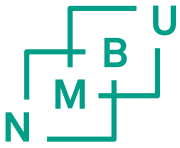
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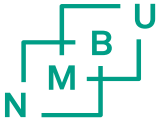

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Abstract

Dairy goats, recently introduced to Zanzibar, play an important role in many small-scale farming systems, improving both income and household nutrition. A survey of 193 dairy goat farmers in Zanzibar was conducted in 2013. The aim was to understand animal husbandry practices, benefits and challenges of dairy goat keeping, and to design support that is useful and encourages economic, environmental and socially sustainable integration of dairy goats in the humid tropics. In 116 questions, the survey addressed topics such as dairy goat feeding, health, milk production, markets and social aspects. Utilizing qualitative and quantitative information increased the scope of the study and enabled a holistic understanding of the farming systems. According to farmers interviewed, key challenges restricting dairy goat keeping in Zanzibar are; disease (57%), drought (49%), lack of funds (21%), low access to health care (18%), and lack of education (14%). Key benefits are income and poverty reduction (35%), manure (33%), milk (18%) and improved household nutrition (15%). A small group (12%) of farmers reported no benefit from keeping dairy goats. Average milk production for a dairy goat in Zanzibar is 0.92 L per day for three months, well below genetic potential. Low milk production was mainly due to poor management, inadequate records and feeding in particular. To help improve management practices, farmers need access to appropriate animal healthcare, milk markets and education on dairy goat husbandry. These findings can inform design of effective extension programmes to help meet farmers' goals to increase production.

Keywords

Small-scale farming systems, Sustainable livelihoods, Goat diseases, Animal health care, Animal nutrition, Small-scale marketing

Introduction

Dairy goat keeping in the humid tropics

Farmers in the humid tropics face challenges on every scale, from local to global. Whether they are taking a stand against exploiting middlemen or climate change, farmers stand on the front line as stewards of land, food and renewable resources. Dairy goats are a recent addition to many small farms in the humid tropics. In East Africa, dairy goats were introduced within the past 30 years. Dairy goats need adequate nutrition to produce milk effectively. Introduced breeds are also less tolerant to tropical diseases (Das & Sendola, 1991), making their management more time and resource intensive than local goats (Peacock, 2008). Raising and crossing with exotic breeds demands planning, management and an adequate gene pool (Escareño *et al*., 2013). Dairy goat projects, both governmental and non-governmental are widespread and support small-scale farmers throughout the humid tropics (Bett *et al*., 2009).

Benefits of keeping dairy goats in the humid tropics

In the humid tropics, goats are reliable producers in bad times, and fast breeders with lower nutritional requirements than cattle because of their small size (Escareño *et al*., 2013). Goat milk provides an important source of protein and a wide range of vitamins and minerals essential for human health (Haenlein, 2004). Dairy goats are smaller and easier to manage than cattle making them more accessible to women (Milne-Price, 2011). Supporting dairy goat development can create jobs in other sectors such as local milk processing and distribution. These jobs can be inclusive and engage women. Dairy goat operations have great potential to support rural women and increase gender equality (Odero-Wanga *et al*., 2009).

Dairy goats are a form of economic security. Selling one goat could buy enough grain to feed a family of five for two to three months (Peacock, 2005). Increasing land pressure and urbanization make dairy goats an attractive and sustainable option for smallholders in rural and semi-urban areas (Fagerholm *et al*., 2011). In systems where farmers cut and carry forage for their goats, goat manure can easily be collected and spread onto vegetable gardens or in nearby fields, increasing soil organic matter and fertility (Juma & Pica-Ciamarra, 2013).

Framework for sustainable dairy goat keeping in the humid tropics

Dairy goats play an important role in many tropical farming systems. To increase benefits for small-scale dairy goat farmers, it is important to consider the environmental, social and economic spheres of sustainability. More than inputs and outputs of the farming system, it is important to consider cause and effect relationships within these spheres and how they interact (Lebacq *et al*, 2013). Our present study uses systems thinking, a holistic framework that encourages farmer participation and qualitative feedback (De Jager *et al*., 2001). Improving overall sustainability of dairy goat husbandry on small-scale farms in the humid tropics is a main focus. For more information on the research framework see *Appendix 2*.

Zanzibar as a case study for tropical dairy goat husbandry

Located off the coast of East Africa, Zanzibar is part of Tanzania and includes two small islands, Pemba and Unguja. Fifty percent of food sold in the market is imported (Bic, 2013). In rural Zanzibar, 73.3% are living below the food poverty line (making less than 7.78 USD per day), while only 26.7% of the urban population live below the food poverty line (Rajab, 2010). Tourism makes up 35 percent of the gross domestic product (GDP) (Makame & Boon, 2008). With projected increases in food imports, tourism and urbanization, farming sustainably and increasing food sovereignty are growing challenges. For more cultural and agricultural information about Zanzibar see *Appendix 3.*

According to Africa Livestock Data (Juma & Pica-Ciamarra, 2013), less than 900 goats were being milked in Zanzibar in 2012. Although several governmental and international dairy goat projects were initiated to support farmers in Zanzibar, information on the impact of these dairy goat projects were not recorded. In addition, apparently no animal husbandry information has been collected about dairy goat farmers in Zanzibar. Gathering information on dairy goat husbandry practices at a farm system level and identifying benefits and challenges according to farmer's experiences and perceptions is valuable for designing effective research and support in the future.

The aims of this study are:

- To describe current dairy goat husbandry practices
- To identify benefits and challenges of dairy goat keeping
- To construct a holistic picture and suggest improvements which will provide useful support to dairy goat farmers and encourage the sustainable integration of dairy goats in small-scale farming systems in the humid tropics

Materials and Methods

A baseline study of 193 dairy goat farmers from all nine districts in Zanzibar was conducted in 2013. Twenty nine Shehias, the smallest governmental unit were included. Smaller than a district, Shehias are made up of one to several villages. One hundred and forty dairy goat farmers (30% of the population) from 18 Shehias in Unguja and 53 dairy goat farmers (60% of the population) from 11 Shehias in Pemba were interviewed. Both Shehias and dairy goat farmers were randomly selected using an online random number generator based on the percentage of the total population the district represented (Urbaniak & Plous, 2013).

The extensive questionnaire with 10 sections and 116 questions was administered by teachers from the Kizimbani Agricultural Training Institute (KATI) in Unguja and by employees at the Ministry of Livestock and Fisheries (MLF) in Pemba. See *Appendix 4* and *5* for the full questionnaire in English and Swahili respectively. The questionnaire was designed and translated to Swahili in collaboration with professors and teachers from the Norwegian University of Life Sciences (NMBU), Sokoine University of Agriculture (SUA) and KATI, specializing in different disciplines related to animal science, agroecology and rural development. The survey was conducted by two to five interviewers each day with two to five interviews completed per interviewer per day depending on the interviewers' availability. For more information on the survey design, translation and testing see *Appendix 6.*

Table 1: Dairy goat farmers selected for this study: the estimated number of dairy goat farmers came from the district livestock officers (DPOs). The number of farmers surveyed in each district was based on the percent of the population that district represents. The days interviewing were determined using a time estimate of 1 hour 30 minutes per interview and three interviews per interviewer per day.

Island	District	Estimated maximum number of farmers	Number of farmers surveyed	Days interviewing
Unguja	Central	116	34	4
Unguja	South	125	38	5
Unguja	North B	41	13	2
Unguja	West	25	7	1
Unguja	North A	150	48	6
Pemba	Michiweni	32	19	2
Pemba	Wete	31	19	2
Pemba	Chake Chake	10	6	1
Pemba	Mkoani	14	9	1
	Total	**544**	**193**	**24**

All the questionnaire data, both quantitative and qualitative, were compiled into an Excel spreadsheet. The questionnaire was designed to capture as much information as possible. Farmers were encouraged to give as many responses or reasons as they could, listing several types of fodder, or challenges instead of their feeling constrained to one response. For this reason, in some cases the results section has a larger number of responses than 193, the sample size. In order to highlight the most important results, only responses common among farmers are discussed. This resulted in numbers of responses and percentages smaller than indicated by total number of interviews. SPSS 6.1 was utilized to verify statistically significant relationships. All correlations were tested at a level of 0.05 significance. One way ANOVA in SPSS was used to analyse categorical variables with more than two categories (SPSS Inc., 1995).

Results

Dairy goat husbandry practices in Zanzibar

Dairy goat numbers, breeds and record keeping

Farmers have 4.4 dairy goats on average. One hundred and eighty five dairy goat farmers (95%) have does while 81 (42%) keep bucks. According to farmers, 50% of the dairy goats are Saanen and 23% are a mix of dairy goat breeds or dairy goats mixed with local breeds, the other common breeds are Toggenburg (17%) and Norwegian (10%). The percentage of different breeds may be inaccurate because many farmers cannot tell the difference between Saanen and Norwegian breeds. For general information about the dairy goat farmers in this survey see *Appendix 7*.

Ninety nine of the dairy goat farmers (51%) keep records on their goats. Records are most commonly kept on; reproduction (27%), medical treatments (26%), births and deaths (20%), diseases (11%) date the animal comes into heat (8%) and milk production (8%). The reasons for keeping records includes; remembering past events and developments (32%), keeping track of diseases and treatments (28%), remembering kidding times (22%), improving management (22%) and knowing the profits and losses (15%).

Forty nine percent of the farmers keep no records on their dairy goat production, 45% due to lack of education, 22% because they did not think it important. Record keeping and years of formal education are positively correlated, the correlation between record keeping and milk production is also significant. The mean milk production for those who keep records is 0.74 L compared to 0.53 L for those who do not. These mean values are low because they include all farmers surveyed, including those who do not milk their dairy goats.

Feeding system and inputs

Intensive goat keeping seems to be important for farmers in Zanzibar. The average farmer owns just 0.65 ha (1.6 acres) of land. Fifty four percent of the dairy goat farmers interviewed (104) have communal land available to them; 87% use the land for crop cultivation, 36% use it for firewood collection and 34% use it for the collection of fodder. Access to communal lands for fodder collection makes it possible for farmers with no owned land to participate in dairy goat farming.

Farmers use three main feeding systems to keep dairy goats in Zanzibar. The first, is a zero grazing cut and carry feed method utilized by 116 farmers (60%). Sixteen farmers (8%) use an extensive system where goats search for their own feed exclusively. The third system is a mix of the two, both intensive and extensive used by 61 farmers (32%). Methods of keeping dairy goats vary depending on the grazing land and time available for feed collection. In high rainfall areas, diseases are a major concern and the cut and carry method which keep the dairy goats out of the mud and off the ground is preferred.

Supplement feeds

Sixty percent (113 farmers) provide supplemental feed for their dairy goats. Of these, 99 farmers (88%) give maize bran, usually not mixed with other feeds. The average farmer provides 2.2 kg/goat/week. While some farmers give supplement feed during the entire dry season, others only give supplement feed during the first month of the goat's lactation period.

Dairy goat fodder

Eighty six farmers (45%) grow fodder for their dairy goats. Instead of growing fodder, the majority of dairy goat farmers cut and carry fodder from communal lands or use open grazing systems. Elephant grass (*Pennisetum purpureum*) is the most common forage grown by 66 farmers making up 77% of all the fodder growing farmers. The remaining 22 farmers (26%) grow *Gliricidia* spp., 10 (12%) grow guatemala grass (*Tripsacum andersonii*) and 4 (5%) grow *Leucaena* spp. When asked why they grow fodder, 53 farmers (62%) say they need it for the dry season. See *Appendix 8* for descriptions of the ten most common forages used by dairy goat farmers in Zanzibar.

One hundred and ten dairy goat farmers (57%) grow vegetables. Some farmers feed their goat's vegetable leftovers, amaranth (44 farmers), sweet potato leaves (15), and other vegetable by-products (15). 42 farmers (38%) have a garden but do not feed their goat(s) vegetables by-products.

Dairy goat reproduction

According to farmers, on average their dairy goats go into heat twice per year and the heat lasts for two days. The average mating age is 10 months and the average kidding age is 16 months according to them. The average kidding interval is 8 months. One hundred and ten farmers (57%)

have dairy goats that produced one kid most of the time. Ninety (47%) commonly have twins and only 3 farmers (2%) had goats that commonly produce triplets. The total number of dairy goat miscarriages in this study was 131, 73 farmers (38%) have goat(s) that miscarried, 51 (70%) do not know the reason for the miscarriage.

Ninety percent (174 farmers) have access to dairy goat bucks. Most farmers borrowed (33%), have their own (25%) or rent (16%) dairy goat bucks. The average cost of renting a dairy buck is 0.81 USD. The most common breeds for dairy goat bucks are Saanen (116) followed by Toggenburg (24), crosses (24) and Norwegian (18). Ten percent of the dairy goat farmers do not have access to improved dairy goat bucks and have to use local breeds. Unavailability of dairy goat bucks is rarely due to the expense of this service.

Dairy goat health

The total number of goat mortalities over one year is 283, 1.5 deaths per farmer. Sixty seven percent (130) had at least one death in the past year, 48 (37%) do not know the cause of the mortalities. Eighty five percent (165) have access to veterinary services. Sixty six percent (127) use veterinarians to determine the cause of death for their dairy goats. Ninety nine percent (191) have access to medicines and 46% (89 farmers) have access to vaccines. One hundred and nine farmers (56%) use veterinarians to treat their dairy goats, 28 use pharmacies, 28 use vet shops, 23 use extension services and 7 use project funded shops.

The most common diseases are: helmithis (91) a group of eukaryotic parasitic worms, influenza (40) commonly known as the flu caused by RNA viruses, minyoo (40) (*Ascaris lumbricoides*) stomach nematodes, pneumonia (36) a lung infection which can be caused by fungi bacteria or viruses, diarrhea (34) a loose or liquid bowel movements with many possible causes and skin diseases (23). 74 farmers treat their goats for helminthis, 38 treat for minyoo, 33 for pneumonia, 28 for influenza and 22 for diarrhea.

Dairy goat milk production

In Zanzibar, the average milk production for the does being milked is only 0.92 L per goat per day. Thirty two percent, (61 farmers) do not even milk their dairy goats because of low production. During the dry season goats produce 0.44 L per goat per day, 0.65 L is produced during the wet

season. These averages include goats that are not producing milk during a season or the whole year. Generally, dairy goats are milked for 3 months. Farmers use 0.44 L of milk for home consumption on average. Only four farmers do any milk processing, making yoghurt locally.

Markets for dairy goat products

The most common dairy goat product sold at the markets is live animals. The average price of a dairy goat varies widely from 12 to 217 USD based on the quality of the goat, the size, age and location. The average price for a dairy goat is 65.41 USD when sold from the farmer directly. The price is 86.99 USD when sold through a middle man. The average price for one litre of goat milk in Zanzibar is 0.87 USD. Seventy nine percent of the farmers use goat milk at home. Only fifteen farmers (8%) mentioned meat as a benefit of dairy goat farming, but 21% use dairy goat meat for home consumption. Forty three farmers (22%) sell all their dairy goat products from home, 59 farmers (31%) do not sell any dairy goats or dairy goat products.

Benefits and challenges of keeping dairy goats

Benefits of dairy goat keeping in Zanzibar

Income and Poverty Reduction: 68 farmers (35%) consider income generation a benefit. 66 farmers (34%) specifically mention selling goats for income. 23 farmers (12%) say they use the income to buy basic necessities such as food, clothing and medicine for their families. 21 farmers (11%) say specifically that they use the money to pay for school fees.

Manure: 64 farmers (33%) consider manure a benefit. It is mostly used to fertilize crops on the farm, while a few sell manure to neighbours.

Milk: 35 farmers (18%) consider milk a benefit. Milk is for sale, home consumption, or both.

Nutrition: 28 farmers (15%) consider the contributions to family nutrition a benefit, particularly the medicinal value of the milk to treat young, old and people with peptic ulcers.

No Benefit: 23 farmers (12%) say they receive no benefit from dairy goat keeping.

Challenges of dairy goat keeping in Zanzibar

Disease: 110 farmers (57%) consider disease an important challenge, 32 (17%) also mention death of goats in general.

Drought: 94 farmers (49%) consider the shortage of feed during the dry season a challenge, and 10 (5%) mention lack of land availability in particular.

Lack of funds: 41 farmers (21%) consider lack of funds a major challenge. 13 (7%) mention the high cost of buying supplemental feeds specifically.

Healthcare: 35 farmers (18%) consider accessibility to healthcare for dairy goats a major challenge because doctors or treatment are not accessible.

Education: 27 farmers (14%) consider lack of education, mostly in regards to general dairy goat management a serious restraint.

The main non-economic benefit for keeping dairy goats is manure according to 156 farmers. When asked if dairy goats provide a significant economic benefit 18% (35) do not report any kind of economic benefit, from either the sale of goats or milk. When asked if they want to expand their dairy goat keeping operation, 88% (170) say yes.

Support and information dairy goat farmers

The average dairy goat farmer has two dairy goat farming neighbours. Sixty nine percent (134) farmers are part of a farmer field school (FFS), 130 are part of a farmer group and 123 are part of a farmer association. The average farmer has been part of a group for 4.25 years. Every farmer group in this study is based at the community level (133) and the average group meets 1.3 times per month. Thirty five farmers (18%) say their group works collectively. For some this means simply exchanging ideas and problem solving together, for others it means caring for dairy goats together as a community.

When farmers are asked where they get information about dairy goat keeping 58% say the Participatory Agriculture Development and Empowerment Project (PADEP) and 15% say the Agricultural Services Support Programme (ASSP). These projects helped 93% of the farmers receive a dairy goat. When asked *what kind* of support projects provided, 104 farmers (54%) say

the project simply gave them a goat. See *Appendix 9* for more information about the projects supporting dairy goat farmers. Other sources of knowledge include, extension agents 73 (38%), personal experiences 18 (9%) and veterinarians 14 (7%).

Only seven farmers (4%) paid for their dairy goats, they paid differing amounts depending on whether or not a project subsidized the sale. Fifty five farmers (28%) say that projects offered them some kind of training or knowledge about dairy goat keeping. The extent of this knowledge varied widely and affected the dairy goat husbandry practices substantially. Seventeen farmers were given money as support, and nine of these were given money specifically for building raised goat barns. Most of the others specified that the money was used to buy dairy goats. An additional eight farmers were given feed or treatment as support. Fifteen farmers (8%) are self-supported. Many self-supported farmers bought dairy goats from friends and neighbours. Others were given a dairy goat by a family member. Only eleven farmers say they were offered no outside support.

Discussion

Challenges of dairy goat keeping in Zanzibar

Lack of record keeping

Milk production increases with record keeping according to our study. This indicates the importance of record keeping, not only to increasing milk production but to improving overall management. Keeping track of important dairy goat information helps farmers to make informed decisions and see how improving husbandry practices can help them deal with other challenges. Illiterate farmers are at a disadvantage. It is more difficult for them to keep records or access information. 15% of dairy goat farmers have no formal education. Education and literacy should be prioritized in future dairy goat projects because they not only improve record keeping and dairy goat production, they also help farmers and offer sustainable and empowering benefits.

Crossbreeding

Incorporating local traits increases disease resistance, decreasing mortalities (Juma & Pica-Ciamarra, 2013). Many of the dairy goats in Zanzibar came from Mgeta, part of the Tanzanian mainland. These goats, both Norwegian and Saanen came from Norway originally. Many have been crossed with local goats but no records or background information was given to the farmers in Zanzibar. Uncontrolled crossbreeding is an important challenge in any future breeding program.

Since 67% of the farmers interviewed had one or more dairy goat die in the past year, crossing local goats with pure dairy goats could be a strategy to improve survival as well as milk production. Some crossbreeds are very productive. In Kenya, crosses between local and indigenous goats produced 1.5 to 3 L of milk per goat per day (Bekele & Akumu, 2009). In Zanzibar production is much lower, just 0.92 L per goat per day. When dairy goats were crossed with local goats in Zanzibar, farmers experience low milk production. 41% of farmers with crossbred goats do not milk their goats compared to 27% for farmers with purebred goats in Zanzibar. Not milking is usually due to low milk production. Some interviewers did not specify whether crosses were between dairy goats or a dairy goat with a local breed. This makes it difficult to draw strong conclusions about the effect crossing with local goats has on milk production. More research on crossbreeding goats in Zanzibar is necessary.

Milk production is influenced by a variety of different factors. Many farmers in this study think poor dairy goat breeds are the main reason for low milk production. Although crossbred goats produce less milk on average, 0.50 L for crossbred and 0.64 L for purebred, the difference is not significant. Other factors have a much greater influence on milk production, for example record keeping and the feeding system.

Disease pressure

Dairy goat farmer's in Zanzibar report disease as the most important challenge they face. The inaccessibility of animal healthcare is the fourth most important challenge farmers' mention. This is not surprising, considering that 67% of the farmers experienced at least one dairy goat mortality in the past year. The high mortality rates reveal a great need for support in terms of information and training for farmers, agricultural extension agents, veterinary doctors, technicians and CAHWs.

Poor feeding practices

In order for dairy goats to meet their genetic potential it is essential for goats to be adequately nourished. During the dry season and the lactation period in particular, supplemental feeds are an important source of nutrients that can greatly increase milk production. Currently, 40% of the dairy goat farmers do not provide any supplemental feed and most do not give feed at the recommended rates.

Low utilization of supplemental feeds means that forage is the most important source of nutrients for growth and milk production of dairy goats. High quality fodders, especially those with high digestibility and crude protein, are essential to improving dairy goat health and milk production. Many farmers with land accessible to them grow fodder, 88% grow elephant grass for use during the seasonal drought. Growing fodder does not significantly increase milk production.

Many farmers find quality dairy goat forages on easily accessible communal lands. Goats are browsers, meaning they prefer to eat trees and shrubs as opposed to grasses. Trees and shrubs are widespread in Zanzibar, especially in coral rag areas. Coral rag areas are predominant near the coast, some plants can thrive in these thin soils that are generally unproductive. Many are drought tolerant trees and shrubs that have the potential to improve dairy goat health and milk production, especially during dry periods (Salem & Smith, 2008). See *Appendix 10* for more

information about the potential of multipurpose and drought tolerant indigenous trees and shrubs as feed for dairy goats in Zanzibar.

According to our study, feeding system and milk production are correlated. Intensive or semi-intensive management systems help farmers increase their self-sufficiency using home grown feed and labour (Peacock & Sherman, 2010). Dairy goats raised in intensive or semi-intensive systems produce more milk than those raised in free grazing systems with a mean difference of 0.67 L. Many farmers using extensive grazing systems do not supplement their goat's diet. The difference in milk yield would likely disappear if farmers started to provide adequate forage and supplementation.

Milk production is not as profitable as selling live animals

In Zanzibar, there is no significant milk processing or value-addition of goat milk. Only three farmers in the survey do any value addition by producing yoghurt. The demand for value-added milk products is increasing, especially in Stone Town where it is used to treat peptic ulcers. For many farmers living far from Stone Town, it is difficult to sell the small quantity of milk produced.

The average time between births for a dairy goat in Zanzibar is 8 months. This shows that milk production is not a priority to farmers. Instead of dairy goats giving birth once a year and producing milk for the rest of the year, many dairy goats are giving birth twice a year. Currently, the market for selling dairy goats is extremely variable between 12 to 217 USD. The number of dairy goats in Zanzibar is increasing rapidly. Once the market becomes saturated, the price for goats will decrease. This will force farmers to focus on milk production. The average price per litre of goat milk is 0.87 USD. Markets for goat milk need to be established so dairy goat famers can sell the milk their dairy goats produce or learn to add value to this raw product. For a report about developing a milk processing unit in Zanzibar see *Appendix 11.*

Lack of information and feedback for farmers

One of the most important challenges farmers face, according to this study, is lack of knowledge and information. Farmers need to know the basics of animal nutrition, health and breeding in order to practice good husbandry. Although farmer field school (FFS) groups help to spread dairy goat husbandry knowledge, more support and new information is needed to confront day to day

challenges. Though a wide range of different dairy goat husbandry books and learning materials are available in paper form and online; most of them are not accessible to farmers or available in Swahili. For the dairy goat farmers in this study with no formal education (15%), it is essential to use means other than writing to make important information accessible.

When asked where they get information about dairy goat keeping 58% of farmers said PADEP and 29 (15%) said ASSP. Organizations like these funded projects helped 93% of the farmers receive a dairy goat. This study demonstrated that the projects initiating dairy goat keeping acted as an important source of information. 58% of the farmers surveyed say the project that provided them with a dairy goat was their main source of information. Projects supporting most dairy goat farmers are already finished, and the ASSP project will be completed in 2014. Support in terms of information will need to come from other sources, for example extension agents or veterinarians.

Benefits of dairy goat keeping in Zanzibar

Social Benefits

Home consumption of milk is a very important benefit for smallholders, on average 0.44 L of the milk farmers produce in Zanzibar is consumed at home, improving the health of the entire family (Peacock, 2008). A well-managed dairy goat in Zanzibar can produce 3 L of milk per day, more than the native zebu cattle which produce on average 2.13 L during the rainy season (Zanzibar Livestock Policy, 2009). Goats are browsers and can eat the shrubs and trees available even in the low quality coral rag areas.

Economic benefits

Selling live goats is currently the focus for most farmers in Zanzibar. Goat milk has the potential to provide consistent and significant economic benefits to farmers, as long as markets are accessible. Most farmers (82%) say they receive substantial economic benefits from dairy goat farming. Farmers use the money generated from the dairy goats to buy basic necessities, 11% specifically mentioned paying school fees as a benefit of dairy goat keeping. In this way, the economic benefits are sustainably improving the livelihood of dairy goat farmers.

Environmental benefits

The average dairy goat farmer has just 0.65 ha of land. Manure from dairy goats provide many environmental benefits, helping farmers to increase the soil fertility of their small farm. Already, 62% (120 farmers) use dairy goat manure to fertilize their farm land. Manure is valued by many farmers, it was the number one non-economic benefit of dairy goat keeping according to farmers. Keeping dairy goats is also a good way to utilize the trees and shrubs found in coral rag areas.

SWOT analysis for dairy goat husbandry in the Zanzibar

Table 2: SWOT analysis describing the key strengths, weaknesses, opportunities and threats of dairy goat farming in the humid tropics.

Strengths	**Weaknesses**
- Easy management: less time, feed, space - High birth rate - Manure for improving soil fertility - Local fodders, shrubs and trees are suitable for goats and accessible to farmers - Dairy goats and sheds are established - Interest and motivation to improve - Nutritional benefits goat milk households - Increased income - Many products to use or sell: live animals, milk, meat, manure - Employment - Farmer groups are established	- Crossing breeds and difficulty identifying - Poor quality breeding bucks - Low milk yields - Increased disease susceptibility - Supplemental feed is expensive - Treatment is expensive - Fodder shortages during dry season - Poor management practices - Lack of dairy goat husbandry education - Farmers already have many enterprises - Few have milk preservation methods - No milk processing - Theft - Little feedback to farmers
Opportunities	**Threats**
- Improving record keeping - Improved breeding bucks - Study tours and further education - Improving accessibility to microfinance - Goat milk value addition - Milk processing facilities - Growing milk markets - Tourist market - KATI interested in participating and improving support to farmers - Collaborative action and co-operative formation	- Poor community education on marketing microfinance or dairy goat management - Low quality bucks available - No community breeding plan - Increasing food imports in Zanzibar - Unreliable markets, inaccessible to individual dairy goat farmers - Little infrastructure or value-addition - Poor feedback and information transfer between farmers and government extension - Programme support is finished Few programmes followed-up with farmers - Organization of dairy goats and records at government and community levels - No statistics available to focus interventions

Suggested improvements

When asked if they have additional comments, 56% (109) of the dairy goat farmers want better quality, purebred dairy goats. This response is simplistic. Due to poor management, dairy goats cannot produce milk at their genetic potential. For improvements to be sustainable, it is important to implement projects that involve communities and use a holistic, participatory approach to improve management at the farming system level (De Jager, *et al*., 2001).

Sustainable dairy goat integration at the farming systems level

Improving record keeping

A positive correlation between milk production and record keeping suggests that records improve management. Information based on recall is an important source of error in this study. Increasing the use of records at the farming system level would increase the government's ability to develop effective support.

Keeping records could help farmers see the cost and benefits of improving their management practices. Helping them to justify making changes in management, such as buying supplemental feed because they see it improves their milk production. Promoting education on the importance of record keeping, and identifying simple, cost-effective and time-saving recording schemes are essential. It is important to link these recording schemes to markets so farmers can see a tangible benefit for keeping records (Wurzinger *et al*., 2011).

Improving feeding practices

If a farmer aims to raise dairy goats for milk production, it is essential to provide adequate nutrition to the goats. Supplemental feeds help to ensure that dairy goats have enough energy to produce milk. Most farmers who give their dairy goats supplemental feed give maize bran. Maize bran is expensive and mostly imported from mainland Tanzania, but can significantly increase the milk yield of dairy goats fed on forages alone. Providing opportunities for micro-finance or buying supplemental feed in bulk as a farmer group from the capital of Tanzania, will both increase the accessibility of supplemental feed for resource poor dairy goat farmers.

Msuka Mashariki, a Shehia in Pemba, is using a creative solution to help improve dairy goat feeding practices for farmers in the community. PADEP provided a rice mill and dairy goat farmers were able to buy the rice bran by-product at a very low price. Rice farmers in the village saved time and money by processing rice at the community mill and livestock keepers could use the bran as a local feed source to improve the health of their dairy goats. Utilizing local sources of supplemental feeds such as rice polish, copra and fish meal could increase the quality, affordability and decrease the environmental impacts; providing an example of improvement across all three spheres of sustainability.

Forages are an essential component of dairy goat diets in the humid tropics. Forages are not equal in terms of feed quality. Leguminous trees can be used as a protein source for dairy goats, providing another way for farmers to improve the nutrient intake and milk production of their dairy goats without purchasing as much expensive supplement feed (Silanikove et al., 2010). Providing resources to farmers so they know nutrients available in different fodders could help them to select high quality forages, improving dairy goat health and production.

Sustainable dairy goat integration at the community and governmental level

Improving breeding and records

Breeding programmes take time to establish and several generations of goats to see a result. Records on the buck's lineage, milk production of the buck's mother and sisters, are essential to know whether the buck will increase or decrease the milk production (Ojango *et al*., 2010). Developing a dairy goat breeding programme in Zanzibar will be impossible if records are not taken by farmers and government officials' alike (Bett *et al*., 2009). Record keeping needs to be improved at the community and government levels, where records are often out-of-date and inaccurate.

Governmental support and commitment to the breeding plan will decrease risk for smallholder farmers, and increase the projects sustainability by incorporating local genetics (Ojango *et al*., 2010). An appropriate breeding goat programme in Zanzibar should be supported by government and non-governmental organizations alongside research and international institutions, increasing

production potential and reducing the risk for small-scale farmers (Ojango *et al*., 2010). Plans are currently underway to establish a dairy goat herd and develop a breeding plan at KATI in Zanzibar.

Improving extension and veterinary services

Extension services can act as important links between the government and farmers, ensuring that information is spread and support is made available (Ahuya & Okeyo, 2002) Extension needs to be demand driven, used as a vehicle to transfer appropriate technologies and information. Individual visits to dairy goat farmers are needed to help troubleshoot problems and decrease the need for expensive veterinary services.

Many farmers in the humid tropics do not buy inputs needed to be successful dairy goat farmers. Extension agents could play a critical role in developing micro-finance and cost-sharing schemes. The provision of important services and information should be included as part of any future interventions, in order to improve the health of poor farmer's dairy goats (Bett *et al*., 2009). Helping farmers get supplement feed, medicine and other essential inputs would improve animal husbandry and the livelihoods of resource poor farmers in the humid tropics.

In Zanzibar, KATI needs to be at the frontline of innovation, encouraging appropriate integration of technology and information for dairy goat farmers. Increasing farmers' empowerment and participation could help extension agents increase their effectiveness through alternative methods, such as farmer field schools (FFS).

Veterinary services in East Africa are usually inaccessible to poor farmers (Heffernan & Misturelli, 2002). Not knowing the causes of illness and other important dairy goat health information was a common occurrence in Zanzibar. Although community animal health workers (CAHW) help to improve poor farmers' access to animal medicines (Milne-Price, 2011). This support is insufficient. Farmer and CAHW trainings need to increase alongside veterinary and extension support in order to improve sustainability of dairy goat production in the humid tropics (Bekele & Akumu, 2009).

Improving goat milk markets and processing

Milk is highly perishable, and often there is no consistent market for goat milk. It is easier and more flexible for farmers to focus on producing animals that can be sold later. Processing milk into

value-added products like yoghurt could increase the price and offer a more consistent market for goat milk. One way for the goat milk processing to benefit farmers efficiently is through a self-sufficient farmer co-operative.

As dairy goat projects are developing, it is important to keep the main objectives in mind. Considering who will benefit from different dairy goat projects is essential. For example, the consequence of developing a milk processing unit could be reducing or eliminating home consumption, taking away the nutritional benefits of goat milk from farmers' families. Although the increase in farmer's income could be used to fill this nutrient gap, it is important for farmers to have education about nutrition and the role of goat milk in their diets. It is also important for extension and policy makers to consider the pros and cons of different milk processing and marketing approaches.

In Zanzibar, half of the population (53.8 %) live below the basic needs poverty line (Fagerholm *et al*., 2011). If the purpose of a project is to provide goat milk products to the community and decrease malnutrition, it is important to make milk products that are affordable and accessible. If goat milk products are affordable, there is great potential for developing school feeding programmes and working co-operatively with small-scale processing units.

Zanzibar has a rapidly expanding tourist market and an increasing demand for value-added products like goat cheese and yoghurt. The tourist market could provide significant economic benefits for farmers. To make this possible, farmers need to organize and measures need to be taken to ensure that benefits are received by the farmers themselves. The focus should be on creating value-chains where farmers, tourists markets and the community all receive benefits from goat milk.

Improving information and feedback to farmers

Improving the education and participation of poor livestock keepers is the key to successful dairy goat keeping. Incorporating farming and animal husbandry principles into school curricula would further enhance the benefits of continuing education.

Participatory research could play an important role in improving dairy goat production. Providing clear feedback after the experiments completion, researchers, farmers and other key stakeholders could work hand in hand to put information to use to improve dairy goat's sustainability. Dairy goat research needs to consider the specific challenges facing smallholders. Both labour and risk must be addressed if innovations are meant to be adopted by smallholders. Focusing on outcomes instead of outputs is another important change that will bring about long-term improvements, increasing the effectiveness of dairy goat research (Wurzinger *et al*., 2011).

Many dairy goat husbandry changes farmers need to make are straightforward. The real limitation is the lack of knowledge. Hoof trimming is a great example of this. Observing the goats, it was clear farmers were not trimming their goats' hooves. One of the most important causes of lameness in goats is caused by not trimming their hooves (Mgasa & Arnbjerg, 1993). Hoof trimming requires no special equipment or training. The only missing component is education. Farmers just need to know how and why it is important.

Incorporating supplementary feeds is another example of a simple and effective change. Adding 20% cotton seed meal, fish meal or other high-protein feeds together with maize bran would increase milk production substantially compared to feeding maize bran alone. In Zanzibar, where 40% do not give supplemental feeds, increasing the use of maize bran would greatly increase milk production. For every 1 kg of concentrate dairy goats produce about 2.5 kg of milk which is worth 2.16 USD on average in Zanzibar. Considering that 1 kg of maize bran costs around 0.22 USD per kg (cost based on information from a livestock extension agent in Zanzibar). The profit is then 1.94 USD, making supplement feeding very worthwhile from an economic perspective. Improving dairy goat nutrition improves health at the same time, decreasing mortalities and increasing benefits for small-scale farmers.

An informational pamphlet was created to provide dairy goat farmers with both the study findings and some basic dairy goat husbandry information, see *Appendix 12.* Making knowledge and feedback from research accessible to dairy goat farmers is essential to improving dairy goat husbandry throughout the humid tropics. See *Appendix 13* for more reflection on the significance and last effects of research.

Uncontrolled variables

Acknowledging sources of error is important in order to accurately discuss results and draw appropriate conclusions. Uncontrolled variables help uncover a more accurate picture of the farming systems, improving the description of the animal husbandry practices given in the results section. Four of the most important sources of error for this study are:

1. The *lists of dairy goat farmers* in each Shehia was not always accurate or up-to-date. It was necessary to speak directly with the DPO to make sure that the number of dairy goat farmers was current. Unforeseen circumstances like farmers with dead, sold and stolen dairy goats were confronted in most Shehias. In order to collect relevant animal husbandry information, only farmers who lost their dairy goat within the past year were interviewed.

2. *Interviewing techniques* and the information collected varied depending on both the interviewee and the interviewers. Eleven interviewers from KATI and MLF conducted the interviews. Power relations and respect for government officials probably influenced the farmer's response in some cases.

3. Many *social dimensions* of the farming system were not captured by this study. Questions about the household dynamic and the other social and political factors were not addressed, although they do present important challenges and benefits that directly impact farmer decisions and dairy goat husbandry.

4. 49% of farmers kept *no records*, thus much of the information was based on recall. This together with a general lack of information about animal husbandry decreased the quality of especially the quantitative data.

Conclusions

Dairy goat husbandry could be greatly improved in many parts of the humid tropics. After considering the dairy goat husbandry practices in Zanzibar, it is clear that farmers face important challenges, both external (drought, lack of healthcare) and internal (lack of records and funds) throughout the humid tropics.

Important challenges for dairy goat farmers include lack of records, crossbreeding, disease pressure, poor feeding practices, few accessible milk markets, and lack of information. Dairy goats benefit farmers by providing a time and resource efficient source of protein for many small-scale farmers who benefit both nutritionally and financially. Understanding key benefits and challenges for dairy goat farmers helps to inform the development of interventions that will sustainably improve the livelihood of farmers in the humid tropics.

To improve animal husbandry practices people at the community, government and farming system levels need to work together to create appropriate solutions. At the farming system level, dairy goat farmers need to keep records, utilize supplement feeds and high quality fodder species. Developing an effective breeding plan, providing relevant and accessible veterinary and extension services and improving the dairy goat husbandry information and feedback to farmers is essential at the government and community level.

Without information and support to face challenges, benefits for small-scale farmers cannot be fully realized. Dairy goats have the potential to improve the livelihood of small-scale dairy goat farmers across the humid tropics. Providing appropriate and accessible education on dairy goat husbandry will help to empower farmers, improving their livelihood, now and into the future.

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Appendix 1: Acronyms and Abbreviations

ASSP	Agricultural Services Support Programme
ASDP-L	Agricultural Sector Development Programme – Livestock
CAHWs	Community Animal Health Workers
DPO	District Livestock Officer
EPINAV	Enhancing Pro-Poor Innovation and Value Addition
FFS	Farmer Field School
HPI	Heifer International
IFAD	International Fund for Agricultural Development
KATI	Kizimbani Agricultural Training Institute
NGO	Non-Governmental Organization
MLF	Ministry for Livestock and Fisheries
PADEP	Participatory Agriculture Development and Empowerment Project
SUA	Sokoine University of Agriculture
SWOT	Strengths, Weaknesses, Opportunities, Threats
TASAF	Tanzania Social Action Fund
Tsh	Tanzanian Shillings (1617 Tsh = 1 USD)
NMBU	Norwegian University of Life Sciences
USD	US Dollar
WHO	World Health Organization

Appendix 2: Research Framework

Sustainability

One of the objectives of this study was to increase the *sustainable* integration of dairy goats onto small-scale farming systems. In order to achieve this objectives, it is important to understand what sustainability is and how it is applied in the context of this study. According to a Report of the World Commission on Environment and Development, sustainability is our ability to meet present needs without neglecting the needs of future generations (Brundtland, 1987). Sustainability can be broken down into three main spheres; environmental, social and economic. All three spheres are essential to true sustainable development. This is especially true at the farming system level where dairy goat husbandry is connected to and affected by many other farming activities.

Environmental sustainability is focused on conserving natural resources and includes a wide array of concerns that are connected to dairy goat keeping. Biodiversity and genetic conservation, soil and water management and even animal and human health are important to environmental sustainability (Peacock & Sherman, 2010). Since farming systems are based on the utilization of natural resources, there are many agroecological indicators and approaches to sustainable assessment. Milk production does not only involve food provisioning, it effects land management, carbon sequestration, water utilization and retention, and other ecological properties, functions and capacities that produce environmental processes effecting sustainability both positively and negatively (van Oudenhoven, 2012). Farming activities need to be environmentally sustainable within the system and externally, both are essential if the system is going to continue indefinitely into the future (Mollenhurst *et al.*, 2006). Environmental sustainability is more than looking at the inputs and outputs of the system, it is important to look at the life cycle and the cause and effect relationships between various environmental components (Lebacq & Baret, 2013).

Social sustainability is vital to the continued operation of all farming systems, but it is nearly impossible to measure quantitatively (Lebacq & Baret, 2013). Social sustainability is important on the farming system, community and society levels. At the farming system level, education, working conditions and quality of life are some of the important concerns (Lebacq & Baret, 2013). At the society level, there are increasingly strong social demands for environmentally sustainable

livestock keeping, control of diseases, improved animal welfare and decreased land degradation within intensified livestock systems (Mollenhurst *et al*., 2006). It is important to use a participatory approach and qualitative methods to increase social sustainability (de Jager, 2001).

Economic sustainability is not focused solely on monetary inputs to a farming system. Although capital is an important concern for many poor farmers, the focus is on prosperity which links the economic sphere very closely to the social sphere. There are three main objectives which help to increase economic sustainability; autonomy, diversification of income and markets and durability overtime (Lebacq & Baret, 2013).

Tradeoffs between the spheres of sustainability means that farmers face many difficult decisions. Farmers need to see how these spheres interact in order for them to make more informed choices that improve the sustainability of their farming system as a whole. Participatory research and feedback can help to improve the overall sustainability of farming systems through education and awareness (de Jager, 2001). A cost benefit analysis could also help farmers to achieve sustainability using an ecosystem services approach (de Groot et al., 2010). This approach is helpful on the policy making level, but it is nearly impossible to quantify well-being and quality of life, which emphasizes qualitative finding as an important part of this study.

Agroecosystem Analysis

In order for dairy goat production to remain sustainable, it is important to use a holistic approach. The lens of agroecology uses “an environmentally and socially sensitive approach to agriculture” (Hecht, 1995). The size of Zanzibar and increasing population pressure, makes considering the ecology of food systems (Francis, *et al.*, 2003) essential if dairy goat production is going to be beneficial; to the farmer, the environment and the community at large.

Agroecology is a theory, a practice and a social movement (Wezel, *et al.*, 2009) grounded in science but aiming to provide ecologically based assessments of food systems. “It is a complex science, one that links the ecological, economic, social, ethical, and legal aspects of food production. All spatial scales are considered, from farm to global and systems approaches are

emphasized" (Sims *et al*., 2004). An agroecological approach was utilized to help develop a holistic and sustainability focused questionnaire.

Systems Thinking

Farms do not operate in a vacuum. For this reason alone, systems thinking is essential in order to understand the situation of dairy goat farmers in a particular area. Systems are made up of complex and dynamic interconnections (Bawden, 2002). Many dairy goats in small-scale farming systems are fed using vegetable by-products. The vegetable garden, in turn, is enhanced using the dairy goat manure. This may seem like a simple interaction, but there are many factors that could change the outcome. Some farmers, chose to sell the manure for the economic gain. In this case, the farmer choses to favor economic gain over the environment gain goat manure can provide. The inherit complexity of farming systems makes it impossible to understand the role of dairy goats without looking at the system from multiple vantage points; social, economic and environmental. These vantage points will help extension to provide appropriate and efficient support.

Dairy goats play an important role in tropical farming systems. Exotic animals like the dairy goat are significantly more labour intensive than their local counterparts. All animals need consistent sources of food, water and shelter. However, local goats can easily be kept in extensive, open grazing systems. This is not usually practiced for dairy goats because of their increased susceptibility to many tropical diseases. Such factors make dairy goat keeping a time and resource intensive farming enterprise. System thinking increases understanding of the current situation by applying theory (systems thinking) to the real situation (Bawden, 2002). Looking at the challenges and benefits of dairy goat keeping from a systems perspective helped create a future wanted situation that aims to improve the farming system and enhance benefits for all.

Appendix 3: Zanzibar Background Information

Zanzibar: Agronomy and Cultural Aspects

Zanzibar is a tropical island located 30 km north-east of Dar es Salaam, the capital of Tanzania. It has an annual temperature of 25° Celsius (Fagerholm & Kayko, 2009). Zanzibar has a long history of spice, slave trading and food insecurity (Walsh, 2009). Zanzibar has a wide range of different natural ecosystems; indigenous scrub and forest, settlement, cultivation and fruit tree plantations (Fagerholm et al., 2011). Zanzibar is made up of two main islands, Unguja and Pemba. The total population is around 1.3 million (NBS, 2011) with an annual growth rate of 3.1 percent (Fagerholm & Kayko, 2009).

Zanzibar enacts its own natural resource management laws (Wily, 2003). The National Land Use Plan promotes the use of coral lands for small ruminants (ZALWEDA *et al.*, 2009) but there is no land policy (Wily, 2003). Zanzibar has a very high population density, 400 people per square kilometer. Education levels are low and 40 percent of the population is illiterate. Life expectancy is also low at 48 years (Jayaweera, 2010). 50% of the food in Zanzibar is imported (Bie, 2013) and tourism makes up 35 percent of the GDP (Makame & Boon, 2008). Population growth alongside a booming tourist industry accelerates land and natural resource degradation.

Approximately half the population (53.8 %) live below the basic needs poverty line (Fagerholm *et al*., 2012), mostly in rural areas (ZALWEDA *et al.*, 2009). 49 percent of the poor, especially women and children, have high micronutrient deficiencies (Boetekees & Immink, 2009). Nutrient gaps include most micronutrients (vitamin A, folate, calcium, iron, zinc) and low protein (Haenlein, 2004). Poor access to social services combined with little education on health and nutrition increases malnutrition (Boetekees & Immink, 2009).

Zanzibar's Livestock Development and Dairy Production

The livestock sector in Zanzibar is dominated by small-holders. There were 100,000 small-holder households in 2003 (Milne-Price, 2011). Thirty-five percent of households keep large or small ruminants, equine or pigs, and over 50 percent keep chickens (Juma & Pica-Ciamarra, 2013). 26 percent (69,000) of the livestock keepers in Zanzibar have goats. The average herd is made up of 6 goats (Juma & Pica-Ciamarra, 2013). Dairy cows and goats in Zanzibar are typically kept in

intensive or semi-intensive systems, living in stables so that crop production can be done on the little land farmers have (Milne-Price, 2011). Many small-scale farmers in Zanzibar are caught in a cycle of poverty because the prices for produce and meat is too low (Milne-Price, 2011). This means that farmers are often unable to buy feed and supplement the diets of their goats.

Dairy products can be sold at a much higher price and can provide a substantial income for subsistent farmers. In the tropics, goats produce 2.8 to 7.1 kg milk per kg live weight, as opposed to cattle which produce 2.4 to 3.4 (Knights & Garcia, 1996). Goats use feed and water more efficiently, making them the ideal choice for small-scale producers (Knights & Garcia, 1996). A productive dairy goat breed in the tropics can produce more milk than the native zebu cattle which produces on average 2.13 L during rainy season (ZALWEDA *et al.*, 2009).

In Zanzibar's dairy sector, 45,000 cows are milked and 96 percent are indigenous. In the dry season, prices go up and milk production decreases to 84,385 L compared to 111,616 L during the wet season (Juma & Pica-Ciamarra, 2013). The current market does not meet the demand for dairy in Zanzibar at any time during the year (Milne-Price, 2011). Even in 1994, milk production in Zanzibar was 17 million litres per year while the demand was 25 million litres (Msangama & Suleiman, 1995). According to Africa Livestock Data, less than 900 goats were being milked in 2012 (Juma & Pica-Ciamarra, 2013). Specialized smallholder dairies give a significant economic contribution to rural and peri-urban areas and have the potential for further growth (ZALWEDA *et al.,* 2009)

To help fill the gap in milk production, twenty-two farmer field schools (FFSs) focused on dairy cows have started to empower farmers and improve management (Zerfu & Kebede, 2013).

Kizimbani Agricultural Training Institute

Kizimbani Agricultural Training Institute (KATI) is a part of Zanzibar's Ministry of Agriculture, Livestock and Environment. The purpose of KATI was originally to fill the gap and train agricultural extension officers and farmers in order for them to give better technical advice and information to farming communities. In 2007, KATI was given more functions as a research base and it also started commercial activities in order to become more self-sustainable.

KATI offers a two year general agricultural course on the principles of crop production and animal husbandry, in order to fulfill its vision which is to offer relevant demand-driven training in these areas. With 70 percent of the population either directly or indirectly connected to agricultural production, there is a strong and growing need for effective agricultural extension. No exact figure is available but it is estimated that Zanzibar is short 1200 agricultural extension agents (Bie, 2013). About 100 students per year are trained in certificate courses. KATI hopes to establish a diploma course in various agricultural disciplines so that students do not have to get all of their education and training on the mainland of Tanzania (MANR Zanzibar, 2010).

KATI is a new partner in the Enhancing Pro-poor Innovations in Natural Resources and Agricultural Value-chains (EPINAV) project. This project is a collaboration between the Norwegian University of Life Sciences and Sokoine Agricultural University. KATI is increasing their dairy goat herd. They plan to have 30 Norwegian dairy goats and a milk processing facility on site. The processing facility will make fresh milk into yoghurt or cheese. It will also follow rigorous food safety requirements. The value-added products produced can then be sold in the rapidly expanding tourist market. Alongside the dairy goat herd expansion, other projects may also emerge. Linking the animal production with vegetable gardens and other initiatives or markets will increase the overall sustainability of this project.

Appendix 4: Dairy Goat Questionnaire in English

Dairy Goat Survey

Hello! My name is Tiffanie Stone. I am a master's student in Agroecology coming from the Norwegian University of Life Sciences. I came to study dairy goats and their role in farming systems in Zanzibar.

The main objectives of this study are:

1. To determine the current animal husbandry practices and the dairy goat product utilization.
2. To find out what the benefits and challenges of raising dairy goats in Zanzibar are.
3. To discover what projects, interventions, or support would be helpful in the future.

I will write a report about my finding as part of my thesis. I will send out a summary of the results upon completion of the project. This project does not come with any funding or with any promise of future funding. I will compile the data and give recommendations that could be used for future decision-making. Thank you for taking the time to complete this survey. Ahsante sana!

District: _____

Shehia: _____

Section A: Profile of Respondents

1. **Sex** : 1 . Male 2. Female
2. **Marital status** : 1. Married 2. Single 3. Widow/ Widower
3. **Age** : _____ 1. 1-19 2. 20-29 3. 30-39 4. 40-49 5. 50-59 6. 60-69 7. 70-79 8. 80-89
4. **Number of children** : _____
5. **Highest level of education for adults** : _____
6. **Experience in goat keeping** : _____ (number of years)
7. **Experience in dairy goat keeping** : _____ (number of years)
8. **Why did you choose to keep dairy goats?**
9. **How many acres of land do you have in production?** :

Total: _____ Land owned (acre): _____ Land leased (acre): _____ Land borrowed (acre): _____

10. **How much of the land you use is family land?** : ____
11. **Is there a communal land in your village?** : 1. Ndiyo 2. Hapana
12. **If yes, what are the purposes of this communal land?** :
13. **Besides farming, what other sources of income does your household have?** :

Section B: Number and Breed of Dairy Goats

14. What dairy goat breeds do you have? : (Please make sure to include every dairy goat)

	Norwegian:	Toggenburg:	Saanen:	Other:_____
Breeding Bucks				
Does				
Weaned Males				
Weaned Females				
Kids				

15. How many other livestock species do you keep? :

1. Cattle: _____ 2. Indigenous goats: _____ 3. Sheep: _____ 4. Other:_____

16. Do you keep records on your dairy goats? 1. Yes 2. No

17. If yes, **what kind of records do you keep on your dairy goats?** :

18. Why do you keep records? :

19. If you do not keep records, why?

20. How many of your dairy goats are currently milking? : _____

21. Where do you get information about how to take care of your dairy goats? :

22. Can you describe the structures you use to keep your dairy goats? :

Section C: Feeding and Inputs

23. Do you grow your own fodder? 1. Yes 2. No

24. If yes, **what kind of fodder do you grow for your dairy goats?** :

25. **Why do you grow your own fodder?** :

26. If no, **why do you not grow fodder?**

27. **Under what conditions would it be possible for you to grow your own fodder**? :

28. **How do you feed your dairy goats?** :
    1. Cut and Carry
    2. Grazing
    3. Both
29. **What are the most common forages** (leaves or grasses) **eaten by the dairy goats?** :

30. **How many times per day do you feed your dairy goats forage?** : _____
31. **About how much forage do you give your dairy goats per day?** : _____ (kg)
32. **What do you use as a supplemental feed?** :

33. **How often do you give your goats supplemental feed? :_____**
34. **How much supplemental feed do you give per goat feeding? :_____** (kg)
35. **Do you have access to clean and adequate quantities of water throughout the year?** : 1. Yes

    2. No
36. If no, **what alternative do you use to get enough clean and safe water?**

Section D: Reproduction

37. **How often are your dairy goats in heat?** :

_____

38. **For how long are they in heat?** :

_____

39. **What is the average age of your dairy goats at first mating?** : _____
40. **What is the average age of your dairy goats at first kidding?** : _____
41. **Are dairy goat bucks accessible to you?** : 1. Yes 2. No

If **Yes, How?** : _____ If **No, How do you service your goats?** :

42. **What buck breeds are available to you?** :

43. **What is your average kidding interval?** :

44. **How many kids do your goats have on average?** : 1. Singles 2. Twins 3. Triplets
45. **How many pregnancies ended with abortion?** : _____
46. **Could you describe the reasons why?** :

Section E: Health

47. **How many of your dairy goats have died in the last year?** : _____
48. **What are the major causes of mortality?** :

49. **How do you establish the cause of death for your dairy goats?** :

    1. Assisted by a veterinarian
    2. Assisted by extension officer
    3. By sending samples to lab
    4. Previous experience
    5. Other (please specify) _____

50. **Do you have access to a veterinarian or other dairy goat health advisors?** :
    1. **Yes**: Vet 2. **Yes**: Health Advisors 3. **No**
51. **What diseases do you treat your dairy goats for?** :

52. **Do you have access to medicine?** : 1. Yes 2. No
53. **Do you have access vaccines?** : 1. Yes 2. No

54. **What disease problems have you had in the past?** :

55. **Where do you get medicine for your dairy goats?** :

Section F: Milk Production

56. **What is the average milk production per goat per day?** : _____
57. **For how long does each goat produce milk on average?** : _____
58. **What is your average household milk consumption?** : _____
59. **How much milk per goat per day you get in the dry season compared to the rainy season?** :

    1. Dry Season : _____ 2. Rainy Season : _____

60. **How would you describe the demand for goat milk in your community?** :

61. **Do you have a way to store milk?** :

62. **How do you process milk?** :

Section G: Benefits, Challenges and Markets

63. **What kind of benefits do you receive from keeping goats?** :

64. **What kind of challenges do you face because of keeping dairy goats?** :

65. **How do these challenges vary over the season?** :

66. **How have you addressed your challenges?** :

67. **What kind of knowledge would help you confront these challenges?** :

68. **What kind of services would help you confront these challenges?** :

69. **What are the main activities for caring for the dairy goats in the dry season?** :

70. **What are the main activities for caring for the dairy goats in the rainy season?** :

71. **How much time does your family spend taking care of your goats each day?** : _____ (hours)
72. **How much time does your family spend taking care of your goats each day in the dry season?** : _____ (hours) and **In the wet season?** : _____ (hours)
73. **How much time is used for milking each day?** : _____ (hours)
74. **How do the members of your family split the tasks of taking care of the goats?** :

75. **Which member of the family spends the most time taking care of the goats?** :

1. Husband 2. Wife 3. Children

76. **Do others help you work with your dairy goats?** :

77. **What dairy goat products do you use at home?** (Milk, meat, animals, other) :

78. **Where do you sell you dairy goat products?**

Milk:

Meat:

Animals:

Other:

79. **How much of the income from your dairy goat products are taken by a middle man?**

80. **How do you get to the market?** :

81. **Do you hope to expand and keep more dairy goats? Why or why not?** :

82. **What value do goats provide, regardless of income?** :

83. **Do you receive an economic benefit from keeping dairy goats?** : 1. Yes 2. No

84. If you receive a benefit, **how significant is this benefit?** :

Section H: Vegetable Production

85. **Do you grow vegetables?** 1. Yes 2. No

If none, skip question **71. – 77.**

86. **How much of the land you farm is used for vegetable production?** : _____
87. **What kind of vegetables do you grow?** :

88. **What kind of vegetable leftovers do you feed your dairy goats?** :

89. **Where do you sell your vegetables?** :

90. **What kinds of vegetables do you use for home consumption?** :

91. **Which vegetables get the best price in the market?** :

92. **Do you use goat manure to fertilize plants?** : 1. **Yes** 2. **No**
93. **If you use the manure, how do you collect the manure?** :

94. **What crops are grown on the manure fertilized fields?** :

Section I: Biogas Energy

95. **What energy sources do you use for cooking?** :

96. **What would be the benefits of establishing a small methane digester on your farm using manure?**:

97. What would be the disadvantages of establishing a small methane digester on your farm using manure? :

98. What information would need to be accessible in order for you to start producing biogas? :

99. What resources would need to be accessible in order for you to start producing biogas? :

Section J: Social Aspects and Information

100. How did you get your dairy goats? :

101. What kind of support did you receive when you started dairy goat farming? :

102. What kind of support, if any, do you think would have been helpful? :

103. How many of your neighbours keep dairy goats? : _____

104. Are you part of a farmer field school focused on dairy goat? : 1. Yes 2. No

105. Are you part of a farmer group focused on dairy goat? : 1. Yes 2. No

106. Are you part of an association focused on dairy goat? : 1. Yes 2. No

If no, **skip question 107. – 116.**

107. What is the name of the group? : _____

108. What is the purpose of the group? :

109. Why did you join? :

110. When did you join? : _____

111. Who are the members? :

112. Where is the group based?

1. Village or Community
2. District

3. Regional
4. National
5. Multi-national

113. How often does the group meet? : _____

114. What are the main activities of the group? :

115. Do you organize collective actions in your group? : 1. Yes 2. No

116. If Yes, **What are these collective actions?** :

117. Do you have any additional comments?

Thank you for your time and for sharing your ideas. Ahsante Sana!

Interviewer observations and additional information:

Appendix 5: Dairy Goat Questionnaire in Swahili

Mbuzi wa Maziwa Dodoso

Jambo, jina langu ni Tiffanie Stone. Mimi ni mwanafunzi wa Shahada yapili kwenyefani ya kilimo mazingira natoka Chuo Kikuu cha Norwegian cha sayansi ya maisha. Nilikuja kujifunza mbuzi wa maziwa na kazi zake kwenye mfumo wa kilimo hapa Zanzibar.

Malengo makuu ya mefunzoiui:

4. Kuchunguza shughuliza ufugaji mbuzi wa vitendo na kileo pamoja na utamiaji wa bidhaa zinazo zalishwa na mbuzi wa maziwa.
5. Kutafuta mafanikio nachangamoto zilizoko Zanzibar kwneye ufugaji wa mbuzi wa maziwa
6. Kugundua miradi sahihi inayoweza kupatikauwa, au kupata ufadhili ambao utasaidia lewa baadae.

Nitaandika ripoti kuhusiana na tafiti zangu kama ni sehemu ya tafiti hiyo. Ntawasilisha ufupisho wa matokeo ya utafiti baada ya kukamilisha mradi. Mradi huu hauji na fedha au ahadi zozote za kifedha. Kwa baadae, nitakusanya taarifa zangu na kutoa ushauri ambao utatumika. Kusaidia maamuzi ya baadae. Ahsante.

Jina la Mhojiwa : _____

Wilaya : _____

Shehia : _____

Sehemu A: Maelezo ya Wahojiwa

1. **Jinsia** : 1 . Mwanaume 2. Mwanamke
2. **Hali ya ndoa** : 1. Umeolewa/Umeowa 2. Hujaowa/Hujaolewa 3. Mjane/Kufiliwa
3. **Miaka** : 1. 1-19 2. 20-29 3. 30-39 4. 40-49 5. 50-59 6. 60-69 7. 70-79 8. 80-89
4. **Idadi ya watoto** : _____
5. **Kiwango chako cha juu cha elimu** :

   _____
6. **Ujuzi katika ufugaji wa mbuzi** : _____ (idadi ya miaka)
7. **Ujuzi katika ufugajiwa mbuzi wa maziwa** :_____ (idadi ya miaka)
8. **Kwa nini umechagua kufuga mbuzi wa maziwa?** :

9. **Una ekari ngapi za ardhi kwa ajili ya uzalishaji?** :

Jumla: _____ umilikiwa ardhi (ekari): _____ Ardhi ya kukodi (ekari): _____ Ardhi ya kuazimwa (ekari):____

10. **Kuna ekari ngapi zinazomilikiwa na kijiji? :** _____

11. Kuna ardhi ya kijiji katika kijiji hichi? : 1. Ndiyo 2. Hapana

12. Kama ndiyo, ardhi hiyo inatumika kwa ajili ya nini? :

13. Mbali na kilimo, kuna vyanzo gani vya mapato katika kaya yako? :

Sehemu B: Idadi na Makabila ya Mbuzi

14. Aina gani za makabila ya mbuzi wa maziwa unayo? : (Tafdhali taja idadi ya kila mbuzi wa maziwa)

	Norwegian:	Toggenburg:	Saanen:	Wengineo:_____
Dumewambuzi wa kupandishia				
Majike				
Dume walioachishwa				
Majike walioachishwa				
Watoto				

15. Una idadi gani ya mifugo mingine ambayo unayoifuga? :

1. N'gombe: _____ 2. Mbuzi wakiasili: _____ 3. Kondoo: _____ 4. Wengineo: _____

16. Je, unaweka aina yoyote ya kumbukumbu kwa ajili ya mbuzi wako wa maziwa? :

1. Ndiyo 2. Hapana

17. Kama ndiyo**, unaweka aina gani ya kumbukumbu kwa ajili ya mbuzi wako wa maziwa?** :

18. Kwanini unafanya unaweka kumbukumbu? :

19. Kama huweki kumbukumbu kwa nini hufanyi hivyo? :

20. Una mbuzi wangapi wanao kamaliwa kwa sasa? : _____

21. Wapi unapata taarifa kuhusu ufugaji na utunzaji wa mbuzi wa maziwa? :

22. Elezea ni mjengo gani utakao utumia kwa kutunzia mbuzi wako wa maziwa? :

Sehemu C: Malisho na Pembejeo

23. Unaotesha aina yoyote ya malisho? : 1. Ndiyo 2. Hapana

24. Kama ndiyo, **ni aina gani yamalisho unayoyaotesha kwa ajili ya mubuzi wa maziwa?** :

25. Kwanini unaotesha malisho hayo? :

26. Kama hapana, **kwa nini huoteshi malisho?** :

27. Ni katika mazingira gani inawezekana kuotesha malisho yako mwenyewe? :

28. Vipi unawalisha mbuzi wako wa maziwa? :

4. Unakata na kuwapelekea
5. Kutafuta chakula chao
6. Zote

29. Aina kuu ya majani yanayoliwa na mbuzi wa maziwa? :

30. Unawapatia majani mbuzi wako mara ngapi kwa siku? : _____

31. Kiwango gani cha majani wanayokula mbuzi wako kwa siku? : _____ (kg)

32. Ni aina gani ya chakula cha ziada unachowapatia mbuzi wa maziwa? :

33. Kwa marangapi katika wiki unawapatiwa mbuza wako chakula cha ziada?

:_____

34. Kiwango gani cha chakula cha ziada unachowapatia mubzi wako wa maziwa? :_____

(kg)

35. Je, unapata maji safi ya kutosha kwa mwaka mzima? : 1. Ndiyo 2. Hapana

36. Kama hapana, unafanyaje kwa kutunzaji wa mbuzi wako maziwa? :

Sehemu D: Uzazi

37. Ni mara ngapi mbuzi wako wanashurufu? :

_____

38. Kwa muda gani wanakuwa katika hali ya kushurufu? :

_____

39. Kwa wastani, unawapandishia mbuzi wako wa maziwa wakiwa na wastani wa umri gani : _____

40. Kwa wastani mbuzi wako wa maziwa alijifungua akiwana na umri gani kwa mara ya kwanza? : _____

41. Unaweza kumpata mbuzi dume kwa ajili ya kupandishia? : 1. Ndiyo 2. Hapana

Kama Ndiyo, **Kivipi?** : _____ Kama Sio, **Ni huduma gani utawapatia mbuzi wako?** :

42. Ni aina gani ya kabila la mbuzi dume ambayo ni rahisi kupatikana kwako wewe? :

43. Ni wastani,wa muda gani uzazi wa mbuzi unapishana? :

44. Kwa wastani, mbuzi huzaa watoto wangapi ? : 1. Moja 2. Mpacha 3. Utatu

45. Ni mara ngapi mimba zinaharibika? : _____

46. Unaweza kueleza kwanini inakuwa ivyo? :

Sehemu E: Afya

47. Ni mbuzi wangapi wa maziwa wamekufa mwaka jana? : _____

48. Ni chanzo gani kikuu kilichosababisha vifo hivyo? :

49. Vipi unaweza kujua sababu ya vifo kwa mbuzi wako wa maziwa? :

6. Ulisaidiwa na dactari wa mifugo
7. bwanashamba
8. Ulichukua sampuli na kuipeleka maabara
9. Ulipata ujuzi kipindi kilichopita
10. Au kuna njia nyenginezo:_____

50. Je, vipi kuhusu upatikanaji wa daktari wa mifugo au mshauri wa mambo ya afya wa mbuzi wa maziwa? :

1. **Ndiyo**: Daktari wa mifugo 2. **Ndiyo**: Wataalamu wa afya 3. **Hapana**

51. Una tibu magunjwa gani wa mbuzi wako wa maziwa? :

52. Je, huwa unahitaji madawa kwa kuwatibu mbuzi wako wa maziwa? : 1. Ndiyo 2. Hapana

53. Unawapatia dawa na chanjo mifugo yako (mbuzi wa maziwa)? : 1. Ndiyo 2. Hapana

54. Maradhi gani yaliyoathihiri mifugo yako katika kipinde kilicho pita? :

55. Wapi unapata madawa kwa ajili ya mbuzi wako wa maziwa? :

Sehemu F: Uzalishaji wa Maziwa

56. Ni wastani wa kiasi gani cha maziwa kwa mbuzi kwa siku? : _____

57. Kwa wastani, muda gani mbuzi huwa anatoa maziwa? : _____

58. Kwa wastani, ni lita ngapi za maziwa huwa zinatumika nyumbani? : _____

59. Ni kiasi gani cha maziwa kwa siku kwa mbuzi ambacho unakipata wakati wa msimu? :

2. Msimu wa ukiangazi : _____ 2. Msimu wa mvua : _____

60. Elezea mahitaji ya maziwa ya mbuzi katika jamii yako? :

61. Kuna njia gani ambazo unazozitumia katika kuhifadhi maziwa yako? :

62. Unatengeneza bidhaa za maziwa? :

Sehemu G: Faida, Changamoto na Masoko

63. Ni mafanikio ya aina gani unayapata kutokana na a mbuzi wa maziwa? :

64. Ni changamoto zipi kati ya hizo ulizozitaja hapo juu zinaleta changamoto kubwa zaidi? :

65. Kivipi chandamoto hizi zinatofautiana hutoka msimu mmoja kwenda mwengine? :

66. Vipi unaweza kukabiliana na changamoto hizo? :

67. Wapi unapata taluma wa kukabilina katika kutatua changamoto hizo? :

68. Wapi unapata huduma za kukabiliana na changamoto hizo? :

69. Ni shughuli zipi kuu zinazofanyika katika kuwatunza mbuzi wa maziwa wakati wa kiangazi? :

70. Ni shughuli zipi Kuu zinazofanyika katika kuwalea mbuzi wa maziwa wakati wa masika? :

71. Familia yako inatumia masaa mangapi kutunza mbuzi kwa siku? : _____ (ma saa)

72. Familia yako inatumia masaa mangapi kutunza mbuzi kwa siku wakati wa kiangazi? :

_____ (hours) na **wakati wa baridi?** : _____ (ma saa)

73. Masaa mangapi hutumika kukamua maziwa kwa siku? : _____ (ma saa)

74. Ni kwa namna gani wanafamilia wanagawana majukumu ya kazi katika kutunza mbuzi? :

75. Ni nani kati ya wanafamilia hutumia muda mwingi kwenye kutunza mbuzi? :

2. Mume 2. Mke 3. Watoto

76. Kuna watu wengine wowote wanaokusaidia kwenye ufugaji wa mbuzi? :

77. Ni bidhaa gani za maziwa ya mbuzi unayotumia nyumbani? :
(Maziwa, nyama, mengineyo)

78. Wapi unauza bizdha zako za mbuzi wa mbuzi? :

Maziwa:

Nyama:

Wanyama:

Zote:

79. Ni kiasi gani cha mapato yanayotokana na bidhaa zinazozalishwa na mbuzi wa maziwa anachokichukuwa mtu wa kati/mchuuzi? :

80. Unazifikishaje bidhaa zako sokoni? :

81. Una matarajio ya ya kuongeza idadi ya mbuzi wa maziwa? Kwanini ndiyo au kwanini hapana? :

82. Mbali na kipato, ni nini thamani ya mbuzi wa maziwa? :

83. Unapata mafanikio gani ya kiuchumi kutokana na ufugaji wa mbuzi wa maziwa?

1. Ndiyo 2. Hapana

84. Na kama yapo mafanikio, **ni kwa kiasi kipi au ni yepi ya zaidi?** :

Sehemu H: Uzalishajiwa Mbogamboga

85. Je, unalima mbogamboga? : 1. Ndiyo 2. Hapana

Kama hapana, unaacha dodoso 86. – 90.

86. Kama ndiyo, nikiasi gani cha ardhi hutumika kwa ajili ya uzalishaji wa mbogamboga? : _____

87. Aina gani za mbogamboga unazozalisha? :

88. Ni aina gani ya majani ya mbogamboga unayotumia kulisha mbuzi wako wa maziwa? :

89. Unauza wapi mboga zako? :

90. Ni aina gani za mboga unazotumia nyumbani kwa ajili ya matumizi (upikia)? :

91. Aina gani za mboga zinazouzwa kwa bei kubwa sokoni? :

92. Jee unaweka mbolea ya mbuzi katika mbogamboga? : 1. **Ndiyo** 2. **Hapana**

93. Kama unatumia, unaikusanya vipi hiyo mbolea? :

94. Ni katika konde zipi za mazao unatumia mbolea ya samadi ? :

Sehemu I: Nishati Biogas

95.Ni aina gani ya nishati unatumia kupikia? :

96.Ni manufaa gani utayapata kwa kuwa na mtambo wa biogas nyumbani kwako? :

97.Ni hasara zipi utazipata kwa kuanzisha mtambo wa biogas? :

98.Ni taarifa gani unazozihitaji ili kuweza kuwa na mtambo wa kuzalisha biogas? :

99.Ni rasilmali gani unazozihitaji ili kuweza kuwa na mtambo wa kuzalisha biogas? :

Sehemu J: Taarifa za Kijamii

100. Uliwapataje mbuzi wako wa maziwa? :

101. Ni msaada gani uliopata wakati wa kuanzisha mradi wa mbuzi wa maziwa? :

102. Taarifa gani za msaada unafikiria wewe zingekusaidia? :

103. Ni majirani wako wangapi wanafuga mbuzi wa maziwa? : _____

104. Je, wewe ni miongoni mwa wakulima wa shamba darasa juu ya ufugaji wa mbuzi wa maziwa? : 1. Ndiyo 2. Hapana

105. Je, wewe ni miongoni mwa wakulima mlioshirikishwa kwenye kikundi cha mbuzi wa maziwa? : 1. Ndiyo 2. Hapana

106. Je, wewe ni miongoni wa wakulima wa ushirika wa ufugaji wa mbuzi wa maziwa?

: 1. Ndiyo 2. Hapana

Kama hapana, **unaacha dodoso 107. – 116.**

107. Jina la kikundi linaitwaje? :

_____

108. Nini madhumuni ya kikundi? :

109. Kwanini umejiunga na kikundi? :

110. Lini umejiunga na kikundi? :

_____

111. Niwepi washiriki wa kikundi? :

112. Ni nini maskani ya kikundi? :

6. Kijiji au Jumuiya
7. Wiliya
8. Mkoa
9. Kitaifa
10. Kimataifa

113. Ni mara ngapi katika mwezi huwa kikundi kinakutana?

:_____

114. Ni zipi shughuli kuu za kikundi? :

115. Je,kuna shughuli za pamoja za kikundi? : 1. Ndiyo 2. Hapana

116. Kama ndiyo, **ni shughuli gani hizo?** :

117. Je, una mapendikezo yoyote ya ziada? :

Ahsante sana kwa kutunia muda wenu na kwa kubadilishana michango yenu. Ahsante Sana!

Yalio jitokeza wakati wa kudahili :

Appendix 6: Questionnaire Design, Translation and Testing

Questionnaire Development

The survey was then reviewed by the director of KATI, two Agroecology Professors at NMBU and three professors at SUA, the director of Extension and Rural Development and two Animal Science professors. After reviewing and revising according to the feedback, the survey was sent to the director of KATI and Mr. Adi Diwan at the Ministry of Livestock and Fisheries (MLF) for a final review.

After the survey was finalized, it was then translated into Swahili by two teachers at KATI, Salma Shehe and Vuai Vuai. The translated survey was reviewed by the director of KATI and several teachers at KATI to ensure that the original meanings of the questions were retained after translation. The Swahili version was also reviewed by the director of Extension and Rural Development at SUA. The two translators involved with the survey testing and all four translators for the survey in Unguja offered feedback in order to improve the question clarity and ensure that everyone was gathering the same information for each question.

Questionnaire Testing

The survey was tested on four farmers with two interviewers. The interviewers, teachers at KATI, were the same that helped to translate the survey into Swahili. Two of the interviewees were from the southern district, Muugoni and two were from the central district, Binguni. The translators interviewed two dairy goat farmers simultaneously and the time it took to complete each section was recorded.

The survey was given in Swahili and the responses were recorded in Swahili for the first two interviews. For the second two, responses were written in English when possible. It was more important to have complete information so if there was any doubt, the translator wrote the words in Swahili and we translated it together later on. The result was that the interview took about the same amount of time in both cases and the time translating the responses afterward was foregone when the responses were mostly in English. Another advantage was the data could be entered into the computer the same day or soon after. Otherwise, translation would have taken days or even a week to complete depending on the interviewing schedule. All schooling in Zanzibar and

Tanzania as a whole is given in English from secondary onward, translating to English was not a significant challenge for most of the interviewers in Unguja. In Pemba, this was a bigger challenge because the MLF employees who acted as interviewers had varying degrees of education and skills.

Filling out the 114 question survey took on average an hour and seven minutes. The survey was reviewed again and some of the questions were simplified or explained further to make it easier for the farmers and the four interviewers to understand. Two more questions were added to the survey after the central district was completed. These questions were about the forages fed to dairy goats, both when and what amount. This feeding information is vital to understanding dairy goat husbandry practices.

In Pemba, there was no separate questionnaire testing. Instead, the survey was reviewed with all the interviewers before they began interviewing. The experienced Unguja interviewer from KATI was able to assist in answering any questions and concerns. This increased understanding and minimized mistakes. When a new interviewer was introduced, the interview was observed so that any questions or obvious misunderstandings could be addressed as the interview was being conducted.

Questionnaire Methodology

This study used both quantitative and qualitative data in order to achieve the set objectives and to best utilize the agroecological framework. Together, the methods gathered a more holistic picture of the farming systems analysed. The qualitative approach looked not only at the questions being asked, but also, at how they could be asked in a way that is both straightforward and comfortable for the interviewee. “The qualitative research interview attempts to understand the world from the subjects’ points of view, to unfold the meaning of their experiences, to uncover their lived world prior to scientific explanations” (Kvale & Brinkmann, 2009). Quantitative research was utilized as an effective means to draw comparisons and figure out some of the relationships between different dairy goat management practices and other aspects of the farming system.

Eleven interviewers, four from Unguja and seven from Pemba conducted the interviews for this study. To ensure cooperation and involvement from both islands of Zanzibar, it was important to use local interviewers. One interviewer, a teacher at KATI took part in the interviews on both islands. This teacher was able to explain the survey and answer questions for the other interviewer from Pemba in advance, which helped to minimize error.

The dairy goat questionnaire is made up of ten sections. Section A, is basic information about the respondents such as age, number of children and years of experience with dairy goat keeping. Section B, focuses on the number and breeds of the dairy goats. Section C, is about feeding and other inputs such as supplemental feeds and water. Section D, focuses on reproduction and section E, is about dairy goat health. Section F, is focused on milk production and processing. Section G, delves into the benefits and challenges of dairy goat keeping. It also inquires about home consumption of dairy goat products and the markets used to sell these products. Section H and I, are about vegetable and biogas production respectively. Section J, is social information, particularly about what dairy goat groups the farmers are part of and what support they received. The survey concludes by asking for additional comments and concerns.

Appendix 7: Dairy Goat Farmer's General Information

51% (91 farmers) were female and 49% (87) were male, similar to the 2012 Census data (NBS, 2011). Out of 193 farmers interviewed, 154 (80 %) were married, 19 (10 %) were widowed and 20 (10 %) were single. The average age of dairy goat farmers was 40 to 49 years old.

The average number of children per household was 5.5, higher than the national census data which gives the average of 5.2 per household. One reason could be that farmers have more children than their city dwelling counterparts (NBS, 2011). Young children are also an incentive for keeping dairy goats. Besides the nutritional benefits of drinking the milk; 21 farmers (11%) specifically mentioned being able to pay for school fees as a benefit of dairy goat keeping.

The years of formal education among dairy goat farmers varied widely, the average being 7.5 years. Years of education is significantly correlated with record keeping. 64% of the farmers with a primary school education (0 to 7 years) did not keep records. For those with a secondary school education (8 to 11 years) 41% did not keep records.

The average years of goat experience was 6.1. The average years of dairy goat experience was 4.6 years. Many dairy goat farmers, started keeping goats for the first time when they received dairy goats. This makes training about general dairy goat husbandry practices an essential part of the dairy goat program. Trainings were essential to provide information about feeding, treatment, reproduction, management practices, and much more. Some farmers received no training and others only attended a two day seminars, with no hands-on practice or follow-up meetings. Farmer field schools (FFSs) helped to fill the gap. However, without proper facilitation or follow-up it was a major challenge for new dairy goat keepers to find the information they need to succeed.

Appendix 8: Common Dairy Goat Forages

Plant Names	Description
White-berry bush, Mkwamba	White-berry bush (*Flueggea virosa*) is a deciduous tree that is both heat and drought resistant. It is widely distributed in southern Africa and the bark is believed to provide treatment for diarrhea and pneumonia. This plant is very low maintenance and not well researched as a source of fodder (Ratshibvumo & Mutshinyalo, 2008).
Creeping guinea grass, Ukoka	Creeping guinea grass (*Panicum trichocladum*) is rhizomatous perennial native to East Africa. It is used a permanent pasture and can survive in shady conditions and dry seasons of up to 7 month. Creeping guinea grass is not tolerant to very heavy grazing. However, with crude protein at 17.5%, it is a high quality feed source that is readily eaten by all stocks. (Cook, et al., 2005).
Glaricidia, Mjenga ua	Gliricidia *(Gliricidia sepium)* is a leguminous tree best used as living fences, in alley farming and as part of cut and carry feeding systems. This tree is suitable in acidic and infertile soils that range in texture from sands to heavy clays. They are extremely drought tolerant and can tolerate repeated cutting. The leaves of gliricidia are nutrient rich containing 18-30% crude protein. Although there are some palatability problems, wilting leaves for 12-24 hours increases intake. Dairy cows have similar or even slightly higher milk yields when supplemental feeds were replaced with gliricidia. (Cook, et al., 2005).
Mdimu msitu	Mdimu msitu (*Suregada zanzibariensis*) is a deciduous shrub or small tree that prefers sandy. Traditionally, the pulped leaves are taken with water to cure diarrhea and expel worms. The leaves also show promise as a cure to malaria. The trees are widespread in southern Africa but not heavily exploited. No research about Mdimu msitus value as an animal fodder has been produced (Bosch, 2008).
Legume spp, Mkundekunde	Legumes (*Legume* spp.) are the third largest group of flowering plants (18,000 species) and are made up of three families; caesalpiniaceae, mimosaceae and fabaceae. Legumes are an important high quality forage because they are 2-3 times richer in protein than cereal grains. At least 75% of the shubs and trees in Africa serve as browse plants for ruminants and many of these are leguminous (Gutteridge & Shelton, 1994).
Elephant grass, Gugumua	Elephant grass (*Pennisetum purpureum*) is a robust perennial grass with an average height of 2-3.5 meters, it is ideally used as part of a cut and carry system. Spreading by rhizome and stolon, this grass is extremely drought tolerant and moderately shade tolerant. Elephant grass is a very palatable, high quality forage but it can cause nitrate poisoning if it is eaten as a sole diet component (Cook, et al., 2005).
Lebbeck leaves, Mkungu	The Lebbeck tree (*Albizia lebbeck*) is usually a 30 meter tall nitrogen fixing leguminous tree. However, by cutting the tree to a stump (coppicing) it can be cut 1-2 times per years. Lebbeck are very drought tolerant and can be used as an alternative to *Leucaena leucocephala*. Both leaves (16-23% crude protein) and pods (19% crude protein) are a rich protein source and an excellent part of ruminant diets (Cook, et al., 2005).
Mango leaves, Majani maembe	Mango leaves *(Mangifera indica)* come from an evergreen tree that is tolerant to water stress. The leaves are palatable and acceptable to ruminants containing 6.5-17% protein. They are safe for goats and can be used as a sole feed with 6.4 grams daily weight gain. When paired with Leuceana leucocopahala the daily weight gain increased to 54 grams (Heuzé et al., 2012)
Banana leaves, Majani ya ndizi	Banana plants (*Musaceae*) yield large quantities of forage biomass (13 tons/ha/year) which can be eaten fresh, dried or ensiled. Although banana leaves and pseudostems cannot meet animal requirements alone, dried banana stalks can make up 20% DM for goat. Studies show that dairy cows can eat up to 15% banana foliage with no effect on milk production (Heuze & Tran, 2013)
Sweet potato leaves, Mriba	Sweet potato leaves (*Ipomoea batatas*) is a multipurpose plant, grown both for its tuber and as a leafy vegetable for human and animal consumption. They can be consumed fresh, dry or ensiled. Sweet potato leaves are a valuable livestock feed because they are very palatable (70% digestibility for fresh forage) and fast growing even in situations where inputs are low. 15-30% of sweet potato leaves DM Is crude protein making it a suitable supply for protein for ruminants (Heuzé et al.,2013).

Appendix 9: Projects Supporting Dairy Goat Farmers

Project	Project Description
PADEP	The Participatory Agricultural Development and Empowerment Project (PADEP) supported 115 of the farmers interviewed. PADEP started as a five year project operating in 5 districts in Zanzibar. With support from the World Bank, it expanded to include 78 Shehias more from four districts including two in Pemba (MANR Zanzibar, 2010). PADEP was administered by the Ministry of Agriculture, Livestock and Natural Resources (MANR) in Zanzibar. The project aimed to promote community involvement in decision making, planning and management of a wide range of agricultural and environmental activities (PADEP, 2003). The project concluded June, 2010 (MANR Zanzibar, 2010). In addition to providing individual farmers and communities with dairy goats, the project also provided some communities with tractors, rice mills and seeds. The dairy goats provided through PADEP were either pure or cross breeds. This represents a major challenge because the dairy goat crossed with local usually produced little to no milk.
ASSP	Agricultural Services Support Programme (ASSP) supported 25 of the farmers interviewed. Agricultural Sector Development Programme – Livestock (ASDP-L), A sub-program of ASSP, is a 15 years intervention coordinated by the Ministry of Agriculture, Livestock and Environment in Zanzibar and funded largely by IFAD (93%) (MANR Zanzibar, 2010). The goal of the project was to increase and sustain agricultural production by improving access to useful agricultural knowledge and technology using a Farmer Field School (FFS) model. ASSP as a whole has already extended and the number of FFS groups keeps increasing rapidly. ASSP is concluding in 2014 and the aim is to smooth the transition into completely farmer led focus groups. ASDP-L works exclusively with livestock keepers. The project purposefully included both men and woman livestock keepers particularly from marginalized groups and those living below the poverty line. Although 405 FFS groups are focused on goats (205 in Ugunja and 200 in Pemba), the number focused on dairy goats specifically is unknown. ADSP-L provided dairy a small number of dairy goats Shehias with FFS groups in to encourage this development.
HPI	Heifer International (HPI) supported 17 of the farmers interviewed. HPI is an international non-governmental organization based in the USA. HPI implements projects using a sustainable livelihoods approach that is focused on using livestock to help resource poor farmers overcome poverty. HPI almost exclusively uses a model where the farmers “pay” for their dairy goat by giving a kid back to the project. The goat kid is then given to the next farmer. (Msangya, 2013). HPI held trainings for the farmers that span a wide range of topics. Some of the farmers interviewed referred to the HPI Dairy Goat Manual as an important resource.
TASAF	Tanzanian Social Action Fund (TASAF) supported 8 of the farmers interviewed. TASAF is a government organization that helps local government respond to community demands with the aim to reduce poverty and meet Millennium Development Goals. TASAF aimed to empower communities and improves their access to opportunities by decentralizing and empowering the local government. TASAF established a National Village Funds that used 120 million USD to assist the poor, especially those who lacked basic social services. (TASAF, 2010). In Zanzibar, some of these funds were used to buy dairy goats.

Appendix 10: Potential of Multipurpose and Drought Tolerant Indigenous Trees and Shrubs as Feed for Dairy Goats in Zanzibar

Dairy Goat Feeds in the Tropics

Dairy goats need sufficient nourishment in order to produce milk at their genetic potential. A major constraint to livestock productivity in tropical Africa is caused by inadequate nutrition. Identifying browse plants that provide high quality fodder for dairy goats while maintaining soil fertility, could greatly improve the livelihood of small-scale farmers (Ngodigha & Oji, 2009).

The most important components of feed are carbohydrates and protein, both are essential for increased milk yield (Simbanda *et al.*, 1997). Goats fed low crude protein (CP) diets had lower milk yield and lower yields of fat and protein than those fed to meet the CP requirements for the protein yielded in the milk produced. CP requirements for goats are between 14-15%, feeding above this level results in little to no increase in milk production (Schmidely *et al.*, 2002).

Although marketing and production of milk is essential (Maass, et al., 2013). Developing and improving feeding systems will increase the quantity as well as the quality of goat milk products produced. Identifying browse plants with potential for providing high quality fodder for dairy goats while maintaining soil fertility can improve the livelihood of small-scale farmers (Ngodigha & Oji, 2009).

Feeding Dairy Goats Trees and Shrubs in the Tropics

Browse plants play important roles within the farming systems of humid tropical Africa, contributing significantly to soil maintenance and fertility (Ngodigha & Oji, 2009). Goats and sheep face serious nutrient shortages when they are dependent on low quality crop residues and expensive supplemental feeds. Feeding fodder trees and shrubs is a solution that can improve dairy goat health and milk production (Salem & Smith, 2008). Leguminous trees also increase soil fertility through nitrogen fixation, firewood for cooking, pollen for insects and perennial cover which controls erosion on steep slopes (Pye-Smith, 2010). In Zanzibar trees and shrubs are especially important fodders during the seasonal drought. Tree leaves have already been successfully incorporated into concentrated supplemented diets of sheep and goats (Azim *et al.*, 2001).

Browse plants, beside grasses, are one of the cheapest sources of feed for ruminants available year-round (Ngodigha & Oji, 2009). 60% of dairy goat farmers in Zanzibar cut and carry food for their dairy goats, this gives farmers the opportunity to choose exactly what their goats are eating. It is important for farmers to understand dairy goat nutrition, especially energy and protein requirements, in order to produce milk effectively.

Nutrient Content of Trees and Shrubs in the Tropics

The major constraint to livestock productivity in this region is inadequate nutrition because the primary feed resources (natural pastures and crop residues) are bulky, high in fiber, low in nitrogen and of poor quality. The identification therefore, of browse plants with the potential for providing high quality fodder for livestock and maintaining soil fertility is a major focus of agro-forestry research in these regions (Ngodigha & Oji, 2009). Nutrient contents of feeds and fodders greatly vary due to soil composition, the manure and fertilizers available, irrigation, stage of growth, frequency of cutting, variety and strain of the trees and shrubs (Upreti & Shrestha, 2006).

Some tree leaves have been successfully incorporated into concentrated supplemented diets of sheep and goats. Nutrient values between tree species vary widely (Azim *et al.* , 2001), due to soil composition, the manure and fertilizers available, irrigation, stage of growth, frequency of cutting, variety and strain of feed resource (Upreti & Shrestha, 2006). Leaf nutrient contents also vary throughout the season. In the spring the CP contents are higher than in the winter (Azim *et al.,* 2001). In many parts of the tropics, where the biggest constraint to dairy goat production is lack of energy and water, farmers who want high milk yields need to feed their goats high-quality supplemental feeds, like fish meal, not just fodder trees (Pye-Smith, 2010).

Tannins are the most widely occurring anti-nutritional factors found in plants. They are found at high levels in some forage trees, negatively impacting livestock health. The intake of tannins at low to moderate levels (2–4 % of dry matter) has a beneficial effect on protein metabolism in ruminants, reducing bloat and decreasing helminthic parasites (Bhat, Kannan, Singh, & Sharma, 2013). Compounds such as polyethylene glycol (PEG), bind to tannins and increase the feed value

(Salem & Nefzaoui, 2003). Wood ash could be used to improve nutrient availability, deactivating tannins found in some shrub and tree leaves (Salem & Smith, 2008).

Leaf meal, processed from fodder shrub leaves, can easily be stored as a supplemental feed. Leaf meals are widely marketed in South and Southeast Asia, and will hopefully be incorporated into more farming systems in Africa. These new enterprises should focus on increasing benefits to smallholders and women in particular (Pye-Smith, 2010). Legumes are a useful protein source, high protein and they improve soil fertility. However, the nutrient values of local protein sources are often unavailable (Salem & Smith, 2008). Several exotic tree species have been the focus of much research in the tropics, potential for using more indigenous trees as fodder.

Dairy goats in Zanzibar

Dairy goats are a recent but increasingly important addition to small-scale farming systems in Zanzibar. Dairy goats provide a much needed, quality source of protein and a host of important nutrients for farmers throughout the tropics (Haenlein, 2004). The three pure bred dairy goat breeds found in Zanzibar are Sanaan, Toggenburg and Norwegian. The average milk production of a dairy goat in Zanzibar is just 0.91 L per goat per day. This is very low compared to the Kenya dual purpose goat which is a cross between local and exotic breeds that produces 1.5 to 3 liters/goat/day on average (Ojango *et al.,* 2010). Low milk production discourages farmers from investing time and money into their dairy goats. Currently, 60% of the farmers do not provide supplemental feeds to their dairy goats.

Dairy goats are well suited for farms in Zanzibar because they are small and require less space and management then dairy cows (Escareño *et al*., 2013). One of the most important constraints for livestock keepers in sub-Saharan Africa is the poor quality feed supply, especially in the dry season. The level of nutrition, together with the management system used, dictates dairy goat performance to a great extent. Considering the rapidly expanding population and milk market, dairy goats can play an important role as efficient milk producers. It is essential to be creative and find local and sustainable feed sources for dairy goats in Zanzibar (Salem & Nefzaoui, 2003).

Improving animal nutrition is a great way to increase milk production. It is important for farmers to get as much energy and protein as possible from the fodder available to them. Utilizing local resources decreases farm expenses and is a more stable and sustainable source of feed compared with the expensive imported supplemental feeds like maize bran. There is little to no information available on the nutrient contents of commonly used indigenous trees and shrubs in Zanzibar. Providing this information to farmer's will help them to make informed feeding choices and more effectively utilize local forages.

Appendix 11: Milk Processing Report

Dairy goat milk processing in Zanzibar: Opportunities and challenges of developing a co-operative goat milk processing unit

Abstract

This report is about developing a goat milk processing unit in Zanzibar; reviewing both the opportunities and challenges of processing goat milk, with an emphasis on the role of the Kizimbani Agricultural Training Institute (KATI) in facilitating this development. Interviews at KATI and at milk processing facilities in Mgeta and Arusha helped to gather a holistic picture and the future wanted situation. Understanding the benefits and challenges of the milk processing units in Tanzania was the first objective. The second objective was to uncover the potential role of KATI in milk processing and to make recommendations that could help expand into the local community and surrounding areas, using accessible technology and a farmer co-operative approach. This approach aims to maximize benefit for local communities and will help to initiate milk processing activities on a small-scale, even before a dairy goat herd at KATI is established.

Introduction

Dairy goats in the tropics

Dairy goats play multiple roles in society throughout the tropics, as reliable producers in bad times, and fast breeders with a lower nutritional requirement than dairy cattle (Escareño, et al., 2013). Supporting dairy goat development can also creates jobs in other sectors, increase gender equality and support rural women (Odero-Wanga et al., 2009). Local goat breeds in Tanzania and Zanzibar produce only enough milk for their young with little excess for human use. Research and development in the field of dairy goat production and breeding is not well developed as it is for many other animals. Especially in the tropics where goats are most prevalent in poor rural households.

Goat milk nutrition

Milk is an important product and food produced on small-scale farms. In Tanzania, two percent of the milk produced is marketed and 70 percent comes from small-holder farms (Alexopoulou-Giannakitsa, 2011). Goat milk production is dominated by small-holders. Ninety percent of the goat milk produced is consumed at home (Lie, 2011). Home consumption of goat milk is important because goat milk can supplement the diet of the entire family (Peacock, 2008). Goat milk contains protein and a host of nutrients including vitamin A, calcium, phosphorus, iron, thiamin, riboflavin, niacin and vitamin B-12 (Belanger, 1989) . Goat milk is also higher in many essential amino acids compared to cow milk and many people who are allergic to cow milk are still able to drink goat milk (Haenlein, 2004).

Although both governmental and non-governmental organizations have begun supporting the development of dairy goat projects in East Africa, research on the impacts of dairy goat introductions is limited. A recent study in Mgeta shows that dairy goats improved household nutrition and created new markets, increasing the farms profitability (Lie, 2011). Selling milk to small-scale dairies could provide a stable income as well as a variety of different employment opportunities locally.

Goat milk in Zanzibar

According to estimates from a baseline survey in 2013, there are approximately 500 farmer's raising dairy goats in Zanzibar, and each farmer has four goats on average. Goats are browsers so they can more effectively utilize the shrubs and tree fodders found in Zanzibar, especially in coral rag areas. Goat milk is more expensive than cow milk and not accessible unless you know a dairy goat farmer willing to sell. Most of the goat milk currently sold in Zanzibar is used for medicinal purposes, but the majority is used at home. Organized milk markets are few and limited. Co-operative goat milk collection is not established so each farmer sells milk individually. Goat milk is rarely processed on a household scale, in a study of 193 farmers only four occasionally cultured milk to sell to neighbors. For this reason, all processed milk products must be imported.

Kizimbani Agricultural Training Institute (KATI)

Kizimbani Agricultural Training Institute (KATI) is a part of Zanzibar's Ministry of Agriculture, Livestock and Environment. The purpose of KATI is to train agricultural extension officers and farmers in order for them to give better technical advice and information to farming communities. In 2007, KATI was given more functions as a research base and it also started commercial activities in order to become more self-sustainable. KATI offers a two year general agricultural course on the principles of crop production and animal husbandry, in order to fulfill its vision which is to offer relevant demand-driven training in these areas (MANR Zanzibar, 2010).

KATI is a new partner in the Enhancing Pro-poor Innovations in Natural Resources and Agricultural Value-Chains (EPINAV) project, a collaboration between the Norwegian University of Life Sciences and Sokoine Agricultural University. KATI plans to establish a herd of 20 Norwegian dairy goats and a milk processing facility. The value-added products produced could then be sold locally or in the rapidly expanding tourist market.

Objectives

The purpose of this report is to help develop of a milk processing unit in Zanzibar. The first aim, was to learn from established milk processing projects in Tanzania, discussing benefits, challenges and opportunities. The second aim, was to apply the knowledge gathered from other projects to make recommendations that help KATI support students, the local communities and surrounding areas in Zanzibar; using accessible technology and a participatory approach. The end goal is to form a milk processing unit that will help dairy goat farmers and KATI develop milk markets and utilize dairy goat milk effectively and sustainably.

Observations and Results

Case 1: TWAROSE Farmer co-operative goat milk processing center, Mgeta

The dairy goat projects in Mgeta region first started in 1988. Currently, there are 63 farmers involved with the project and over 400 farmers raising dairy goats in the area. Mgeta, Nyandira village has a cooperative milk processing unit that makes yogurt for the local market which takes

place two times per week. This cooperative is also part of an Enhancing Pro-Poor Value Addition (EPINAV) project that collaborates closely with Sokoine University (SUA) which is located just less than two hours away in Morogoro. The university and project support supplements the dairy goat project costs and also helps to provide yogurt to two local primary schools.

TWAROSE has five board members. In 2009, TWAROSE was legally registered as an association, making it easier to sell milk. On average the processing facility collects 120 to 174 L of milk per week. Even though the capacity of the facility is around 200 L per day. TWAROSE only collects the amount of milk they think they will sell.

Tchenzema is the village where most of the dairy goat farmers live. 70 out of roughly 100 L of the milk collected at the TWAROSA processing center comes from this area. Tchenzema is not located near a main road so it is difficult to access a stable market for goat milk. Tchenzema is dependent on the TWAROSA collection center in order to sell their milk. Since collection only takes place twice per week, and farmers can only sell the milk from that day, it is difficult to expand and produce more milk. Lack of markets represents a major challenge for dairy goat farmers in this key village. This is not an important concern in Nyandira where you can sell goat milk on the street or to restaurants at a higher price, 0.62 USD (1000 Tsh) versus 0.56 UDS (900 Tsh) at the processing center.

The processing unit in Mgeta has a road which has been greatly improved in the last years. Even so, steep mountains and poor upkeep make transportation an important challenge to overcome before dairy goat products in Mgeta can be sold in outside markets. Because of the high cost, not many local people can afford to buy the yogurt produced. This is not the case for many in Morogoro and surrounding areas where people have more disposable income.

Expanding the market for the goat milk adds a number of additional costs and considerations. The yoghurt produced will need to consistently meet all food safety and quality requirements in order to be successful. The increased transportation and packaging costs, along with competition from a number of established large milk processing companies in town are important challenges that must be overcome.

Primary school feeding programs: Kibuko Shule ya Msingi, Mgeta

Two primary schools are currently involved in a feeding program that supplements the cost of providing dairy goat yoghurt to students. One of the participating schools is Kibuko primary school, a government school with 400 children, 2 teachers and 3 helpers who have been educated to form four. The school provides a meal consisting of beans and corn meal (ugali) two to three times per week. All the food eaten at the school was grown on campus. Yoghurt is also available once per week, provided by the TWAROSA processing center. The school is hoping to increase the number of days they provide a meal for the students by producing more food on the land available to them.

Students with the help of teachers, parents, farmers and community members grow corn, yams and beans but they plan to expand and keep a vegetable garden. Last year, the school produced sixty eight 100 kg bags of corn and 800 kg of beans. The school also keeps eleven dairy goats. There are four student leaders in each class, two are primarily responsible for the dairy goats and two work mostly with the crops.

Many students wanted to work with the goats but due to the limited number of dairy goats only a few were selected. The students were trained first by the orphanage project in Mgeta. The first training the trained orphans came and taught all the students for one day about dairy goat husbandry. The second training was more intensive. The student leaders working with the dairy goats were able to go for a two-day intensive workshop to learn more about dairy goat husbandry. This workshop gave student important knowledge in order to care for the dairy goats properly. The school hopes to build another goat shed and expand so that more students can learn about dairy goat husbandry.

Experienced dairy goat farmers in the community also help the students to face problems. Farmers said they taught the students how to use traditional medicine to help treat sick goats without the cost of expensive modern medicine which is not available in the area. Involving parents, farmers and community members is a very important part of the school's success. Initiative and interest from both students, teachers and the community has been an essential part

of the schools success. Good leadership and commitment to an integrated learning model produces real benefits for the students in terms of both knowledge and nutrition.

TWAROSE Feedback: Developing an effective milk processing unit

A meeting with the five TWAROSE board member was set up to discuss the opportunities and challenges and important considerations to keep in mind when setting up a milk processing unit based on their experiences in Mgeta.

1. Form a strong co-operative with good leadership

It is essential to form a strong co-operative so that farmers can benefit from milk processing. Without co-operative action it is difficult to organize and hold processing units accountable to the farmers. It is important for the value-addition benefit to be captured at a farming system level. Group member should be able to elect leaders and decide what activities the group is involved in and how the group functions.

Co-operative members should also receive benefits that help them improve their dairy goat production. Buying fodder together and sourcing it from Dar es Salaam for example reduces the price for group members. Buying medication in bulk is another way to reduce costs for individual farmers. In the same way, collecting milk together helps farmers to access markets and gain additional benefits. Collecting milk as a co-operative also gives processing units a more stable flow of milk. This is especially important to consider with dairy goats because they do not milk continuously for a whole year.

2. Internal interest and market

In order to start a milk processing unit, *internal* interest and market for the product is essential. The processing unit idea and motivation needs to come from association members. This unit should not be started using a loan, instead it should be established little by little so it is sustainable. The advantage of an internal market is two-fold, it increases local nutrition and decreases initial costs. Once a stable market has been established locally, the co-operative can choose to expand

to reach other markets. The school feeding programs are a very important market for TWAROSA. It provides a stable, local market for the yoghurt produced.

3. External information and assistance

Although motivation and leadership should come from the farmer group, information and knowledge is an essential input. Working together with institutions like schools or colleges help to promote the product and can support the co-operative in various ways.

Organizing study tours is another way to help farmers get training, information and motivation. These tours can vary greatly depending on the time and resources available. Some tours can be done locally or in a nearby village, just to get an idea of what successful farmers are doing. It could be useful to see an established project that is doing similar work.

Case 2: KALALI Women Dairy Co-operative, Moshi

KALALI Women Dairy Co-operative was established in 1988 and currently has 263 active members and nine employees. The average farmer has two milking cows and milks twice a day producing 10 L of milk per cow per day. The KALALI co-operative buys cow milk for 0.43 USD (700 Tsh) per litre and currently produces cheese, butter, ghee, cream, fresh milk and cultured milk. Only the butter is certified by the Tanzania Bureau of Standards (TBS) and can be sold in supermarkets in both Moshi and Arusha. The rest of the products are sold locally or by order. In addition to local markets, they also provide cultured milk twice per week to 3000 children from 13 schools. On Monday Finnish donors pay for the milk and on Thursday the parents must contribute for the milk at supplemented prices.

There is a 6.18 USD (10,000 Tsh) entrance fee to become part of the co-operative but members receive a variety of benefits. First, the co-operative will not refuse milk from co-operative members so they have a stable market for milk even in the rainy season when there can be a milk surplus. Members also get free training and the children of members are sent to school, paid for up to the university level. Microfinance is also available to farmers through the co-operative.

Important challenges for KALALI include:

1. Lack of skilled labor: Training and education is essential component of value addition. Understanding the processes taking place and being able to troubleshoot problems is essential in order to produce safe, quality products.
2. Hierarchal management: At KALALI, one person is making all the production decisions. A board from the co-operative should be working together to increased participation and capacity building which are essential to the projects sustainability.
3. Inconsistent electricity: KALALI dairy is highly mechanized and dependent on electricity that is inconsistent. Their generator is not strong enough to keep the cold storage room cold. If the electricity goes out for a few days all the products are spoiled and production is compromised. Reducing dependency on electricity and having a viable backup plan, either a generator or a low tech backup, is a good way to reduce food waste and profit loss.
4. Corruption: Accountability, especially when delivering the donor supported milk to the schools is a major challenge. The people responsible for delivering milk were not followed up with and many packets were never delivered to the children. It is important to have procedures, such a record keeping and signatures from teachers put into place in order to reduce corruption and ensure that money and milk products are going where they are supposed to.
5. Dependency on donor support: KALALI is currently not self-sustainable. They operate with the support of many donors. If KALALI is going to operate sustainably, they need to become profitable. This will require changes in management and perhaps simplification of the operations, reducing the number of products produced. KALALI produces a wide range of dairy products, it is important for them to know the cost and benefit of each product in order to make good decisions about future production.

Discussion

Benefits and challenges developing a goat milk processing unit

Benefit of developing a goat milk processing unit

Processing milk locally would lower the cost and increase the accessibility of value-added milk products for farmers and local communities. With great potential of improving the nutrition of the community. Imported processed milk products are expensive and all the benefits of value addition are externalized. Milk processing could provide important feedback loops between a growing tourist industry and local farmers. The economic benefits of producing value-added milk products are high.

Products like fermented milk and yoghurt do not require sophisticated equipment and can be profitable even at a small scale (Odero-Wanga et al., 2009). Making value added products minimizes waste and increases the price (Omore & Kaitibie, 2008). High quality livestock products such as yoghurt and cheese could provide an important pathway out of poverty for poor producers and small-scale actors in the value chain (Omore & Kaitibie, 2008).

Challenges of developing a goat milk processing

There are some important challenges involved when establishing a goat milk processing unit. If the goal is to reach larger "upscale" markets, is essential for farmers to collect milk together as a group in order to produce products consistently.

These markets also require that the products meet rigorous food safety standards. In order for farmers to succeed, effective and appropriate food safety regulations at a government level need to be developed. Because currently low-income populations and small-scale local markets rarely follow and set of food safety guidelines (Omore & Kaitibie, 2008). Milk storage is an important concern that directly affects the food safety and quality of the milk. Finding simple, low tech ways to cool the milk to less than 10 degrees C will likely prevent spoilage for three days (Kurwijila, 2006).

Accessibility of technology would help farmers compete with large scale manufacturers. By adapting these technologies for small-scale and low input productions farmers could produce value added products. Currently, the equipment is too expensive so creative alternatives need to be developed and promoted (Odero-Wanga et al., 2009).

Most women lack access to credit and the training and skills to process milk (Odero-Wanga et al., 2009). Extension agents should target women in particular those who are already processing milk at a local level. If women are involved, the current workload and time availability after other household responsibilities are taken care of is an important consideration.

KATI's future role in milk processing: future wanted situation

After meeting with the director of KATI, the future wanted situation for KATI is as a model, educational milk processing unit that will operate at the smallest possible scale. KATI will be a pilot that will support farmer groups and have trainings for farmers in both Unguja and Pemba. The aim is to start projects that support farmer groups in making value-added goat milk products.

The problem is not market because in Unguja there is a high demand value-added milk products. A much more important concern is having enough milk and a consistent milk supply. Proper feeding of dairy goats is another important issue for KATI and for dairy goat farmers at large. Concentrate feeds are expensive, these prices can be reduced if farmer groups can order directly from the mainland in bulk.

Recommendations for developing a milk processing unit

Encourage Farmer involvement and co-operation

Approximately 69 % of all dairy goat farmers in Zanzibar are involved in community based farmer groups. Farmer groups need to be motivated, dedicated to dairy goat production and willing to try something new. Without internal leadership and motivation no goat milk processing project can remain sustainable. Group member participation and engaged leadership is the first step. It is important for the members to work closely together and make decisions as a group or as a board, to avoid a situation where one group member is making all the decisions, which was the case with KALALI.

In Zanzibar, farmer field school groups are widespread. However, just 18 % have any co-operative action within the group. Transitioning from a loosely formed farmer group to a farmer group that works and organizes together is a big step. This requires commitment from all members and good

organization and planning from leaders locally. Finding a community with a strong co-operative and motivated leadership is the first and most important step to developing a goat milk processing unit.

Develop local markets

Milk processing and distribution go hand in hand. When dealing with a perishable product like milk, it is especially important to establish a stable market for the products. Creating local markets and demand value added goat milk products is the first step to sustainable goat milk processing. Although the tourist market is expanding rapidly, it is important to start by capturing the nutritional and culinary benefits at a local scale. School are a stable market and providing goat yoghurt can be a great way to improve childhood nutrition.

A farmers market has recently started in Stone Town by the Association of Vegetable and Fruit Growers (UWAMWIMA) in Zanzibar. Although this is a new development in Stone Town, many villages have their own local markets that could be another excellent venue for value-added milk products like yoghurt.

In Zanzibar, 49 percent of the poor have high micronutrient deficiencies, especially women and children (Boetekees & Immink, 2009). Schools are over-crowded and most do not have a feeding program. For this reason, including a school feeding program in Zanzibar's dairy goat milk processing unit plan would be doubly beneficial. The school would provide a stable, local market for the goat milk processing unit and the processing unit would help increase the nutrition of children in Zanzibar.

75 percent of poor in Zanzibar are living in the rural sector which employs 40 percent of the population. This sector generates 20 percent of Zanzibar's GDP (Zerfu & Kebede, 2013). Few schools have agricultural land so teaching students using a hands-on approach is a difficult challenge. One of the benefits of keeping dairy goats is that they require little land and few inputs. Giving students the opportunity to learn about animal husbandry at a young age gives them a head start and will help them to keep dairy goats humanely and profitably in the future.

In Zanzibar, establishing a local market will vary significantly depending on the location. The huge importance of tourism and the large markets in this sector could tempt people to exploit only this market and ignore the development of local markets. However, it is important to keep in mind the sustainability of the project. Local markets are more resilient and forgiving, especially considering the new project and the challenges to be overcome, focusing first on local markets reduces the risk and will allow for growth and troubleshooting before expanding to include tourist markets which necessitate a host of different food safety and quality requirements.

Establish access to external information and markets

In Zanzibar, KATI could be an excellent source of information for dairy goat farmers. By using new information distribution methods and by focusing on trainings and building farmer's capacity using creative informational campaigns and different modes of transmission, such as radio programs and text messages. External information is especially important in the beginning phases. Offering advice and expertise in the areas of milk sanitation, milk processing scale and accessible technology is necessary to begin.

1. *Milk sanitation* begins with clean goat housing and does not end until the product has safely reached the consumer. Milk is a fragile product that requires proper handling all along the way. Using sanitary milking practices does not take a lot of equipment, only time and knowledge. Milking away from where the goats are living is an important but also more expensive and time consuming change many goat farmers in Zanzibar need to make. The most simple and effective milk sanitation practice that should start immediately is thorough washing of the udder before milking. Another very simple change is throwing the first strips of milk, these first drops of milk have high bacterial counts. A strip cup should also be used to check for mastitis (Kurwijila, 2006). Most farmers in Zanzibar are not aware of proper milking procedures and do not follow any milk sanitation protocols. If cooperative collection of milk is initiated it is important to train farmers about sanitary milking practices. It is also essential to test the milk being delivered to ensure that it is not contaminated or altered in any way. Pasteurisation is another method to decrease bacteria. Heating the milk to 63°C for 30 minutes or 72°C for 15 seconds kills 90 percent of bacteria (Kurwijila, 2006). Adopting practices, policies and

institutions that recognize and support both formal and informal food supply systems and helps to keep milk processing and profits local as opposed to importing milk from elsewhere.

2. It is important to consider the *scale* of the milk processing unit. The scale will depend on the amount of milk and the consistency or milk production, commitment, time availability, equipment costs and transportation options available to dairy goat farmers. Many of KALALIs challenges were due to its large scale and dependency on electricity. Small-scale processing units could be developed with very little money, equipment and milk. This type of processing is best suited for local markets because small and medium scale milk processors cannot easily access niche markets due to quality assurance and food safety standards (Omore & Kaitibie, 2008). Small-scale milk processing units can be less dependent on electricity, which is inconsistent. This reduces risk and can increase profits because there is then no need for expensive equipment.
3. Using simple, *accessible technology* can increase the viability of a small-scale dairy. For example, it is important to test the milk, not only for sanitary purposes but also to ensure quality of the milk. Lactometers can be used to check if the milk has been adulterated by adding water. The test uses milks density which ranges from 1.026 to 1.032 g/ml, adding water lowers this density (Kurwijila, 2006). Processing yoghurt without the use of electricity reduces costs and helps to ensure consistent production. Electricity in Zanzibar is not consistent. Reliance on electricity is not necessary when dealing with small-scale production of yoghurt. Research needs to focus more on value addition technologies that are relevant and appropriate for small-scale processing. These technologies should be time saving and both accessible and affordable (Odero-Wanga et al., 2009).

Student engagement

One way to increase the engagement of students at KATI is through a student group. A Dairy Goat Student Group would be a student run group that works together with voluntary facilitators. Students would join the group based on their interest. Milk could be collected every Tuesday afternoon. The group would meet every Wednesday evening to discuss dairy goat husbandry and goat milk processing. Various milk products like yoghurt and cheese could be tested and sold at

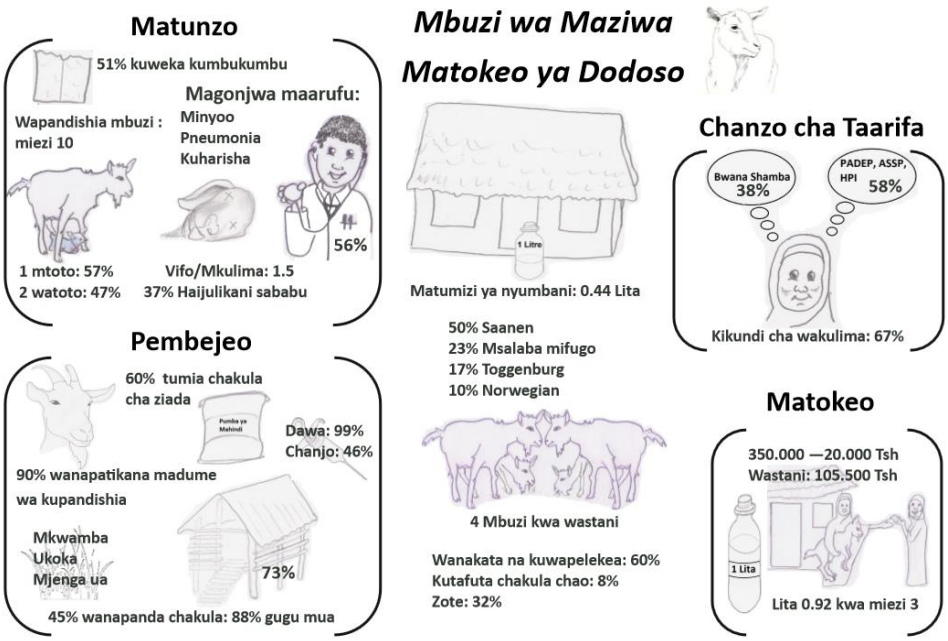
the newly established Zanzibar Farmer's Market. The objectives would be to Produce, Sell and Educate. First, to test and optimize farmer accessible yoghurt and cheese making procedures (Produce). Second, to sell goat products at the local farmers market encouraging the use of goat milk in short value chains, all the proceeds will go back into the project making the group self-sustainable (Sell). Third, to act as a source of information and inspiration for farmers and current livestock extension agents (Educate).

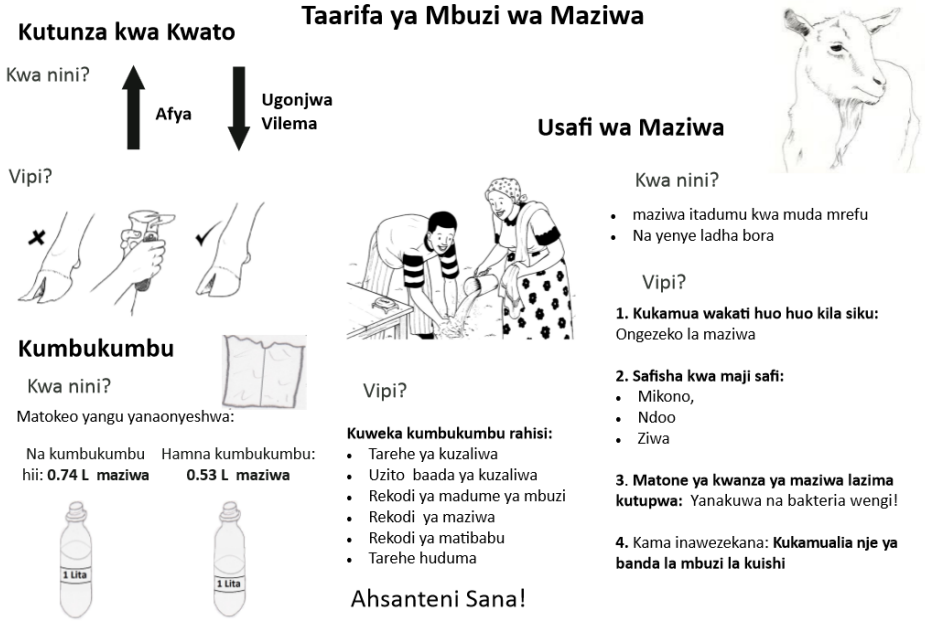
Conclusion

Making value-added products from goat milk in Zanzibar clearly has the potential to help farmers, school children and the local community. KATI has the potential of acting as a source of knowledge and training for farmer groups throughout Zanzibar as long as they make goat milk processing a priority. It is essential to focus on improving the expertise and capacity of teachers and students alike at KATI. By encouraging farmer co-operation, using a small-scale model, improving milk sanitation, developing local markets and using accessible technologies; a sustainable milk processing unit with localized benefits could be developed in Zanzibar.

Appendix 12: Information Pamphlet

The education level of dairy goat farmers vary significantly. However, just one interviewee had more than 11 years of education, 29 (15%) of the interviewees have had no education at all. To include all the interviewees in the results, a pamphlet using simple pictures and words in Swahili was drawn up and distributed. One side of the pamphlet displayed key results of the study. The other side, provided important and basic animal husbandry advice. These pamphlets were laminated and distributed to farmers via their local extension agents.





Appendix 13: Authors comments on the significance and lasting effects of research

How do I make my work matter? Will all the time spent organizing, conducting interviews, collecting data, analyzing results and writing reports make any difference? Will my work be a small step forward for dairy goat farmers in Zanzibar?

Many theses never make it past the desks of the advising professors. After submitting this big work, it is finished, people move on and open up new chapters in their lives. Although, I too hope to start a new job or internship after graduating, I am not satisfied to do research for research's sake. Especially when I have both the information and opportunity to advocate for small-scale farmers that many times, and throughout the world, are not given a voice.

As a student of Agroecology, I focus on the sustainability of food and farming systems. This sounds simple enough, but when "sustainable" includes social, environmental and economic influences; all of a sudden you are looking at both the percent of nitrogen in a particular field, the impacts of ever changing global markets and a host of other influences on this system, both internal and external. Turning theory into practice is one of the main objectives of Agroecology. As a student researcher, I am left wondering, how I can be a part of this process of change.

At this point, I should probably explain what I am researching and why I think it is important in the first place. My thesis work was conducting the first ever survey of dairy goat farmers in Zanzibar, a small island off the coast of East Africa. Dairy goats were introduced to Zanzibar from Northern Europe less than 30 years ago by projects, both national and international, with hopes for improving both the income and household nutrition of small-scale farmers.

My survey aimed to understand animal husbandry practices, benefits as well as challenges, in order to increase effective support for dairy goat farmers. Animal husbandry, includes everything from records, to breeds, health and feeds. Working together with teachers at the Kizimbani Agricultural Training Institute (KATI), the government institution responsible for training agricultural extension agents in Zanzibar, we interviewed 193 dairy goat farmers in all 9 districts in Zanzibar.

With their crazy eyes and ability to eat just about anything (I have seen goats eating the roof from over their own heads), it is no wonder goats survive in even the harshest of conditions. The

problem is, farmers are used to keeping local goats and they keep dairy goats in the same way. This is not possible if you aim to produce milk. Goats need to enough energy and protein to produce milk efficiently. A dairy goat in the tropics can produce over 3 liters of milk per day, more than the local zebu cattle. One dairy goat can produce as much edible protein as 33 Tanzanian goats when farmers are using good animal husbandry practices.

In Zanzibar, the average milk yield for a goat is only 0.92 L of milk per day. According to dairy goat farmers, the key challenges they face are disease, drought, lack of funds, low accessibility to veterinarians and healthcare, and lack of education. The key benefits are income and poverty reduction, manure, milk, and improved nutrition.

Working with dairy goat farmers in Zanzibar, it became clear that lacking basic dairy goat husbandry information is a key issue. The projects who brought dairy goats have all ended leaving farmers with only the expertise within their friend and farming groups. Very little information about dairy goat husbandry is accessible for farmers in Swahili.

From the time I could write, I could type and search for information on the internet. Information of all kinds is easily accessible at the click of a button, or at my local library. Being surrounded by an abundance of material wealth and consumption, it is difficult to keep in mind that easily accessible information is not the norm. 37 % of farmers in Zanzibar did not know the reason for the death of their dairy goat. 49% of dairy goat farmers kept no records at all. The main reason for not keeping records, according to farmers, was due to a lack of education and not knowing the importance.

Providing feedback and accessible knowledge to the dairy goat farmers I worked with is a vital part of my research. 15% of the farmers interviewed have had no formal education, making information widely accessible is a key challenge. Using simple words and pictures I drew up an information pamphlet for dairy goat farmers in Zanzibar. The pamphlet is one page, feedback and information from my survey on one side and general husbandry information on the other. The information is focused on small changes that farmers can start with to immediately improve their practices. I am no artist, so together with my dad we drew up the final pamphlet, which was laminated so it will last, and distributed to farmers through livestock extension agents.

Making an information pamphlet is a small step. There is so much more that could and should be done to help improve dairy goat husbandry and the livelihoods of small-scale farmers in Zanzibar. These steps for improvement are discussed in the journal article I am writing and hoping to publish. The article will be published in English, and almost completely inaccessible to the farmers I aimed to support with this work. I am writing this article to give farmers a voice in academic and governmental circles where big decisions are made. However, catering only to these circles of influence would be a mistake. Taking small steps to include farmers is not only relevant in Zanzibar or the humid tropics, it is important everywhere.

As researchers, we should have the responsibility to share the knowledge we create in a way that is accessible to those who need it. I would not ask you to read a 100 page thesis but maybe this small article is enough to spark your interest in dairy goats, Zanzibar, small-scale farms or accessible information. Whatever your interests, taking small steps to support local farmers makes a big difference and helps spread knowledge, not just to farmers but to consumers as well.

Farmers all around the world are facing challenges on every scale, local to global. Whether they are taking a stand against exploiting middlemen or climate change; farmers stand on the frontline as stewards of land, food and renewable resources. It is time to stand together; farmers, researchers, educators, consumers, people from all disciplines, working to find sustainable solutions to the challenges we face. Creating and sharing knowledge is the first step to greater understanding and better solutions in the future.

Appendix 14: Acknowledgements

It would be impossible to thank all the people who have supported me in completing this thesis project. I feel only gratitude as I think about all the time and energy others have invested in making this project a success. I would like to express my sincere thanks to all the supervisors, mentors and friends who contributed. I hope the knowledge is used to help farmers both now and in the future.

First, I would like to thank the Enhancing Pro-Poor Innovation and Value Addition (EPINAV) for funding this study, making it all possible. From the Norwegian University of Life Sciences (UMB), I would like to give a big thank you to Lars Olav Eik. He introduced me to the EPINAV Project and took the time to discuss the work as it evolved. He made the connections in Tanzania and ensured that I had the support I needed to complete my thesis I would also like to thank all of my Agroecology professors and especially Charles Francis and Suzanne Morse. They provided helpful feedback and guidance, in terms of the agroecological principles and objectives.

The supportive team of faculty at Sokoine University of Agriculture (SUA) also made a significant contribution to this work. Dismas Mwaseba, George Kifaro and Ali Aboud all gave helpful feedback to improve the questionnaire. Dr. Kifaro and Dr. Aboud were particularly helpful in writing the animal husbandry portion. Dr. Mwaseba reviewed the Swahili version and helped to ensure that all the questions were translated correctly and could be answered clearly.

This project would not be possible without Mohamed Rashid and the whole team of supportive staff at the Kizimbani Agricultural Training Institute (KATI). I would like to give a special thank you to Mama Tawadudi for helping me to get my research permit and my residence permit quickly. I would also like to thank Salma Yehya Shehe, Vuai Abeid Vuai, Abubaker Hassan Kisoma and Khamis Mohammad Khamis four teachers at KATI who helped with translating the survey and conducted interviews with the dairy goat farmers in Unguja. And to Shamata Khamis, Abdullah Khamis, Juma Haji, Omar Jabir, Abdalla Abdalla, Ali Ali and Ali Hamad; all Livestock and Fishery Ministry employees who helped with conducting interviews in Pemba. I want to acknowledge Vuai Abeid Vuai especially for traveling to Pemba, providing explanations to the new interviewers and for helping to organize the survey details.

I also want to thank Adi Mohammed Diwan at the Ministry of Livestock and Fisheries (MLF) in Unguja. He compiled the lists of the dairy goat farmers in each district and connected me with district livestock officers (DPOs) who informed the farmers about this study. This being said, each DPO and livestock extension agent involved was essential in order for the survey to run smoothly. Last but not least, I would like to thank all the dairy goat farmers who took the time to meet with me. I hope that this information can help kick-start interventions that are helpful and efficient.

Finally, I would like to thank my family and friends who have been a source of endless encouragement for me throughout this project and my life. I especially need to acknowledge my parents, Amy and Marty and grandparents, Faye and Douglas who have been there to offer advice and correct my grammar all along the way. Thank you! Ahsanteni sana!

Appendix 15: Reflection Chapter

This reflection chapter begins with an overview of the work and projects I have participated in as part of my thesis study, both process and content in chronological order. In the next section, I reflect more deeply on the process and how it has impacted this learning process. Finally, I will reflect more deeply on the content of this thesis study. For more information and reflection, go to http://www.tiffanielovesdairygoats.wordpress.com.

Reflection on thesis process and content

Lars Olav Eik, a professor at the Norwegian University of Life Sciences (NMBU). I looked into some of the projects he was involved with online had an opening for a student interested in working with dairy goats in Zanzibar at the Kizimbani Agricultural Training Institute (KATI). At this point, I decided to pursue the 60 credit thesis option which would give me the time necessary to develop a project that is useful.

The summer before I left for Tanzania I conducted a literature review on a project to compare 20 farms, 10 with dairy goats and 10 without using sustainability indicators, to see how dairy goats impact the sustainability of small-scale farming systems. After arriving in Tanzania at Sokoine University of Agriculture (SUA) in September, I realized that no information about dairy goat husbandry was available in Zanzibar. In order to gather information that is representative for dairy goat farmers in Zanzibar, to fill this information gap, and provide useful information about dairy goat keeping in the humid tropics, I decided to use a survey approach instead of the originally proposed case study. Together with professors at SUA, NMBU and teachers at KATI, we developed a 116 question survey.

Writing and re-writing the survey was followed by translation into Swahili. After one day of testing the survey, more adjustments were made to increase question clarity. The field work for this survey started in the second week of October. We conducted interviews 5 days a week, leaving Friday and Sunday free. After a long day of conducting interviews, the rest of the day was spent entering data into the computer. Friday was spent organizing the interviews and catching up with data entry.

I received the lists of dairy goat farmers from Pemba and was able to plan and randomly select Shehias and farmers for this part of the study. All the detailed plans for transportation and accommodation in Pemba were arranged the day before. Since there were so few recorded farmers (87 total), and because of prior field experience in Unguja, organization was less difficult. With support and cooperation from the Ministry of Livestock and Fisheries, after just one day of planning, we started the field work in the second week of November. We worked every day and finished the Pemba portion of the survey in six consecutive days. After completing all the interviews, the final day in Pemba was spent going through the questions to make sure there was no missing information or misunderstood questions. We were able to make corrections and finalize the excel spreadsheets.

After Pemba, at end of November, the survey was completed. Time was dedicated to sorting, organizing and performing the basic data analysis. At the end of December, all the basic analysis was completed. At SUA, I was able to finish the data analysis and start writing the thesis report.

By the end of January I finished writing the first rough draft of the thesis and journal article. I was also working on a part two feeding experiment. This feeding experiment aimed to use local supplemental feed to increase milk production of dairy goats. Discussion with professors at SUA, finalized the experiment set-up. After writing material to distribute to farmers we began searching for goats that could participate in the study. After contacting several DPOs and visiting two Shehias, it was clear that there were not enough goats that met the qualifications of my proposed experiment.

After the feeding experiment fell through, I developed a list of 6 different ideas for research and projects to conduct at KATI. Together with the director at KATI and Professor Lars we decided it would be most useful for me to focus on a forage experiment. We decided it would be most useful to look at a wide variety of different species and to focus on only indigenous trees and shrubs.

A Norwegian Peace Core Volunteer and I looked at goat milk processing projects in Tanzania. In Zanzibar there are no milk processing units, which means that value-added milk products must be imported. After visiting two milk processing units, one in Mgeta and the other near Moshi on the

Tanzania mainland, I wrote a report on our findings. I shared the report with the director of KATI and several teachers involved in animal production, in order to support their work and offer suggestions.

My next task was to compile a list of the tree and shrub species to use in my study. To do this I took the information gathered from my survey. I went through this list with an animal production teacher at KATI. To supplement the information I collected and to get more information, I met with a botanist at Jozani National Forest. Once the list was compiled I collected samples together with students and a teacher at KATI, both in and around KATI and at the coral rag areas near the airport of Unguja.

I used a small drier at KATI to dry the samples before transporting them to SUA where there is equipment to do the leaf sample analysis. Upon arriving at SUA, I found out that more than half the samples had been over-dried, because the wrong temperature for drying had been recommended. The samples had to be collected for a second time because results from over-dried samples would not be reliable.

My last few weeks in Zanzibar were spent preparing to submit my thesis, finalizing the reflection chapter and writing an article for a more general audience. I also printed and laminated 200 information pamphlets which were given to extension agents from the Ministry of Livestock and Fisheries to distribute to the dairy goat farmers in the survey.

The results from the part two experiment looking at the nutrient content and digestibility of indigenous tree and shrub and species were not finished in time to incorporate them into this report. The results of this study will be used to make another informational pamphlet to help farmers select the most nutritious tree and shrub species for their dairy goats. I was offered a position as a Norwegian Peace Corps volunteer (FK) which means I will be working at KATI for another six months. In this time, I will write a short scientific article on these findings and also teach a course at KATI about dairy goat husbandry and entrepreneurships. The final project for this course will be organizing a farmer field school for dairy goat farmers in Zanzibar. By then, a small herd of 35 dairy goats will be established at KATI and will be used for demonstration.

Further reflections on the process

Many unforeseen circumstances had a profound impact on this thesis work. Everything from transportation to printing took more time than it would at home. Although, this made writing my thesis a much greater challenge at times, I learned a lot more from my case study by experiencing the life and culture of Zanzibar for a more extended period of time. I know this improved my understanding of the situation here and the quality of my thesis.

For my eight month stay in Zanzibar I was living on campus at KATI. This situation came with some major benefits and constraints. The most important benefit was being incorporated fully into daily life at KATI, my house was right beside the classrooms and if anyone needed something, it was easy to find me. This also presented challenges because many people, especially the students, would drop by for a cup of tea and stay for several hours. Life at KATI was isolating at times, because transport is impossible and everyone goes to sleep not long after dark.

While I was conducting the survey in Pemba, I was moved into the girl's dorm at KATI, first due to a farmer field course held in my house and later due to construction. I did not have access to a gas cooker making cooking impossible. This was a difficult challenge because I only had access to one meal per day on campus and the rest of the time food had to be eaten fresh. It was a chance to make meaningful friendships with the diploma students but it also cut down on the time I had to work because there is no office and often no quiet place for me to study without interruption.

At the beginning of February I was very sick for almost two weeks. After two nights in the hospital I was put on antibiotics. I am still not sure what the cause of my illness was. Being ill was part of my learning experience but it put me a few weeks behind in developing part two of my thesis.

The language barrier was a major challenge I needed to overcome when I arrived in Zanzibar. Although some of the teachers speak English fairly well, I needed to speak Swahili with most of my neighbors and some of the teachers in order to be understood. This challenge became less and less important as time went by. I was able to build relationships and understand the culture on a deeper level by learning the language. Understanding some Swahili also helped me to connect

with the dairy goat farmers in the survey and gather firsthand information from farmers as well as DPOs.

At the end of January, Tuva a Norwegian Peace Core Volunteer moved in at KATI. From then on, we worked together to develop the dairy goat projects. I benefitted so much from having someone to discuss ideas and travel with on the milk processing study trip. It is also very important to provide continued support during the beginning phases of this goat project at KATI.

Research methods do not make sense to many people I worked with in Zanzibar. Taking the time to explain why something needs to be done in a particular was very important. Despite many challenges, I am thankful for all the support I received at KATI. It was essential to be flexible and understanding when plans frequently changed. The interviewers and others I worked with also had to be flexible my methods and ideas which were new to them.

Further reflections on the content

My thesis work will have several outputs. Two articles, the first is the first ever survey of dairy goat farmers in Zanzibar, the second is a nutrient analysis of native trees and shrubs used as fodder for dairy goats in Zanzibar. In addition, an information pamphlet was created and distributed to dairy goat farmers. Finally two public interest articles have been written and will be submitted to the appropriate venues with the hope of extending the results and lessons learned from this study to a more general audience.

My main objective in coming to Zanzibar was to work with and learn from small-scale farmers with the hope of creating something that will be valuable for them. Working with KATI, the agricultural school that trains agricultural extension agents helped me to achieve this objective. Working together with like-minded people and involving both teachers and students will help this project benefit small-scale farmers in the future. For the next three years Norwegian Peace Core students will exchange with teachers at KATI with the intention of building capacity for improved dairy goat management at the governmental (KATI) and farm system level. Together, Tuva and I developed a plan that aims to increase the sustainability of the dairy goat projects.

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