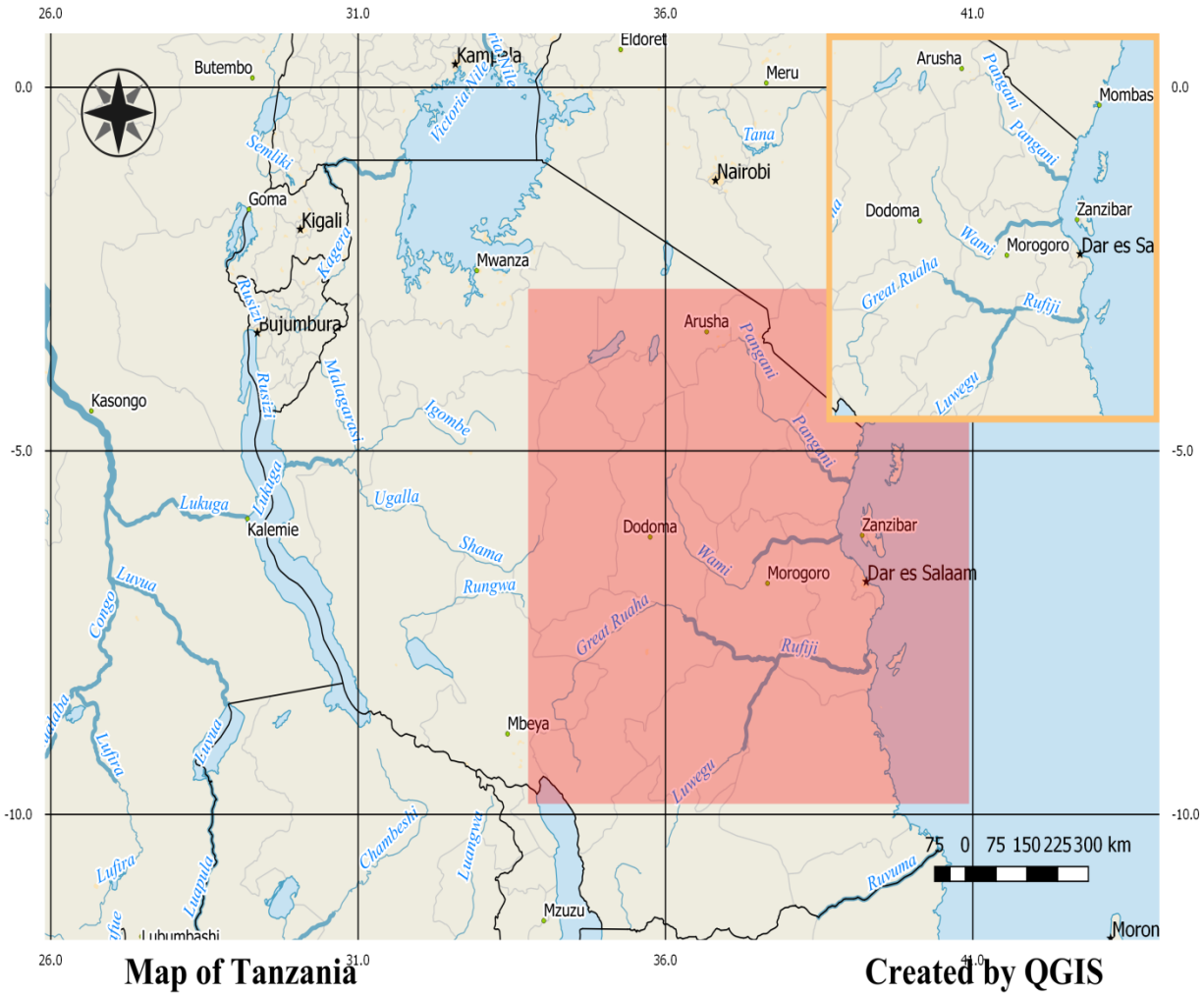

Figure 3.1: Map of Tanzania showing Morogoro region

3.2 Study design

The study focused mainly on goat farmers under both small scale intensive system and extensive pastoralist system and primary data was collected from them. Small scale intensive goat farmers in Tchenzema and Nyandira wards together with pastoralists counterpart in Mangae and Dakawa wards were visited and interviewed to obtain information on herd size, goat management, challenges they face and their suggested solutions. In the each visited ward stratified random sampling technique was employed where by farmers were divided in the strata and only those keeping goats were interviewed even though they had other types of livestock. In Tchenzema and Nyandira wards only stratified farmers who were part of Enhancing Pro-Poor Innovation in Natural Resources and Agricultural Value Chains (EPINAV) - dairy goat project was randomly selected and interviewed. On the contrary apart from using strata to select pastoralist goat farmers once in the strata the selection of farmers was done randomly relying on livestock officer information of the residents. Each farmer in the strata had a fair chance of being included in the study though selected farmer could be replaced if the most knowledgeable member of the household was not available or stopped keeping goats one year prior to study visit.

3.3 Data collection

The interview and informal discussion tools were used for data collection. Therefore, a total of 58 goat farmers were interviewed. Among those, 21 were small scale intensive goat farmers, 13 farmers from Tchenzema and 8 farmers from Nyandira wards, and 37 were extensive pastoralist goat farmers in the rangelands with 18 farmers in Mangae and 19 farmers in Dakawa wards. There was only one type of questionnaire used which included a formal list of open ended questions to capture as much information as possible. The formal questionnaire was written and pretested before administration to the respondents, and hence the ambiguous questions were improved for smooth participation in the study.

During data collection, only the household which had kept goat for more than one year or had experience over the dry period of the year were chosen and an individual who was most knowledgeable about household goat management's practices was interviewed to help obtain the reliable information. In addition, there were informal discussions with the key informants namely Ward Livestock Officers (WLO). WLO in the pastoral wards of Melela and Dakawa together with their intensive counterpart in Nyandira ward were asked about the major issues facing the goat farmers in their localities.

3.4 Data Analysis

Data collected was categorized based on wards, sex of the respondents and production system. Also respondents' answers regarding consumption of milk and meat were categorized as the source of food. Thereafter analysis was done to obtain information on the feeds and feeding of goats, periods with feed shortage, methods to mitigate shortage, challenges facing farmers and suggested possible solutions. Statistical Package for Social Science (SPSS IBM 22) was used to code and analyze questionnaire to generate descriptive statistics (frequency, percentage and bar chart). Mann-Whitney U test for non-parametric distributed independent

valuables in the SPSS was used to analyze the herd structure and size with the confidence interval of 95% in order to compare the differences between the production systems, namely pastoralists and intensive small scale goat farmers. Correspondingly, chi-square was used to test the proportional difference in challenges facing farmers and their suggested solution between the production systems and was considered significant at $P \leq 0.05$.

4.0 RESULTS

4.1 Herd structure and size

There was significant difference ($p < 0.001$) between the median intensive and pastoralists herd structure and size (Table 4.1). Intensive goat farmers had a median of 0, 4, 1 and 6 for buck, doe, kid and total herd size respectively. On the contrary their counterpart pastoralists had medians of 4 for buck, 16 for doe, 7 for kid, and 26 for the total herd size.

Table 4.1: Goat herd structure and size

	Intensive farmers			Pastoralist farmers		
	Mean	Min-Max	Median	Mean	Min-Max	Median
Buck	0.7	0 – 4	0^a	5.7	0 – 40	4^b
Doe	3.9	1 – 8	4^a	20.2	2 – 70	16^b
Kid	1.6	0 – 7	1^a	11.4	0 – 40	7^b
Total	6.1	2 – 14	6^a	37.2	2 – 120	26^b

Medians with different superscript were significantly different

4.2 Goat uses and importance

Goats were kept for various reasons by pastoralists and intensive farmers (figure 4.1), 91.9% of interviewed pastoralists (total n = 37) and 76.2% of interviewed intensive farmers (total n=21) said they kept them as a source of income to meet their daily needs after selling the live animals or their products. Also goats were kept as source of nutrients rich diet and consumed as meat, milk or butter by 100% and 78.4% interviewed intensive farmers and pastoralists respectively.

Moreover 2.7% pastoralists and 95.2% intensive farmers said they also get manure from the goat that was used in the crop cultivation. Additionally, there was extra importance of goat production among pastoralists, 43.2% mentioned that goats are used as the insurance in the time of emergencies, such as source of money during sickness of both people and animals. Goats also have part in traditional uses (10.8%) it was explained that pastoralists used goat during different traditional ceremonies and goat products such as butter are used as the remedy for delivered women.

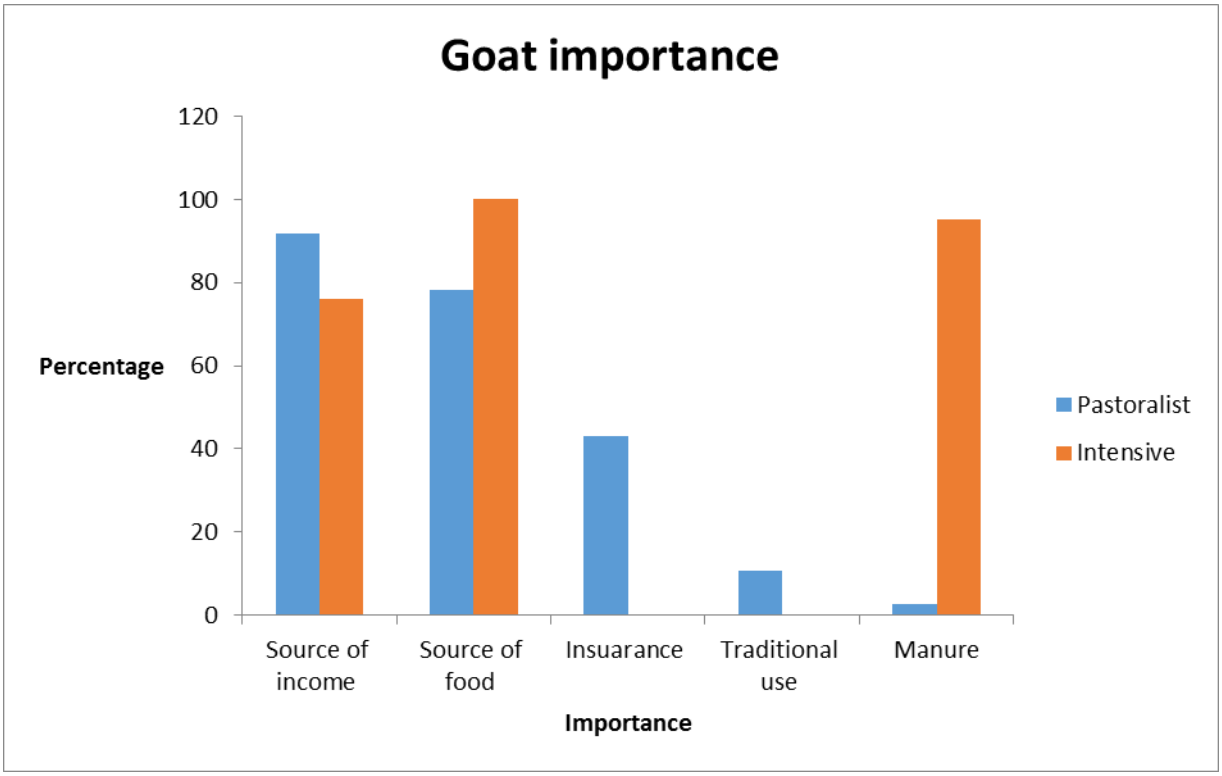

Figure 4.1: Goat importance to the farmers

4.3 Goat feeds and feeding

All of the interviewed intensive farmers in Tchenzema and Nyandira wards (total n = 21) said that they tether their goats on the pasture fields and feed them concentrates such as maize brans, seed cakes and occasionally about once a week they supplement them with minerals as well. It was further clarified by the livestock officer in the locality that goats are tethered during the day and fed concentrates in the evening during milking for lactating doe or resting for other age groups.

Conversely the entire group of interviewed pastoralists (total n = 37) relied on the communal rangeland where they graze freely for the goat feeds. Although some (5.4%) claimed to also supplement grazing with concentrates mainly maize brans from the local mills. Livestock officers in these areas explained that apart from free grazing and concentrates feeding there is also provision of mineral blocks to the goat for licking during the night when goats are confined in their housing.

Dry period was mentioned as the period of the year when goat feeds' are relatively scarce by the interviewed pastoralist. Melela and Dakawa livestock officers claimed this period is between July and October. On the contrary intensive farmers were divided about the goat feeds scarcity, 95.2% said they experience shortage during the time when their farm fields are prepared for crop cultivation and 4.8% said they do not have feed shortage at all throughout the year. Mgeta livestock officer added that feed shortage in his area occurs in the dry period (July – October). Also during the period of land clearance for crop cultivation (September-December) when land is left stands bare without grasses.

To mitigate feed scarcity goat farmers in the two production systems (Figure 4.2) had different strategies. Most of the intensive farmers opted for cut and carry system (71.4%) where they were cutting grasses from far areas and bring them to their goat instead of sending them out there. Others claimed to tether their goats elsewhere (42.9%) especially along the main roads where there are no farm fields and area belongs to no one. Another strategy was feeding goat planted pasture *Setaria spp* (28.6%); some farmers had established their own pasture plots. Other mitigations strategies included to leave a portion of prepared land for goat tethering (14.3%) and increased use of concentrates such as maize brans and seed cakes (14.3%). Lastly use of alternative feed resources such as banana trees leaves by cut and carry system.

In contrast 73% of the interviewed pastoralists claimed that they migrate to other areas with their goats in search for green pasture during feed shortage and immigrate to Ngade where there is a river. As the result of the depletion of forage some pastoralist said that they sometimes give alternative feed resources like browsing shrubs and other fodder trees (27%) to their goat. Feeding of concentrates (16.2%) including maize brans was mentioned as one of the mitigation strategies. Last of all was changing of grazing system, (2.7%) pastoralists said that they were grazing continuously throughout the day without taking break in the noon. This was done to ensure that their goats consumed enough of the available feed resources.

Generally, Mgeta livestock officer mentioned that during scarcity goat farmers are reducing feeding frequency to only twice per day and use own produce stored maize straws and cobs as the major feedstuff. Alternatively, Melela and Dakawa livestock officers mentioned the use of concentrates as the feed mitigation strategy to supplement the continuous grazing on the grass deprived rangelands.

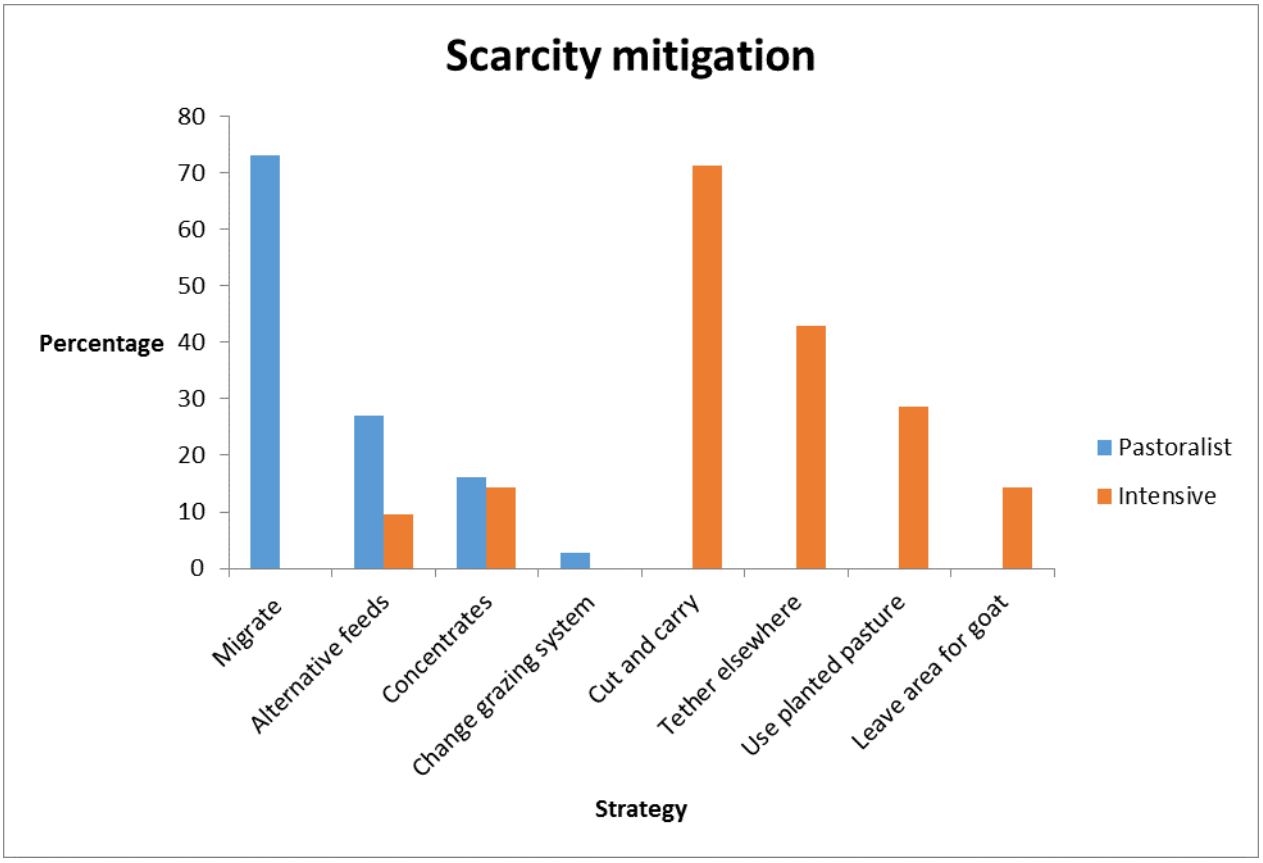

Figure 4.2: Feed scarcity mitigation among goat farmers

4.4 Other challenges

Apart from feed shortage, the other major challenge mentioned by both pastoralist and intensive goat famers was diseases. This included infectious diseases such as Contagious Caprine Pleuropneumonia (CCPP), foot rot, foot and mouth diseases (FMD) and lumpy skin. There were also other diseases mentioned like mastitis, diarrhea, coughing, neck paralysis, abortion, bloating, sudden death, worms, ectoparasites and fever, to mention a few. Disease challenge was not computed by chi-square (X^2) since it was observed to be constant in all production system.

Other challenges were more specific for each production system (table 4.2). Except marketing, 35.1% of interviewed pastoralists and 33.3% of interviewed intensive farmers said there was poor market for live animals and goat products such as milk. However, market challenge was significant between the two systems (P = 0.01). Goat theft (8.1%) and wildlife invasion (2.7%) especially elephants were reported by pastoralists in Mangae ward while intensive farmers complained about poor production (4.8%). Other challenges (including goat theft and wildlife invasion among pastoralists against poor production among intensive farmers) were shown not to be influenced by production system and there were no significant differences (P = 0.845).

Table 4.2: Other challenges facing goat farmers

Pastoralist		Intensive	
Marketing	35.1%	Marketing	33.3%
Theft	8.1%	Poor production	4.8%
Wildlife invasion	2.7%		

Correspondingly Mgeta livestock officer added that apart from diseases and lack of butchers for marketing of goat meat there was lack of many goat breeds so that hybrid vigor could be improved. His counterpart in Melela also mentioned diseases especially CCPP as the big problem, but also added theft, water shortage and, most importantly, goats do destruct other people's crops and cause conflicts.

4.5 Farmers' suggested solution

Farmers had different suggestions (figure 4.3) to solve various challenges they encounter. 59.5% of pastoralists suggested proper and prompt treatment of diseases, they claimed that some of the medicines are ineffective in treating goats' diseases. Both pastoralists (27%) and intensive farmers (14.3%) suggested that farmers should be trained on better ways of keeping their goats and mitigate feed shortage.

Vaccination against CCPP, the most notorious disease, was mentioned by 9.5% and 18.9% of intensive farmers and pastoralists respectively who claimed it was very scarce. Other suggestion by pastoralists (10.8%) and intensive farmers (23.8%) included improvement of the farm inputs availability such as medicines. Intensive farmers in Nyandira and Tchenzema wards added pasture seeds were scarce hence limit the maintenance of their pasture plots.

Moreover, both pastoralists (2.7%) and intensive goat farmers (28.6%) proposed improved market of live goats and their products. Additional pastoralists specific suggestions included land management (5.4%) whereby they requested individual ownership of the communal grazing land and wildlife control (2.7%) especially elephants who are regularly attacking and destroy their homes causing panic and restlessness.

Intensive farmers' specific suggestions included planting of pasture (47.6%) to be used during the feed shortage. Medicine price (14.3%) they suggested the price of medicine was sky high and need to be subsidized since they cannot afford it. To sum up they proposed studies on the cause and treatment of diseases (9.5%) especially those that were unfamiliar to them, like the sudden death of the goats that started in 2012 in Tchenzema and Nyandira wards.

Generally, farmers' suggestions relating to animal health (vaccination, study on diseases, medicine availability, medicine price, proper and prompt treatment) was different between pastoralists and intensive farmers ($P = 0.001$). Also suggestions associated with improvement of goat nutrition (farmers training and improve inputs) were not associated with the

production system (P = 0.17). Conversely other suggestions (market, land management and wildlife invasion) were not statistically different between the production systems (P = 0.659).

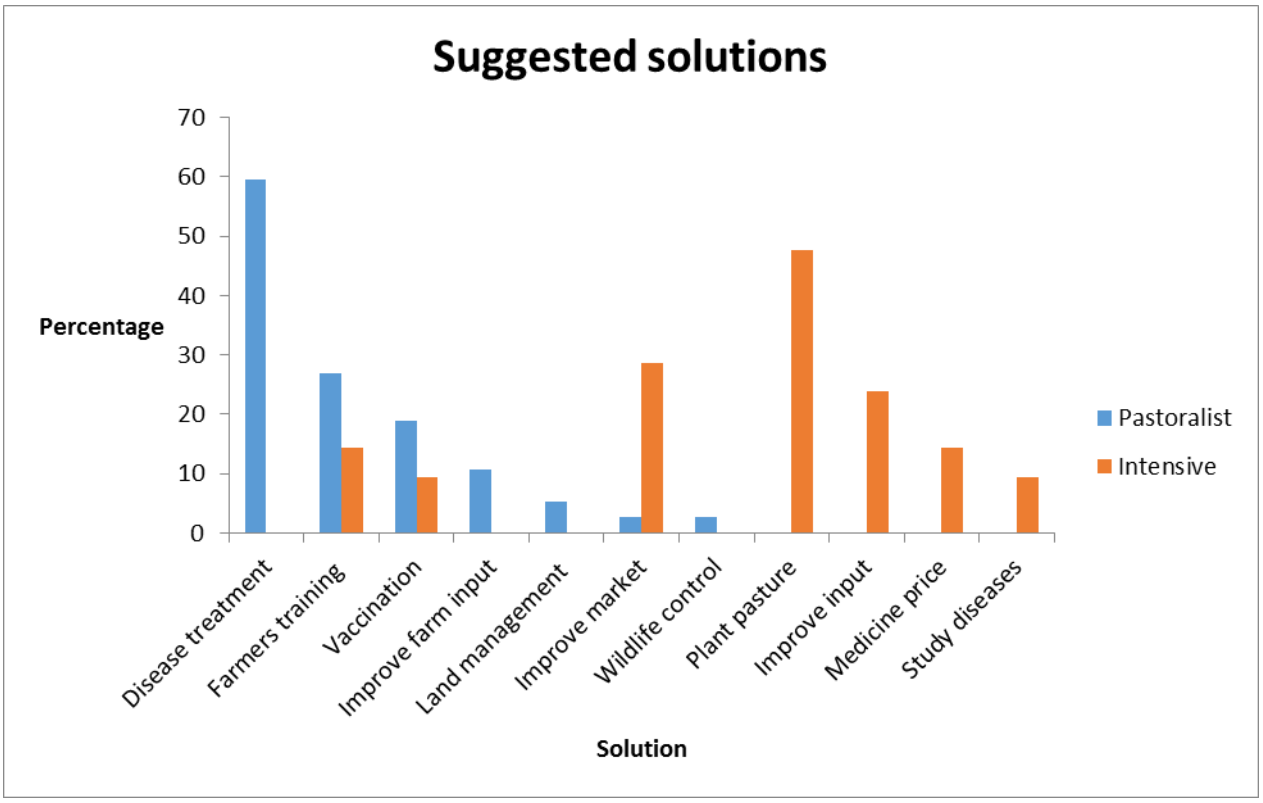

Figure 4.3: Farmers' suggested solution to solve other challenges

Finally, livestock officers had suggestions of their owns, Melela livestock officer proposed the improvement of water storage infrastructure to meet ever increasing demanding of water for livestock, farmers training, plant and use of multipurpose trees and early reports of sick animals. Dakawa livestock officer suggested use of concentrates during dry period and routinely deworming of goats. Provision of goat breeds for meat production, establishment of goats' meat butchers by the government and training of farmers on handling of milk to avoid foul smell were suggestion proposed by livestock officer in Mgeta.

5.0 Discussion

5.1 Herd structure and size

The reported statistical difference ($p<0.001$) in goat herd structure and size between pastoralists and intensive farmers in the current study was similar to the previous report by Jackson *et al*. (2014) but differed from the small ruminants' studies conducted in Kenya by Kosgey *et al*. (2008). This could be due to the incorporation of the sheep as the part of the herd in the previous study. The reported mean bucks, doe, kids and total herd owned by both intensive farmers and pastoralists in the current study were higher than previous study conducted in Central Tanzania (Chenyambuga and Lekule, 2014). In contrast the intensive farmers' bucks and kids' means reported here were lower than the same study conducted in semi-arid and sub-humid part of Tanzania (Jackson et al., 2014). The variation could be due to the different production system and dividing of kids in male and female groups in the previous studies.

In the current study pastoralists' herd structure and size were higher compare to the intensive farmers. This could be explained by reliability of the pastoralist to the livestock as the sole source of income compare to the intensive farmers who might have other off farm sources (Dercon, 1998). Also livestock are used as the sign of wealth among pastoralist (Homewood et al., 2006). Though it is anticipated that pastoralist might have higher number of goats compare to the reported figures due to the fear of authorities as the result of widespread rumors on the establishment of livestock taxes and the need to reduce their herd size.

The size and structure of the goat herd among the intensive farmers was relatively small as previously noted by Jackson *et al*, (2014). The reported 0.7 mean in bucks was the lowest among the different animal categories. This could be explained by the breeding practice conducted by the intensive farmers being part of the dairy goat project with central buck rotated among project farmers until it is terminated (Jackson et al., 2014). Likewise, selection intensity could reduce the number of males selected for mating (Philipsson et al., 2011). Their pastoralists' counterpart with no breeding program had to rely on conventional mating where bucks run with does on grazing lands and mate when on heat (Chenyambuga and Lekule, 2014). Moreover, the low selection intensity among pastoralists could feature the large number of bucks they kept for breeding purpose (Terefe et al., 2012).

5.2 Goat uses and importance

The use of goat as the source of income by pastoralists and intensive farmers in the current study was in agreement with the previous studies by Kosgey *et al*, (2008) and Dercon (1998). Also goats' meat and milk were used as the source of food by all intensive farmers and some pastoralists (78.4%); goat products are rich in protein (Steinshamn et al., 2014). Moreover, they are not subjected to religious taboos (Chenyambuga *et al.*, 2012) and its milk is said to be useful to people with lactose intolerance (Haenlein, 2004). Though not all pastoralists mentioned that they used goats as the source of food this was not clear why that is and it was not further investigated in the current study.

The use of animal dungs as manure as mentioned by pastoralist and intensive farmers in the current study is the efficient way of recycling nutrients. Goat manure is rich in nitrogen and phosphorus (Schlecht et al., 2011) the essential minerals needed for the optimum plant growth in order to ensure sustainability (Hariadi et al., 2016). Moreover, the reported use of the goats as the insurance against emergencies and traditional uses by pastoralist in the current study was similar as the Kosgey *et al*. (2008). It was argued that farmers use goats as the insurance due to the easiness of selling them during emergencies. Chenyambuga *et al.* (2012) also reported the use of goats as the means of paying dowry to the brides' family. The mentioned source of income and insurance by pastoralists seems to overlap each other. It could be explained that source of income was referring to the regular monetary value obtained from the selling of the goat for subsistence. Insurance was inclined to the "bank on the hooves" (IFAD, 2009) where they could easily withdraw money by selling goats to solve problem in the household.

5.3 Goat feeds and feeding

The reported goat tethering and concentrates supplementation among the intensive farmers was the same as the study conducted by Jackson *et al.*, (2014) whilst free grazing and little supplementation among pastoralists agreed with Chenyambuga and Lekule (2014) who argued that extensive pastoralist are free grazing in the communal land. The goat production systems in the current study met the criteria for the systems classification based on the use and availability of resources; high input in intensive and low to none in the pastoralism (Escareno *et al.*, 2012).

There were two different period of feed shortage between the two production systems. To the intensive farmers their livestock officer claimed that due to the integrated livestock-crop production; feed shortage is when they prepare their farm plots (September-December) and have to clear all the grasses. This in turn makes them rely on concentrates which become very expensive (Ben Salem and Nefzaoui, 2003) due to competition from other farm animals' species such as poultry (Teguia and Beynen, 2004) and pigs that are fed concentrates continuously. Conversely, to the pastoralists feed shortage is when the grazing land is bare and there are no enough pastures for their livestock as previously noted (Fleischer et al., 2000). Hence they are the most affected due to their low input uses in terms of feed availability and nutrients turnover (Diogo et al., 2010).

The mentioned dry period in the current study of July to October and hence goat feed shortage around the same time differed from the previously mentioned dry months of June to October (Gamoyo et al., 2015). This could be explained by the gradual change of the season and that feed shortage is not abrupt, and hence raise a question about the nutritive value of the available forages during this transitional period (Adjorlolo et al., 2014).

Intensive farmers' solutions for feed scarcity mitigation mentioned in the current study included cut and carry system. This could be attributed by the small herd size they keep (Jackson et al., 2014) and limited land space owned (Msuya, 2013). Also tethering of goat elsewhere because the natural pasture was not really depleted but rather cleared to use the land for crop cultivation hence the uncultivated land will be available for tethering. Lastly

establishment of pasture and use them during the dry period in the current study was sustainable and encourage land use planning to the household (Chenyambuga and Lekule, 2014). Also the adoption of the pasture establishment strategy among the intensive farmers could be attributed to EPINAV – dairy goat activities in the area. Although their activities involved introduction of multipurpose trees but pasture establishment could be part of conservation agricultural practices to improve livelihood (Disch et al., 2014). Further studies are needed though on the project effect on conservation agriculture long after it is gone since this study was conducted shortly after the project phased out.

Other mitigation strategies by intensive farmers like leaving a plot of land for goat is economical and help in the farm risk diversification. Feeding concentrates mentioned by both intensive farmers and pastoralists might need economical evaluation around this period. This is due to the high price of concentrates (Ben Salem and Nefzaoui, 2003) and low livestock price in the markets with high market integration (Bizimana, 2012; Mwanyumba et al., 2015). Although goat's market weight is one of the criteria of fetching higher price in the market (Teklewold et al., 2009). The use of alternative feeds is possible due to the browsing behavior of goat (Nyamangara and Ndlovu, 1995). Also high protein content in some fodder trees makes them interesting (Komwihagilo et al., 2005) though care should be taken due to the presence of anti-nutritional factors in some of these plants (Mtenga and Laswai, 1994).

To sum up, the migration to other areas and continuous grazing done by the pastoralist in order to mitigate the feed scarcity is unsustainable. Besides, this might not be kept for so long due to the use of land for other economic activities such as tourism (Maleko et al., 2012) and it might be the reason for delayed animals' growth (Mushi, 2004; Shija et al., 2013). Also the fast population growth necessitates for efficient food production (NBS, 2013) and increased demand in efficient farm inputs uses. Correspondingly the use of untreated maize straws mentioned by livestock officer is not enough since goats could not digest poor quality forages very well (Muhammad *et al.*, 2014). Therefore, forage treatment should be done to improve nutrients availability (Fleischer *et al*., 2000).

5.4 Other challenges

In the current study after feed shortage the next challenge facing goat farmers was diseases. Infectious diseases such as CCPP, foot rot, FMD and lumpy skin are reported to be the major setback of goat production in Tanzania (Chenyambuga and Lekule, 2014). These diseases are designated as transboundary animal diseases (Brown, 2011). Other diseases mentioned here included mastitis, diarrhea, coughing, neck paralysis, abortion, bloating, sudden death, worms, endoparasites and fever. Diseases like bloating are known to associate with management (Wang et al., 2012), mastitis is common among high producing pure and crossbred dairy goats (Kifaro et al., 2009). Some mentioned diseases like coughing; neck paralysis, fever and abortion were just mere symptoms and could be any one of the several diseases (Albuquerque et al., 2011; Bamaiyi et al., 2015).

Poor marketing of the live animals and goat products revealed by pastoralists and intensive farmers is due to undefined livestock value chain within the country (FAO, 2015). Lack or underperformance of goats' products processing plants (Dogan and Gokovali, 2012) and

seasonal fluctuation of production could cause market saturation during rainy season (Mioć et al., 2008). Establishment of farmers' cooperative groups could provide them with the bargaining power (Lie et al., 2012). The poor production mentioned by intensive farmers could be due to diseases (Kifaro et al., 2009) and managerial practices (Mushi, 2004; Shija et al., 2013). Theft on the other hand mentioned by pastoralist could be attributed by their grazing practices (Chenyambuga and Lekule, 2014) where in the communal land herds from different households are mixed together. Wildlife invasion as described in this study was also reported by Maleko et al., (2012) who mentioned spotted hyena (*Crocuta crocuta*) as the deadliest one by killing goats. Though livestock interaction with wild ungulates is perceived as competitive it can also be beneficial through long term modification of rangeland (Augustine et al., 2011). Destruction of other people's crops as mentioned by livestock officer could be one of the reasons to fuel pastoralist-farmers conflict in Eastern Tanzania (Benjaminsen et al., 2009). Also the difference among these challenges (goat theft, wildlife invasion and poor production) between pastoralists and intensive farmers is due to different production systems, level of production and targeted final product.

5.5 Farmers suggested solution

Proposed solutions by the farmers in the current study were mainly addressed towards two major challenges diseases and goat nutrition. These mainly two suggested solutions were shown not to be statistically different between the two systems. Proper and prompt diseases treatment proposed due to ineffective livestock treatment suggest the misdiagnosis (Ole-Miaron, 2003) or drug resistance among goats (Geerts et al., 2001) though livestock officer comment that farmers delaying in reporting diseases could also be taken it account. Vaccination of goats as mentioned here could be a better solution against diseases such as CCPP though it needs to be repeated annually (Thiaucourt et al., 1996). However, some diseases vaccines are still under development (Diallo et al., 2007) so might not be available yet and farmers could not be aware that vaccines are neither available nor developed.

Farmers training proposed by both pastoralist and intensive farmers could be the best tool to integrate indigenous knowledge and modern farming techniques for sustainable development (Dolinska and d'Aquino, 2016). Other challenges (market, land management and wildlife invasion) were different between pastoralists and intensive farmers. Proposed market improvement in the current study might be attained through farmers' cooperative groups (Lie et al., 2012) and not necessary through government intervention. Suggested land distribution by the pastoralists might be the crucial solution, as this will force individual farmers to improve pasture on their acquired land (Chenyambuga and Lekule, 2014) and also will reduce their crash with crop farmers (Benjaminsen et al., 2009). The use of bee hives might be useful in wildlife control especially elephant the major wild animal reported to terrorize goat farmers' village (Vollrath and Douglas-Hamilton, 2002), and might also help in diversifying farm economy (Girma and Gardebroek, 2015).

Generally, in the current study it was noted that there were different in response concerning various issues between farmers and livestock officers and among livestock officers themselves. The difference between livestock officers and farmers' response could be due to the fact that extension officers are very few and work in various wards at the same time

(Rutatora and Mattee, 2001). Hence their response could also be touching other wards not necessary the ones under study. As key informants, they might as well be representing opinions of goat farmers who were not selected to participate in the study (Kothari, 2004). The different among livestock officers could be attributed to different farming systems.

6.0 Conclusion and Recommendations

Conclusion

The farmers in the two production systems had different period of feed shortage. Among intensive farmers as the result of integrated agriculture this is the period when they do clear their farm fields for crop cultivation (September-December). Conversely to the pastoralists who rely sole on the natural pasture this is during dry period (July - October). Intensive farmers mitigated scarcity by changing managerial activities and feedstuffs while their counterpart pastoralist opted for migration as the major solution though alternative feedstuffs could be used occasionally.

It was also noted that there was widely adoption of the pasture establishment among intensive farmers as part of feed shortage mitigation. This could be due to EPINAV – dairy goat activities in the area though this reject the hypothesis that farmers used multipurpose trees and conserved forages for scarcity period. Pastoralists did not have any modern mitigation strategy practices. This is probably because of lack of the project activities addressing this problem in their localities.

Generally, apart from feed shortage, the next problem affected goat farmers in Eastern Tanzania was diseases including both infectious and other specific diseases per production system. Market of goat products, wildlife invasion, theft and poor production had their own role in hindering goat farming. Most of the farmers proposed solution were targeting the two major problems feed shortage and animal health; land management, farmers training, vaccination, proper and prompt treatment, and improved input availability were among of the voted solutions each with different practicality.

Recommendations

From the current study the following recommendation could be made to improve goat production

1. Pastoralist goat keepers are still relying on natural communal graze land hence improvement of these areas is important either to improve or maintain plant biomass.
2. Further studies are needed on the available feed resources fed to goats throughout the year and their nutritional values in order to understand if they meet animal requirements.
3. Future studies should also base on the addressing other farm challenges facing goat farmers including marketing and diseases.
4. Another studies on effect of long term versatility of the implemented projects on mitigation strategies after they are finished.

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Appendix

Appendices I: Goat farmers' questionnaire

This study is about goat production and mitigation to the feed shortage in the Mvomero district. You are invited to participate in this interview. The study consists of 7 questions and will take approximately 20 minutes to complete. Please answer the questions to reflect your opinions and experiences to the best of your knowledge. If you would like clarification on any of the questions, please do not hesitate to ask the interviewer. If you wish not to answer any particular question(s), please say so and the interviewer should be able to proceed to the next question. In participating please answer the questions as read to you by the interviewer who will enter your responses in the questionnaire's blank spaces and tick where appropriate. The interviewer should be able to inform you when the interview questions are complete. Your participation is highly encouraged and appreciated.

Name of the participant ……...

Age ……... Sex …….

Village …….. Ward ……

1. Describe the number and structure of your herd

Buck	Doe	Kid	Total

2. Describe the importance of goat farming to you?

3. What feedstuff do you feed your goats?

4. What months/period of the year goat feeds is relatively scarce?

5. How do you mitigate the feed scarcity in your area?

6. Describe other challenges you face in your farm

7. What do you suggest should be done to alleviate these challenges?

Appendices II: Intensive farmers herd structure and size

Statistics

		Herd_buck	Herd_doe	Herd_kid	Herd_total
N	Valid	21	21	21	21
Median		.00	4.00	1.00	6.00
Skewness		2.234	.568	1.405	.916
Std. Error of Skewness		.501	.501	.501	.501
Minimum		0	1.00	.00	2.00
Maximum		4	8.00	7.00	14.00

Appendices III: Pastoralist herd structure and size

Statistics

		Herd_buck	Herd_doe	Herd_kid	Herd_total
N	Valid	37	37	37	37
Median		4.00	16.00	7.00	26.00
Skewness		3.172	1.072	1.127	1.043
Std. Error of Skewness		.388	.388	.388	.388
Minimum		0	2	0	2
Maximum		40	70	40	120

Appendices IV: Intensive farmers' goat uses and importance

		Frequency	Percent
Valid	Source of income	16	76.2
	Source of food	21	100.0
	Manure	20	95.2
	Total	21	100.0

Appendices V: Pastoralist goat uses and importance

		Frequency	Percent
Valid	Source of income	34	91.9
	Source of food	29	78.4
	Traditional use	4	10.8
	Insurance	16	43.2
	Manure	1	2.7
	Total	37	100.0

Appendices VI: Intensive farmers' goat feeds

		Frequency	Percent
Valid	Tethering	21	100.0
	Concentrates	21	100.0
	Total	21	100.0

Appendices VII: Pastoralist goat feeds

		Frequency	Percent
Valid	Free grazing	37	100.0
	Concentrates	2	5.4
	Total	37	100.0

Appendices VIII: Intensive farmers' period of feed shortage

		Frequency	Percent
Valid	Farm preparation	20	95.2
	None	1	4.8
	Total	21	100.0

Appendices IX: Pastoralist period of feed shortage

		Frequency	Percent
Valid	Dry period	37	100.0

Appendices X: Intensive farmers' mitigation strategy

		Frequency	Percent
Valid	Cut and carry	15	71.4
	Concentrates	3	14.3
	Tether somewhere else	9	42.5
	None	1	4.8
	Feeding planted pasture	6	28.6
	Leave area for goat	3	14.3
	Feed alternative feeds	2	9.5
	Total	21	100.0

Appendices XI: Pastoralist mitigation strategy

		Frequency	Percent
Valid	Migrate to other area	27	73.0
	Feed concentrates	6	16.2
	Feed alternative feeds i.e. shrubs	10	27.0
	Change grazing system i.e. continuous	1	2.7
	Total	37	100.0

Appendices XII: Other challenges facing intensive farmers

		Frequency	Percent
Valid	Diseases-infectious	21	100.0
	Marketing	7	33.3
	Poor production	1	4.8
	Diseases-others	1	4.8
	Total	21	100.0

Appendices XIII: Other challenges facing pastoralist

		Frequency	Percent
Valid	Diseases-infectious	33	89.2
	Diseases-others	4	10.8
	Market	13	35.1
	Theft	3	8.1
	Wildlife invasion	1	2.7
	Total	37	100.0

Appendices XIV: Suggested solution by intensive farmers

		Frequency	Percent
Valid	Study on diseases	2	9.5
	Improve input including medicines	5	23.8
	Reduce price of medicine	3	14.3
	Improve market	6	28.6
	Plant improved pasture	10	47.6
	Farmer training	3	14.3
	Vaccination	2	9.5
	Total	21	100.0

Appendices XV: Suggested solution by pastoralist

		Frequency	Percent
Valid	Proper and prompt treatment	22	59.5
	Vaccination	7	18.9
	Improved farm inputs availability	4	10.8
	Land management	2	5.4
	Farmers training	10	27.0
	Wildlife control	1	2.7
	Improve market	1	2.7
	Total	37	100.0