Rapid assessment of nutrition & food safety risks in dairy value chains in Tanzania

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

ACIAR	Australian Centre for International Agricultural Research
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
ASF	Animal Source Foods
CAC	Codex Alimentarius Commission
CGIAR	Consultative Group on International Agricultural Research
CFU	Colony Forming Unit
CRP	CGIAR Research Program
FAO	Food and Agriculture Organization of the United Nations
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GRUMP	Global Rural-Urban Mapping Project
HPI	Heifer Project International
IFPRI	International Food Policy Research Institute
ILRI	International Livestock Research Institute
KADADET	Kagera Dairy and Development Trust
KALIDEP	Kagera Dairy Development Project
KAP	Knowledge Attitude Practice
LGA	Rangeland based arid/semi-arid systems
LGH	Rangeland based humid/sub-humid systems
LGT	Rangeland based temperate/tropical highland systems
MRA	Mixed arid/semi-arid systems
MRH	Mixed humid/sub-humid systems
MRT	Mixed, Temperate/Tropical highlands
NGO	Non-governmental organisation
OIE	World Organisation for Animal Health
PCR	Polymerase Chain Reaction
PRA	Participatory rural appraisal
RIA	Rapid integrated assessment of food safety and nutrition
RVC	Royal Veterinary College
SECAP	Soil Erosion Control Project
SHDDP	Southern Highlands Dairy Development Project
SPS	Sanitary and Phytosanitary Measures
TADAT	Dairy Trust
TAMPA	Tanzania Milk Processors Associations
TAMPRODA	Tanzania Milk Producers association
TBS	Tanzania Bureau of Standards
TBT	Technical Barriers to Trade
TDDP	Tanga Dairy Development Project
TFDA	Tanzania Food and Drugs Authority
WF	World Fish
WHO	World Health Organization

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1 INTRODUCTION

Malnutrition and disease are closely interlinked, affecting the overall health and nutritional status of individuals and populations. Although this relationship is recognised in nutritional frameworks, disease and nutrition intake are often assessed in a disaggregated way, potentially leading to decoupled policies. Disease control measures such as culling of livestock may reduce the availability of nutritious foods; similarly initiatives to increase production of nutritious foods may also increase risks of foodborne diseases.

Animal source foods (ASF) are important sources of micro and macro nutrients, but at the same time constitute a source of foodborne disease. Livestock value chains also support the livelihoods of millions of rural and urban poor, for whom livestock and fish related activities can act as pathways out of poverty. Interventions to develop such value chains need to explicitly consider impacts on food safety, nutrition and livelihoods.

Many ASF products in low and middle income countries are sold in the informal market in which conventional regulation and inspection methods often fail and private standards are non-existent or weak, thereby leading to potential burden of food borne diseases and food quality loss in both rural and urban communities. In order to respond to the problem of unsafe food and quality losses in the informal market, the Australian Centre for International Agricultural Research (ACIAR) funded the International Livestock Research Institute (ILRI), WorldFish (WF) and the International Food Policy Research Institute (IFPRI) to assess food safety and nutritional risks and benefits in an integrated way to identify research opportunities for improving nutrition and decrease health risks in three informal value chains in Egypt, Vietnam and Tanzania. This was expanded to another three value chains in (Uganda, Senegal and Ethiopia) with support from other donors. The Royal Veterinary College was contracted by ILRI to provide inputs on framework review and development; methodology and tool development; and, to lead assessments in Egypt and Tanzania.

A Rapid Integrated Assessment (RIA) of nutrition and health risks in informal livestock chain was carried out in each country to gather relevant information in relation to the study objectives. The overall objectives of the project were to

1. Develop methods and approaches for assessing ASF value chains in relation to nutrition and health and;
2. Assess food quality and safety in value chains with high potential for pro-poor transformation, focusing on six different value chains in six countries, including dairy value chains in Tanzania.

As a first step, a framework was developed to combine value chain analysis with risk assessment, taking into account consumption and nutrient content in the risk characterisation. Within this framework, the main outcomes of interest in relation to a specific ASF value chain are risks of foodborne disease in people and nutritional contribution of the food product to people's diet.

Along the ASF value chain, foodborne hazards and nutrient contents of food products change, impacting the risk of foodborne disease and the quantity and nutritional quality of the food produced. The activities and changes taking place within the value chain also have indirect impacts on the health and nutrition of consumers and the people living and working in the value chain by for example changing affordability and acceptability of food produce, incomes and health environments. Therefore, we propose to use economic and social science methods, in particular value chain analysis and participatory methods, to assess how economic, social and cultural factors impact on people's behaviour, attitude, and perception and how they relate to risky practices.

Based on this conceptual framework, a generic data collection toolkit was developed that served as a basis for country specific data collection. This rapid integrated assessment toolkit includes participatory methods, structured questionnaires, observation checklists and biological sample collection protocols. These instruments are applied at the production, bulking (i.e. wholesale or collection points), processing, retail and consumption stages in various countries to explore the key research questions listed below. This report presents the results of this work for the **informal dairy value chain in Tanzania**.

The **key research questions** this project addressed were categorised into five broad themes:

1. **Food safety**
    - What are the main hazards likely to be present in the ASF food value chain?
    - What risks do these hazards pose to value chain actors?
2. Food and nutrition **security**
    - What is the role of the ASF food in question in diets of poor farmers and consumers?
    - What is the relationship between livestock keeping and livestock eating?
3. Combined **food safety and nutritional issues**
    - How does nutritional quality and food safety change along the value chain?
    - What are trade-offs between food safety and nutrition?
    - Are there trade-offs, synergies, between feeds and foods?
    - How do the different ASF VC compare in meeting nutrition and safety needs?
    - How is VC development likely to affect nutrition and food safety?
4. **Social and gender** determinants of health and nutrition
    - Who gets the nutritional benefits and bears the health risks of ASF? How do gender roles and poverty influence health and nutrition risks?
    - How do cultural practices affecting health and nutrition risks?
5. Trends and possible **interventions**
    - How could investments enhance consumption of nutrients and decrease risks?

2 BACKGROUND

2.1 Selection of study area

The selection of the study areas in Tanzania was driven by the following considerations (International Livestock Research Institute 2011):

- **Potential for scaling up interventions and solutions**: agro-ecological conditions of the site are representative of large areas elsewhere in Tanzania.
- **Growth and market opportunity**: evidence for either the importance of dairy value chains in the country, or increased demand for these products, either locally or regionally.
- **Pro-poor potential**: evidence that the poor can play a significant role in increased production, be employed in value chain activities, or are likely to benefit from increased consumption.
- **Researchable supply constraints**: the presence of constraints, such as large productivity gaps or transaction costs, for which research may be able to provide solutions, and thereby improve livelihoods.

Milk supply in Tanzania has increased 130% over the last decade to about 1.64 billion litres (Ministry of Livestock and Fisheries Development 2011), which translates to 41 litres per capita per year. Average milk prices for producers have fallen from about US$ 0.4 in 2000 in some areas to about US$ 0.12 currently, implying that producers have less profit unless they have changed their technology. Arusha and Kilimanjaro regions supply about two-thirds of the national milk supply. Other significant producing regions are Tanga, Mwanza, Kagera, and Dar Es Salaam (International Livestock Research Institute 2011).

Demand for milk has been rising sharply, driven mainly by a human population that is growing fast at 3.3% per annum and a high economic growth rate of about 7% per annum over the last decade. The **gap between demand and local supply** is predicted to continue to widen in the medium term to 2020. The market continues to be dominated by raw liquid milk. The unmet demand in Tanzania presents an important opportunity for improving the welfare of producers and their market agents, through income and employment generated in dairy production, processing and marketing (International Livestock Research Institute 2011).

Growth in the dairy industry has been ranked by the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) and the International Food Policy Research Institute (IFPRI) as the most important agricultural subsector in the region in terms of potential GDP gains (Omamo et al. 2006). The **potential for growth in the dairy sector** in Tanzania may be comparable to neighbouring Kenya where growth has been much faster and production is six times that of Tanzania thanks to improved cattle genotypes and private sector growth. The International Livestock Research Institute (2011) hypothesises that a rapid rise in demand and a liberalized economy provide Tanzania with similar impetus for growth.

The **dominance of small-scale production** and associated marketing systems in Tanzania is not only typical of dairy systems in East Africa but seen in many parts of the developing world. Limited feed availability and poor quality feeds are common constraints in these systems. Further, endemic and epidemic diseases such as foot-and-mouth disease, East Cost fever and mastitis, combined with limited capacity and resources of animal health services cause direct losses for producers. Lessons from dairy research and development in Tanzania can therefore be widely applicable.

Small-scale dairy **production and marketing opportunities** are predicted to benefit the poor in many ways, especially where increasing demand enhances such opportunities, as in Tanzania. These include opportunities for intensification and enhanced productivity leading to livelihood improvement including through employment, besides nutrition benefits for the poor either directly or indirectly (International Livestock Research Institute 2011). It has been estimated that dairy farming generates about 50 full-time wage-labour opportunities per 1,000 litres of milk produced on a daily basis, and up to 20 full-time jobs (17 direct, 3 indirect) per 1,000 litres of milk handled on a daily basis by informal traders (Omore et al. 2004). While these jobs are a source of income, participation in expanding markets may place extra demands on women thereby reducing time available for childminding. It was found that 95% of the milk in Tanzania is marketed through informal markets (Omore et al. 2009); this constitutes a challenge for taxation, regulation, financing, reforms and provision of social services, as commonly no contributions are made to social security, health, and unemployment insurances.

Conclusions of the assessment of the study area highlight that the dairy value chain in Tanzania offers ample opportunities for development and growth and describe the following key characteristics (International Livestock Research Institute 2011): 1) There is substantial **potential for an increase in demand** driven by population growth, currently low average per-capita dairy product consumption and urbanisation; 2) production projections suggest that, under current trends, production is very likely to fall short of demand presenting an important **opportunity for improving the welfare of current and potential smallholder dairy producers** in Tanzania and their market agents, through income and employment generation in dairy production, processing and marketing, 3) investment in agriculture is critical to the process of ensuring a decline in poverty, it offers **pathways out of poverty** at the household level, and 4) research has the potential to **provide solutions for constraints in production** posed by feed resources, seasonality, limited quantity and quality of feed, shortage of replacement start-up stock, and poor breeding services. For these reasons, Tanzania has been selected as one of the study areas for this project.

2.2 Description of the study region

Key findings of a scoping study conducted in 2012 called “Targeting animal production value chains for Tanzania” are presented here to give a general description of the study area. For details and further maps, please refer to the original report (available from the authors or ILRI on request).

Seré and Steinfeld (1996) developed a global livestock production system classification scheme with four production categories: landless systems (typically found in peri-urban settings), livestock/rangeland-based systems (areas with minimal cropping, often corresponding to pastoral systems), mixed rain fed systems (mostly rain fed cropping combined with livestock, i.e. agropastoral systems), and mixed irrigated systems (significant proportion of cropping uses irrigation and is interspersed with livestock). In Tanzania, the mixed irrigated systems cover less than 1% of the surface land area. About one third of the agricultural area in Tanzania is under grasslands supporting (agro-)pastoral livestock production, but the most common production system is **mixed rainfed crop-livestock systems**, covering just over 50% of the land (Figure 1). Bovine densities are highest in the mixed arid/semi-arid (MRA) and humid/sub-humid (MRH) systems as well as in urban areas. The lowest bovine densities are found in rangeland humid/sub-humid (LGH) systems (Table 1).

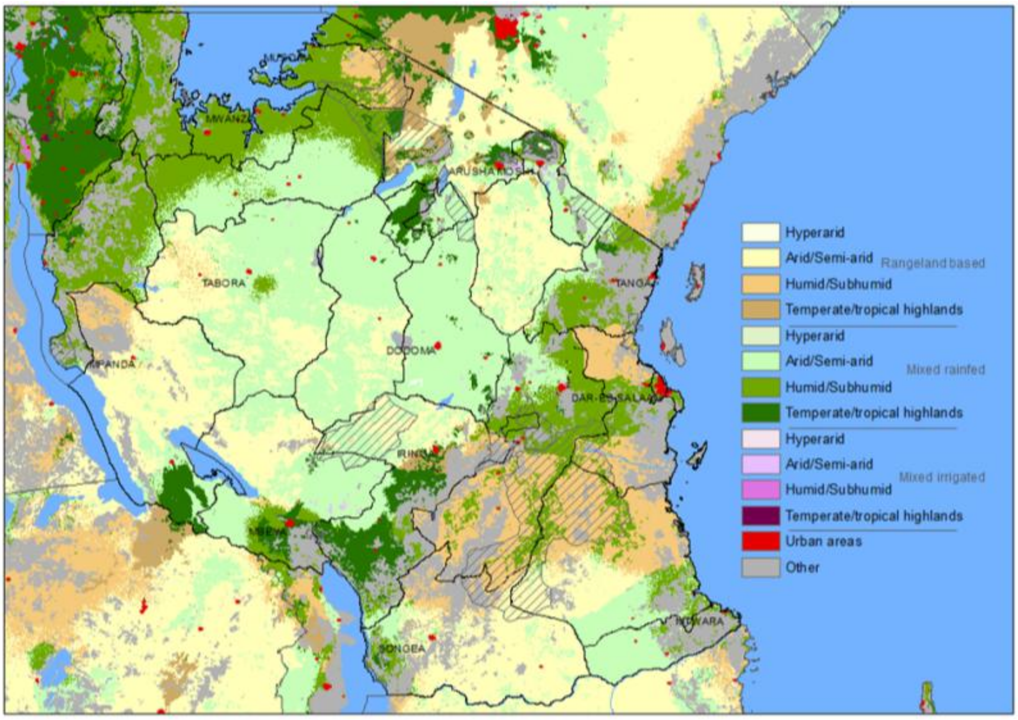

Figure 1: Distribution of production systems in Tanzania. Source: Report "Targeting animal production value chains for Tanzania".

The average milk production in kg per km^2 and year is highest in urban areas followed by rangeland based temperate/tropical highlands (LGT) and MRH and lowest in rangeland based arid/semi-arid (LGA) systems (Table 1).

Table 1: Bovine milk and meat production in Tanzania by production system. Source: Report "Targeting animal production value chains for Tanzania"; feed includes grazing, stover, grain and occasional fodder.

Production system	Average bovine heads/km^2	Average milk production (kg/km^2/year)	Ratio milk production : density	Feed required for milk production (ton/km^2/year)
Rangeland based, (Hyper-) Arid/Semi-arid (LGA)	11.8	666	56	4.1
Rangeland based, Humid/Sub-humid (LGH)	6.4	1,262	197	2.7
Rangeland based, Temperate/Tropical highlands (LGT)	18.8	2,794	149	10.1
Mixed, (Hyper-) Arid/Semi-arid (MRA)	28.2	1,331	47	11.0
Mixed, Humid/Sub-humid (MRH)	31.2	2,555	82	14.9
Mixed, Temperate/Tropical highlands (MRT)	16.5	1,969	119	6.3
Urban	23.1	6,418	278	12.9
Other	8.8	1,965	223	4.3

Human population densities derived from data of the Global Rural-Urban Mapping Project (GRUMP) for the year 2000 show that in the rangeland areas the lowest population densities prevail (mean 10.1-11.3 people/km^2; SD +/- 4.2-4.9), while densities increase in the mixed systems (32.7-52.0 people/km2, SD +/- 31.8-44.1) (Figure 2). With poverty defined as living on less than US$2 per person and day (the US$2 poverty line) and extreme poverty as living on less than US$1.25 per person and day (the US$1.25 poverty line), 85.6% of people in Tanzania are classified as **extreme poor** and 89.0% as **poor**. As most people live in mixed production systems, the absolute number of poor people living in these areas is highest as well. Of the 23 million people living on less than US$2 per day in areas where rangeland and mixed systems dominate, 78-93% depend on farming systems.

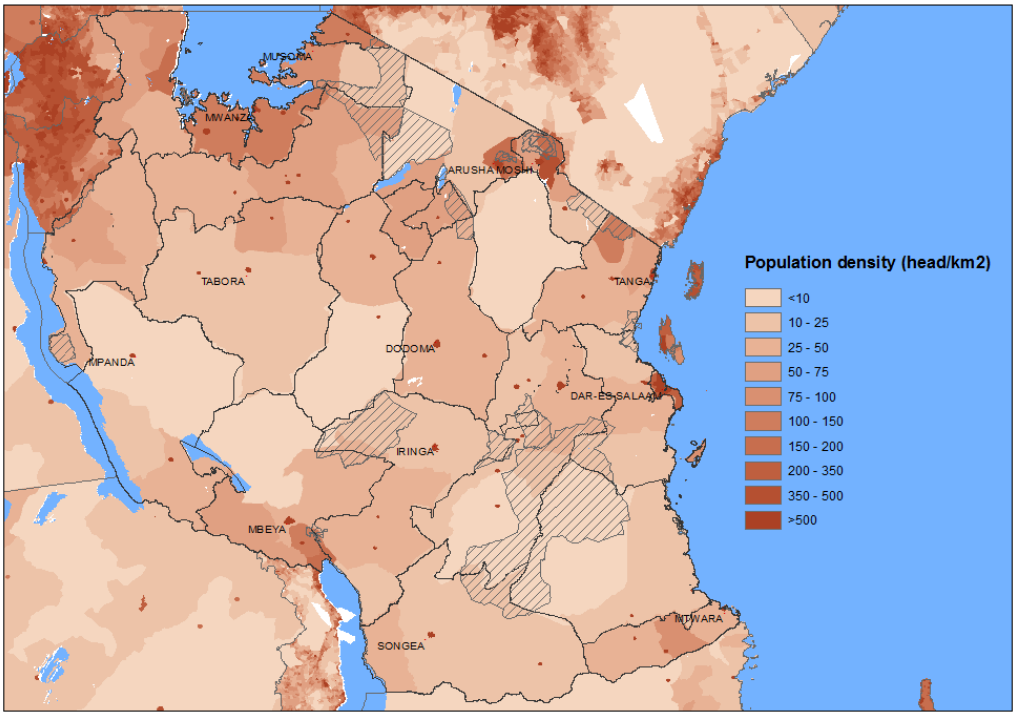

Figure 2: Distribution of human population density in Tanzania. Source: Report "Targeting animal production value chains for Tanzania"

Tanzania has the third largest livestock population in Africa after Ethiopia and Sudan. The **livestock population** includes 22.8 million cattle, 15.6 million goats and 6 million sheep[1]. The regions of Shinyanga and Tabora had the highest number of cattle, followed by Mwanza, Arusha, Mara, Manyara, Singida and Dodoma. The number of cattle per inhabitants is 0.55, which is similar to Ethiopia with 0.58 cattle per inhabitants (Ethiopia has the largest livestock population in Africa), and higher than Kenya with 0.42 cattle per inhabitants. At the household level, livestock keeping is important and an integral part of agriculture based livelihoods for a significant proportion of the Tanzania population.

Travel time to market centres reflects market accessibility and shows the likely extent to which farming households are physically integrated with or isolated from markets. It is important to farming households and other producers to have access to markets in order to trade/sell their goods. Travel time in (peri-)urban areas is lowest, and increases quickly in the mixed systems with large regional variation.

The average **milk consumption** in rangeland areas (LGA, LGH and LGT) is between 203 and 222 kg/km^2/year (as comparison, the urban consumption is 39,381 kg/km^2/year), whereas it is between 663 and 1,046 kg/km^2/year in mixed systems (MRA, MRH and MRT).

[1] These figures have been updated for this report with data from a presentation by the Hon. Minister of Livestock and Fisheries development to the Tanzania Agribusiness Investment Showcase event on 27/11/2012.

2.3 Summary of the dairy value chain

Key findings of a value chain analysis done in 2012 called "Report on participatory rural appraisal to inform the three project of MoreMilkIT, Safe Food Fair Food & MilkIT projects in Morogoro and Tanga regions, Tanzania" by Sikira *et al.* (2012) are presented here to give a general overview. For details, please refer to the original report (available from the authors or ILRI on request).

2.3.1 GENERAL OVERVIEW

The livestock production sector represents the **second largest employer** after other agricultural production in Tanzania and is characterised mainly by **subsistence production**. Of the 4.9 million agricultural households, 35% engage in both crop and livestock production and 1% are pure livestock keepers. The livestock sector contributed 5.9% to the total GDP in 2006, of which 30% was linked to dairy production.

Milk production is rural and divided between various types of production systems, namely extensive and semi-intensive/intensive systems. About 70% of the milk produced in the country is estimated to originate from **indigenous breeds** (Tanzanian Short-Horn Zebu and Boran) which are kept mainly in extensive production systems. Around a third (30%) of milk is estimated to come from **commercial dairy breeds** (mainly Friesian, Jersey and Ayrshire) which are more commonly found in more intensive dairy production systems. Out of the 22.8 million cattle in Tanzania, only 700,000 are dairy cattle breeds or crosses, which are known for their higher productivity potential.

Milk production in Tanzania between 1995 and 2009/10 increased from 555 million to 1.64 billion litres (Ministry of Livestock and Fisheries Development 2011). This increase was accompanied by a substantial increase in cattle population: Compared to the 2002/03 Agricultural Census, the **cattle population** among smallholders increased from 16,999,793 to 21,280,875 in the 2007/08 Census, representing an increase of about 25% giving an annual growth rate of about four percent per annum (Ministry of Agriculture Food Security and Cooperatives et al. 2008). A small amount of the milk produced is marketed into urban areas, while most milk is sold in rural areas, mainly to neighbours and local restaurants.

2.3.2 SELLING CHANNELS

Milk production and marketing is **highly seasonal**, especially in the extensive system where feeding options are limited (i.e. mainly communal grazing land, where other systems also use planted grasses, crops residues and some supplements). There is abundant feed during the long and short rainy seasons, leading to high milk production and lower prices. The inverse trend is observed during the dry season. Seasonal migration of animals in the extensive system to areas where there is pasture and water is practised during the dry season (i.e. end of July to October). This affects milk availability and contributes to the price increase in the dry season (apart from shortage due to reduced production). The downstream marketing system has limited capacity to accommodate seasonal peaks due to deficient transport and storage options, even though some traditional processing methods are used (e.g. fermented milk, butter, ghee).

In the intensive system, **three main selling channels** were identified namely, selling to the collection centres (Tanga Fresh and Tan Dairies), to local restaurants and to neighbours/households, mainly through vendors. The majority of extensive smallholder farmers sell milk directly to neighbours and restaurants due to the high prices offered by these channels; however, there is a preference of vendors' to sell milk to the collection centres even when the price is low due to security/supplier loyalty: collection centres will continue to buy large amounts of milk during the long rainy season, when milk production exceeds demand by accessible consumers. Milk retained at home can be processed by women into fermented milk which will be sold directly to consumers within the village. Milk selling channels in the **extensive systems** are restricted to the selling of milk to neighbours and local restaurants by the farmers or through vendors. In both semi-intensive and extensive production systems, a **lack of market for milk** during the rainy season has been linked to the small number of collection centres that deliver to major processing centres. Price setting for the households, neighbours and restaurants relies often on verbal agreements with some influence from the marketing price offered by the collection centres.

2.3.3 DETERMINANTS OF MILK PRODUCTION

At farm level, **poor feeding and general management practices** of cattle leading to seasonal milk production, coupled with poorly organized marketing procedures and fluctuating prices were hindrances to commercialization of dairy products.

The following **hypotheses** can be derived from the value chain report for further investigation in the rapid assessment:

- Prices of **veterinary inputs** are generally high in all production systems.
- Animal health knowledge is more robust among extensive production farmers, but accessibility of animal health services is greater for intensive farmers.
- There is a **gender division of responsibilities** in the extensive system. Men are the decision-makers with respect to livestock production activities, while women oversee the milking and selling of milk. There is no such clear divide of tasks between men and women reported in the semi/intensive systems.
- Livestock production represents the main source of income among farmers in the extensive system, with crop production being the second source of income. The opposite applies to semi/intensive systems.

2.4 Map of the dairy value chain

Figure 3 provides an overview of the main people and activities involved in the extensive dairy value chain in Tanzania. Veterinary inputs commonly stem from agro-vet shops and auction markets; feed is pasture based. The majority of farmers sell milk to neighbours and restaurants due to higher prices offered by these channels. However, in the rainy season, a large part of production is sold to the collection centres. The channels for processing through the milk collection centres are mainly Tanga Fresh and Tan Dairies, which receive milk mostly through vendors. Fresh milk hawkers generally play an important role, as they sell milk from producers directly to consumers, households, and the milk collection centres. There are no vendors involved in the distribution of fermented milk. Generally, the proportion of sales to neighbours, restaurants, and collection centres depends on the village and the related ethnicities, consumption practices, other income sources and cultural practices.

Semi-intensive systems include maize bran (a milling by-product) and inputs from animal health officers. The distribution channels differ in that there is less selling of milk directly to households and a large part of the milk is marketed through vendors.

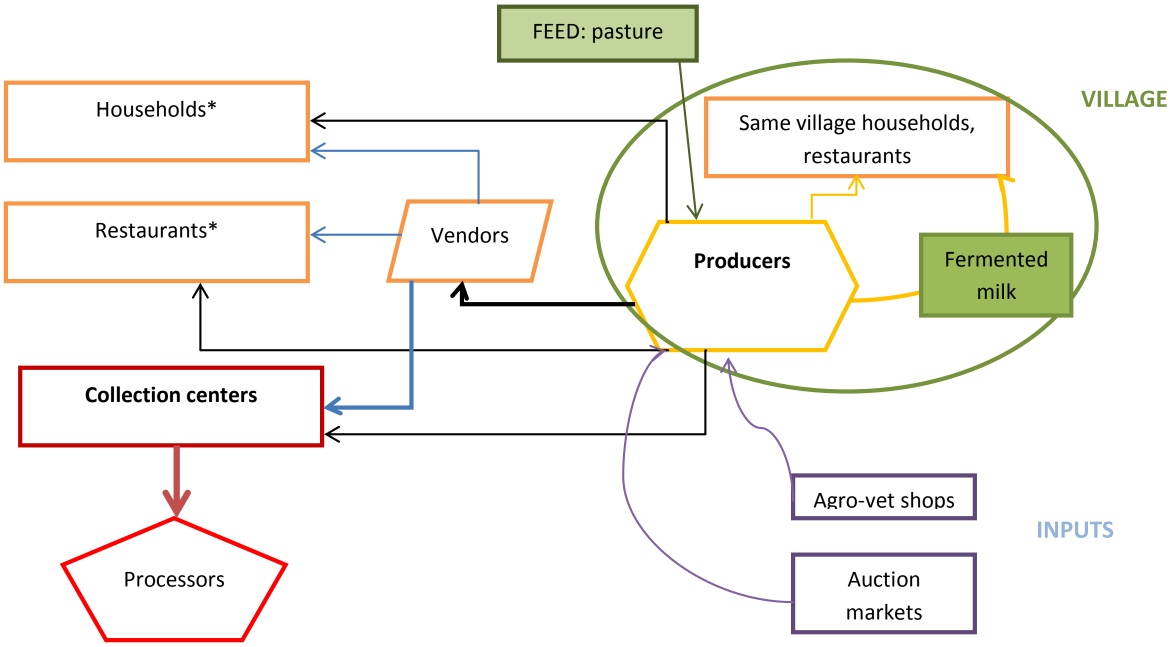

Figure 3: Map of the extensive dairy value chain in Tanzania. The relative importance of channels is illustrated by arrow size. *During the rainy season, a large part of the small-scale production is sold to collection centres through vendors. Source: drawn based on information from (Sikira et al. 2012)

2.5 Literature review of hazards in the food chain and nutrition issues

A literature review on foodborne hazards in Tanzania is available as an independent document at ILRI.

2.6 Situational analysis of regulatory frameworks

A situational analysis was conducted in 2011 by Kurwijila *et al.* to get an overview of the regulatory frameworks that govern and drive the dairy value chain in Tanzania. This information is critical to be able to understand the factors that promote or hinder changes in the value chain, the wider context of regulation, power and relationships, and the general decision-making and resource allocation structures. By taking into account these frameworks from the start, research activities can be tailored towards research questions and possible future interventions that have a high likelihood of being practical, accepted and successful.

The description of the regulatory frameworks in this section are a summary of the report "Safety of Animal Source Foods in Tanzania: A Situational Analysis" (Kurwijila et al. 2011); for details please refer to the full report.

In Tanzania different segments and activities of the food value chain fall under the command of **multiple government ministries, departments and institutions** creating a complex net of regulators with often overlapping functions. This can lead to duplication of efforts, unclear institutional responsibilities, a deficient chain of command, and difficulties in understanding the regulations and therefore compliance among the people working in the value chain. Apart from the fisheries export industry, where substantial investments have been made, there is no financial government support for institutions involved in food safety and quality control. There seems to be a firm belief among government circles that market forces, more so than regulations, will bring about improvements in food safety and quality and also to the local, informal food supply.

Under the local government reform programme Tanzania's governance system has been decentralized to the District level hence **enforcement of food law** is done at the local government level, with the central government retaining inspecting and legislative functions.

Many rural households obtain animal products from their own farms or purchase from their neighbours. In Tanzania, the **majority of milk consumed off-farm comes from direct farmer to consumer transactions**. In such cases there is no formal inspection of milk, and products from sick animals may be consumed by rural customers or by the household members themselves. Some milk is also sold on wet markets, in small shops, groceries and supermarkets, where vendors or hawkers play a significant role in connecting producers to consumers (in particular in urban and peri-urban centres).

About 99% of the livestock in Tanzania are owned by traditional smallholders, which provide an important source of nutrients for the national population. However, the informal sector is not subject to a formal inspection process established by the government. There are production guidelines set by the Tanzanian Food and Drugs Authority (TFDA) as well the National Bureau of Standards (TBS), but milk buyers often define their own testing regime. For example, some **private initiatives** in the form of **milk producers and processors** test the quality of milk upon delivery in the milk collection centres. If the milk does not comply with their minimum requirements defined, it is being rejected by the centre. The main producers and processors of milk in Tanzania include Tanga Fresh (Tanga), Azam Dairy (Dar Es Salaam), TanDairies (Dar Es Salaam), ASAS dairies (Iringa), x-TDL Northern creameries (Arusha), CEFA Njombe Milk (Njombe), and International Dairy Products (Arusha); together they handle less than 3% of marketed milk in Tanzania. Some of them (e.g. Tanga Fresh) are known to use HACCP guidelines. Due to poor milk collection and marketing infrastructure most of them are operating below capacity. Moreover, they often offer lower prices lower prices relative to other (informal) outlets. Capacity used in 2009 was 58.3% for ASAS dairies, 62.9% for Tanga Fresh, 75% for TanDairies, 60% for International Dairy Products, 25% for x-TDL, and 20% for CEFA Njombe Milk. Given an estimated annual average of about 30% utilization capacity of chilling plants nationally (personal communication Amos Omore), these figures are likely to reflect peak seasonal utilization. These milk processing plants collect milk from small scale producers for processing into pasteurised milk, yoghurt, fermented milk, ghee (purified butter), cheese and butter. The products are then sold in the formal market chain. Usually cold chain storage is maintained throughout the transportation marketing pathway. Absence of electricity both in rural areas and in some sections of urban and peri-urban areas limits marketing in low income settlements.

In terms of **high-level regulatory frameworks**, the Tanzania Agriculture Policy 1997 and the Livestock Policy 2006 provide the foundation for broader food and agriculture policy objectives. The cornerstone of these policies is to achieve food and nutrition security for the nation and commercialization of smallholder agriculture in an environmentally sustainable manner. Another instrument is the food and nutrition policy for Tanzania, prepared by the Ministry of Health (1992).

The **Food and Nutrition Policy for Tanzania** (1992) gives background information on malnutrition and addresses food and nutrition problems and their causes. These include protein, energy, and iodine deficiency, malnutrition, nutritional anaemia, iron deficiency disorders and vitamin A deficiency, especially amongst children. The policy document further describes how to improve food security, to care for vulnerable groups like young children or pregnant women, to create a healthy environment through water, sanitation, shelter, and education and describes the roles of committees and the government to achieve these aims. The main objective of this policy is the elimination of malnutrition and related health problems in the population. While the policy addresses food quality issues it does not touch on the importance of food safety aspects.

Tanzania laws and regulations on animal health and food safety cover general animal health, the use of veterinary drugs, food hygiene, labelling, use of additives, transportation of meat and raw milk, treatment of food unfit for human consumption, appointment of dairy inspectors, production of dairy products, food irradiation, waste disposal, and national standards. Under the local government reform programme Tanzania's governance system has been decentralized to the District level since 1996. The decentralized nature of Tanzania's system of government requires delegation of law enforcement to Local Government Authority, that is, local districts and municipal authorities. Consequently food control is regulated and purportedly audited by the central government, but **enforcement is the responsibility of Local Government Authorities** – a system which is also found in many other countries (e.g. Mexico, Bolivia, or Switzerland). This structure is not conducive to a homogenous or balanced allocation of scarce resources among the various districts and municipalities, which commonly lack properly trained staff, equipment and tools for appropriate enforcement of national food safety laws and regulations.

Existing food control legislation does not define the rights of consumers to safe and healthy foods nor does it make any reference to the responsibility of food producer and processor to provide safe and wholesome foods. Tanzania has ratified the World Trade Organisation's Agreement on Sanitary and Phytosanitary Measures (SPS) and the Agreement on Technical Barriers to Trade (TBT) that govern food safety and agricultural products in international trade. As such, the country recognizes the standard and guidelines established by FAO/WHO Codex Alimentarius Commission (CAC) and the related phytosanitary measures stipulated by the World Animal Health Organization (OIE). However, these agreements are for products traded internationally and there usually are no legally binding agreements for national production and marketing.

The **traceability system** ratified by the government and stipulated in national legislation in 2010 is still under development.

The revised **Food Law** implemented in 2003 (Tanzania Food and Drugs Cosmetics Act, 2003) places food safety control actives under the TFDA that operates as a single system in which the Director General is responsible for all food safety issues whereby local authority inspectors cannot be involved in inspections unless appointed by the Director General. Under this Act, the TFDA has the overarching mandate for food safety. However several other agencies are also involved. None of these agencies including TFDA use any documented formal risk assessment methods, as for example suggested by the CAC or the OIE.

The **national inspectorate** employs about 50 personnel while the local government authorities employ about 500 employees at district level and below (ward and village level). Most of the inspectors are employees of central government agencies or of the local government authorities throughout the country. Most hold post secondary school certificate and diplomas as well as university degrees especially those manning district and regional level positions. They fall under three categories of specialization: health officer, veterinary officer, and food technologist.

More emphasis is placed on **inspection** of food meant for export or being imported in the country than foods produced for local consumption. In the 1.6 m small-holder farms there is no regular inspection instituted and it is estimated that about 0.1% are inspected informally every year. Of the formal milk collection sites, 100% are inspected to check processes and compliance with legislation. Following up the chain to the level of the consumer, various inspections are conducted in the formal chain, whereas the informal chains are rarely inspected. There are two exceptions: 40% of informal eating places are inspected, whereas there is no inspection at all at consumer level. These inspection frequencies were translated into probabilities of an animal source food having been inspected at different points in the value chain (Table 2).

Table 2: Probability of inspection for various animal source foods (Kurwijila et al. 2011)

Type of food	Probability of being inspected
Street foods	1/1000
Animal Source Foods sold in small rural villages	1/100
Animal Source Foods sold in pastoralist areas	0/1000
Animal Source Foods sold in open markets	1/1000
Animal Source Foods hawked door to door	1/1000
Animal Source Foods at celebrations, feasts, events	0/1000
Animal Source Foods in remote areas	0/1000
Animals killed for home consumption	0/1000
Animal Source Foods in institutions (hospitals, schools, canteens)	1/100
Animal Source Foods sold in supermarkets	1/1
Animal Source Foods sold in eating places	1/100
Animal Source Foods exported	1/1

Inspections are commonly based on legislative requirements regarding specific risk factors such as zoonoses, adulterations, expiry dates, labelling etc.

There is currently no institutionalized **food borne diseases surveillance** system. However, TFDA is conducting a pilot food borne diseases surveillance system in 17 districts of Dodoma, Singida and Manyara regions. There is sporadic monitoring of chemical (including pesticide and veterinary drug residues and mycotoxins) or microbial contaminations of local food supply. Consequently, there is lack of data on which to base risk assessment of food borne hazards and /or justify subsequent risk mitigation strategies.

There are hardly any **private processors** who have defined their own standards that are above those set by regulatory bodies and the TBS. Most, if not all, struggle to meet the legal requirements, standards, procedures, guidelines and codes of practices. Business member organizations include the Tanzania Milk Producers Association (TAMPRODA) and Tanzania Milk Processors Associations (TAMPA). They are in the process of establishing themselves and recruit more members countrywide.

Under the TBS procedures for setting standards, the private sector is represented in the industry (dairy, meat, poultry, animal feeds) technical committee that drafts standards before inviting public comments and reviews. This is as far as the private sector gets involved in standard setting.

Coping strategies by consumers to ensure food safety in the informal sector include boiling of animal source food and serving while hot. However, this may not always be adequate to get rid of some chemical contaminants which may emanate from mishandling of livestock products along the value chain or from husbandry practices. This is also equally true in the formal sector when it comes to hazards such as drug residues in milk and meat.

In conclusion, regulatory measures need to address the situation in informal or traditional markets if they are to offer a level of public health protection that is responsive to the risks that may be posed by the prevailing conditions of the current food supply systems operating in the country.

3 METHODS

The rapid integrated assessment toolkit includes participatory rural assessments, focus group discussions, structured questionnaires including observation checklists, and biological sample collection. These instruments were applied at the production, bulking (i.e. wholesale or collection points), processing, retail and consumption stages in 10 villages and one city in the provinces of Tanga and Morogoro, as described in the next section.

3.1 Site selection

The site selection was a structured process under the lead of the CGIAR Research Program Livestock and Fish taking into account the information collated in the report "Targeting animal production value chains for Tanzania" (report available from the authors or ILRI on request).

First, **geographical targeting** of potential regions for consideration was performed using GIS technology based on global datasets to illustrate human and cattle population density and the farming systems, where the focus was on mixed production systems. Within these maps, five major milk sheds were identified based mainly on GIS data and partly complemented by expert opinion: Tanga, Morogoro, Southern Highlands, Great Lakes, and Northern Highlands. Next, stakeholder consultations were conducted to define critical selection criteria and to select two **study regions**, namely **Morogoro and Tanga** (Figure 4). Both regions showed seasonality of feed and milk production, generally low production per cow, neither cultivation of fodders nor any conservation, very little milk processing, and very low proportion of improved cattle. In Morogoro, some ethnic groups did not have a habit of milk consumption, and it was concluded that there was large potential for future development of both production and consumption. In Tanga, pastoralists were observed to keep a high number of cattle in their herds. Tanga Fresh Ltd has a monopoly on milk processing in the region and therefore the power to set prices. Some organisation of milk producers was also observed in the area.

Within these two regions, districts were prioritized in another stakeholder consultation in March 2012, which focused on districts with dairy cattle populations and milk collection channels. Finally, three districts per region were selected for a scoping visit to gather local information: Kilombero, Mvomero and Kilosa districts in Morogoro region and Handeni, Lushoto, and Muheza districts in Tanga region. The districts were assessed in terms of their rural production to urban or rural consumption, dairy farming practices, presence of milk collection centres, seasonality effects, and agro-ecosystems (Lukuyu et al. 2012).

Figure 4. Location of the two targeted regions Morogoro and Tanga in Tanzania

The **districts** finally chosen were **Lushoto and Mvomero**, which represented rural production to rural consumption, and rural production to urban consumption (Lukuyu et al. 2012). The site selection team reported that Mvomero district had a cattle population of 187,350 with an average milk production of about 5 litres per cow per day. About 5% of cattle were improved breeds and the majority of the 178,036 indigenous cattle kept by agro pastoralists. Seasonality effect was reported as a major constraint on production, leading to long travel distances in search of feed and water. Milk was mainly supplied to the nearby Morogoro urban centre by private milk traders. In Lushoto district, there were 119,492 cattle of which 24% (29,200) were improved breeds. Most cattle were reported to be found in the highlands, where 65% of households own cattle. The average number of cattle per household was 2-3 in the highlands and >10 in the lowlands. 75% of the milk was sold to Tanga Fresh Ltd through four available milk collection centres in Lushoto, Shume, Mwangoi and Bumburi, whereas the remaining 25% were sold locally. There were three livestock keeper networks that drew membership from farmer groups. Key characteristics of the two districts are summarised in Table 3.

Table 3. Key characteristics reported for the selected Mvomero and Lushoto districts (compiled using data from Lukuyu et al. 2012). TSH = Tanzanian Shilling

District	Zero/semi grazing (%)	Grazing	Milk price collection centres (TSH)	Milk price local markets (TSH)	Rural to rural	Link to urban markets	Potential to improve feed
Mvomero	10	90	-	700	Low	High	Medium
Lushoto	25	75	500	700-800	Low	High	High

Within each district, a **shortlist of 25 suitable villages** was created taking into account the dairy cattle population, trade flows, location, the production system and local practices, such as milk consumption.

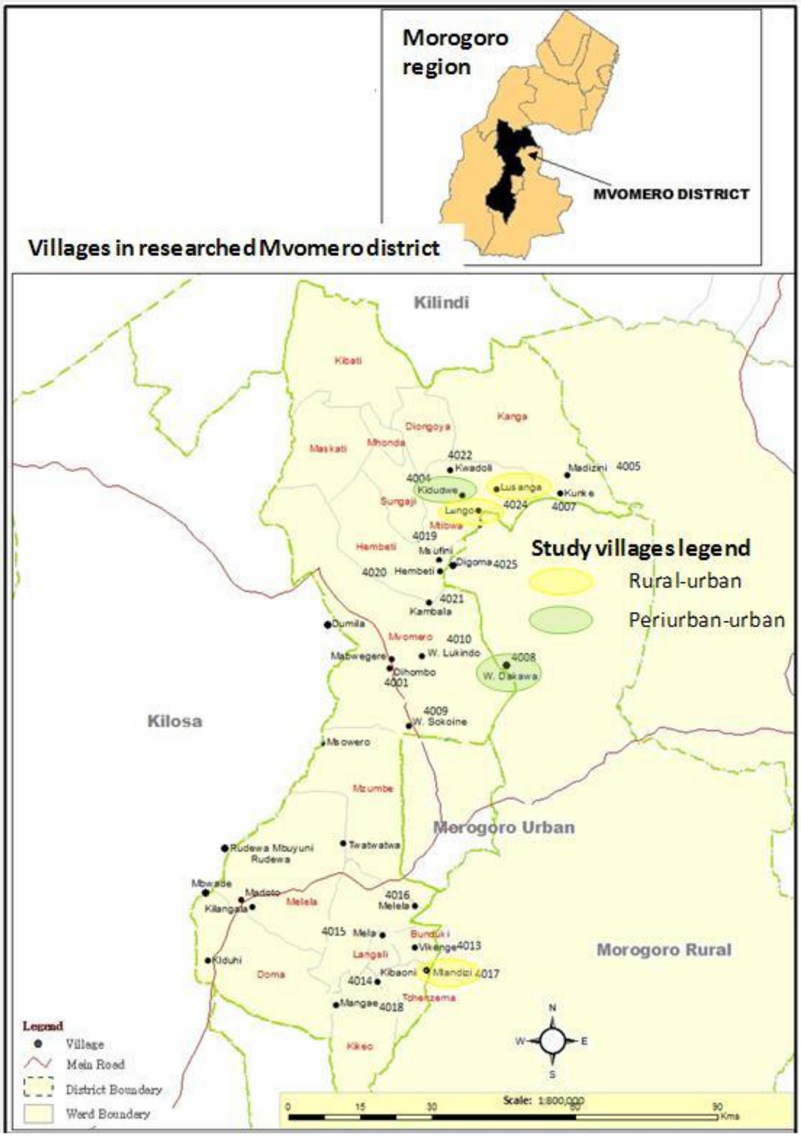

Figure 5: The five villages Kidudwe, Lubungo, Lusanga, Wami Dakawa, and Mlandizi selected in Mvomero district in Morogoro region.

From the sample frame of 25 purposively selected villages, five per district were randomly selected with the aim to represent extensive/(agro)pastoral, semi-intensive/sedentary and intensive/also sedentary systems. Researchers from each region then visited site locations and consulted further with research partners and other stakeholders to assess the willingness of the community to participate in further studies, and accessibility to researchers. If the village was found not to be suitable, another village was randomly selected. The final ten villages included in this study are illustrated in Figure 5 and Figure 6.

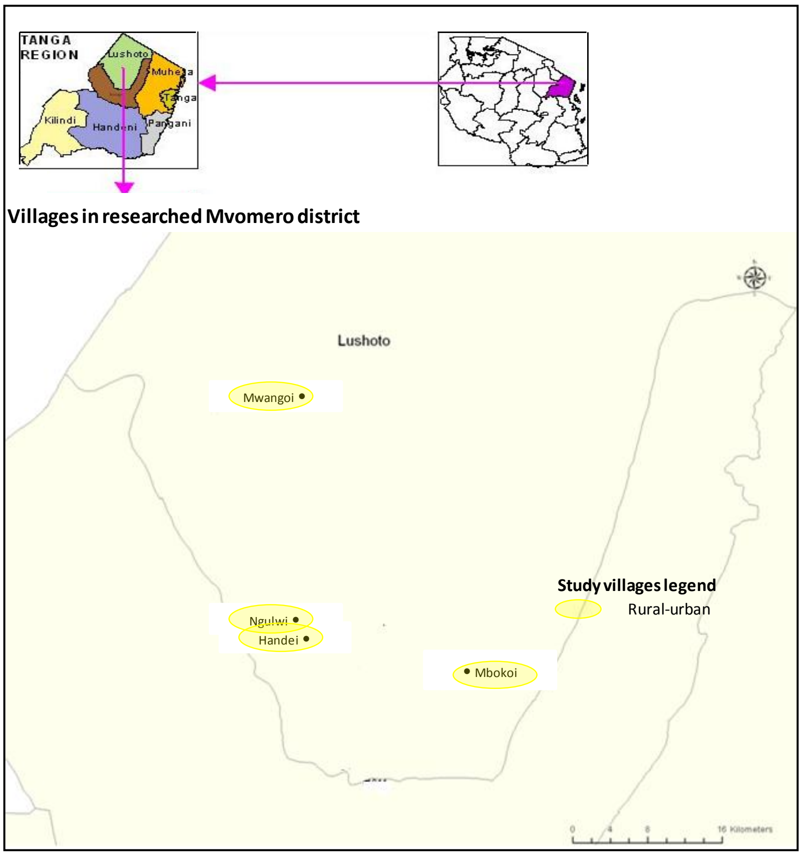

Figure 6: The five villages Mbokoi, Mwangoi, Ngulwi, Handei and Manolo selected in Lushoto district in Tanga region (Manolo is not visible on this map, as it lies further North).

3.2 Study design

The ten villages that were selected using the approach described in the previous paragraph were considered to be broadly representative of the administrative region. Because of the limited number of people available for interviewing in the study sites, it was not possible to follow products along the chain with forward and backward tracing and systematically interview people linked in the chain (e.g. producer-vendor-consumer). Therefore, it was decided to carry out a cross-sectional survey instead at the level of producer, transporter, retailer, and consumer. Only the biological sampling was conducted along the same dairy chains (see below).

3.3 Compliance

The sampling protocols were submitted to the ethics committee of the Royal Veterinary College, London, UK, and ethical clearance was granted (reference number URN 2012 1191). Moreover, the protocols were submitted to and approved by Sokoine University of Agriculture in December 2012 (reference number SUA: SUA/ADM/R.1/8) and to the ILRI Institutional Research Ethics Committee (IREC), from which approval was received in June 2013 (reference number ILRI: IREC2013-03).

Because no samples were taken from living animals or exported to another country, no further approvals or permits were needed.

3.4 Sampling strategy

For the **participatory data collection activities**, local partners with support from the responsible extension officers invited a group of 6-8 producers and consumers each to participate in the study. The discussions were open to anyone who met the criteria. Participants were randomly selected from the village representing the target group of interest. The sampling frame was the list of all household heads. A table of random numbers was used to select producers and consumers, respectively. Arrangements were made to ensure that in each household, a man and woman were picked interchangeably to avoid mixing husband and wife participants in the same group.

Key informant interviews were targeted at people with a critical role in the dairy value chain and a good understanding of how the chain works and its formal and informal rules, enforcement, and power structures (e.g. animal health officers).

The sample size calculation for the **consumer survey** was based on the following key indicator estimates:

- Prevalence of a key hazard – unknown, anticipated 50%
- Proportion of milk and dairy products in diet by weight – anticipated 5%
- Self-reported gastro-intestinal illness in last 2 weeks –anticipated 10%

With a 95% confidence interval, a margin of error of 5% and assuming a design effect of 2, the targeted number of households to be interviewed in the 10 villages was 300, i.e. 30 households per village. Enumerators obtained a list of households per village and randomly selected 30 households for the interviews using Microsoft Excel random number generator function. Finally, they contacted the households and scheduled visits with the head of the household or any other person authorised to talk to the enumerators.

The sample size calculation for the **producer survey** was based on the following key indicator estimate:

- Prevalence of a key hazard – unknown, anticipated 50%

With a 95% confidence interval, a margin of error of 5% and assuming a design effect of 2, the targeted number of producers to be interviewed in the 10 villages was 300, i.e. 30 households per village. Enumerators obtained a list of producers per village and randomly selected 30 producers for the interviews using Microsoft Excel random number generator function. Finally, enumerators contacted the households and scheduled visits with the producers. In villages where not enough producers were available for interview (e.g. when producers were long distances away with their cattle in different grazing grounds), as many producers as available were included in the sample.

Biological sampling

In two independent Master of Science studies conducted at Sokoine University of Agriculture (Joseph 2013; Shija 2013), five villages each in Mvomero and Lushoto districts were visited. The villages were randomly selected from the list of 25 villages described above. Households were randomly selected in the 10 villages. In addition, samples were also collected along the chain starting from the producer household, following the milk bought by vendors and collection and selling centres as well as consumption centres such as kiosks/restaurants. The inclusion criteria of the study participants were availability of milk during the time of sample collection and willingness to participate in the research. In total, 328 milk samples were obtained, namely 166 samples from Tanga region (102 samples from Lushoto and 85 samples from Handeni districts), and 109 samples from Morogoro region (60 samples from Mvomero district, 49 samples from Kilosa district). In Mvomero district, the five villages visited were Madizini, Manyinga, Wami Sokoine, Wami Dakawa and Wami Luhindo; in Lushoto district the five villages visited were Ubiri, Magamba, Chakechake, Irente and Hamboyo. Mainly raw milk was collected although a few fermented milk or local milk product samples were also received from willing farmers. Collection of samples was done early morning between 6 and 7 am by using 50ml sample collection tubes from the milk containers owned by the respondent. When there was more than one container in the household, samples were taken from each of the containers. Samples were transported in an ice packed cool box and stored in an 4°C refrigerator for a maximum of four days. Thereafter the samples were transferred and stored at -80°C in the laboratory of microbiology at Sokoine University of Agriculture until analysis.

3.5 Tools used

A rapid assessment of potential food safety and nutrition risks and benefits within the dairy value chain was conducted using participatory rural appraisals (PRAs), focus group discussions (FGDs), cross-sectional surveys and biological sampling. The protocols for the PRAs and FGDs can be found in Appendices 1, 2 and 3.

The **PRA for producers** included the following:

- **Seasonal calendars**, where counters were used to indicate dairy production and consumption, rainfall, and times of general food shortage during the year.
- **Pair-wise matrices on constraints**, for which producers listed constraints on increasing volume or quality of dairy production. These constraints were then entered along two sides of a matrix and respondents were asked to identify the most important constraint from each column-row pairing. The total number of times each constraint was listed as the most important of a pair was used to allocate an overall ranking for the whole matrix.
- **Problem-opportunity matrix**, in which previous and potential interventions for the major constraints on production were discussed.
- **Proportional piling to assess herd entries and exits** on farms (proportion of animals entering and leaving the herd, proportion of deaths attributed by farmers to different causes, proportion of animals affected by different diseases)
- **Knowledge, attitudes and practices** (KAP) surrounding food quality and safety.

The **PRA for consumers** also included seasonal calendars and KAP investigation. Additional tools were:

- **Listing, rating and ranking of the role of all animal source foods** (ASF) in the diet.
- **Venn diagram** to indicate proximity and importance of different sources of dairy products.
- **Flow charts** to demonstrate the typical pathway of food preparation and handling between purchase/harvest of dairy products and consumption.
- **Listing and elaboration of the role of ASF** in diets of young children.

Focus group discussions (FGDs) were also conducted with mothers of young children, and included questions on food preparation practices, consumption of food products by different members of the community, possible associations between food and health problems, and the importance of food waste or animal feeds competing with food for people.

The **consumer survey** included open and closed questions on the respondent's sex, age, ethnicity, education, role in the household, composition and assets of the household, livestock keeping or work in the dairy industry, household food security, milk purchasing, processing and consumption practices, human illness, and statements to enquire about people's knowledge and attitude regarding milk intake (Appendix 4).

The **producer survey** included open and closed questions on the respondent's sex, age, ethnicity, education, number and type of cattle kept, use of inputs, biosecurity, milking and milk hygiene, outputs, and statements to enquire about people's knowledge and attitude regarding milk safety. The protocol also included a checklist based on observation by the enumerator including biosecurity, worker condition, storage conditions, and management (Appendix 4).

3.6 Data collection and analysis

Data was collected during the PRAs and FGDs by dedicated note-takers. Qualitative data was left intact. Semi-quantitative and quantitative data was entered into a spreadsheet and cleaned. Ranking of constraints was converted to a scoring system (highest rank = highest score) to allow comparison between sites. Data from the surveys were analysed descriptively and combined with the information from the PRAs and FGDs to address the research questions posed.

Testing of biological samples

Samples were analysed for coliform counts and total plate counts and subjected to PCR analysis for brucellosis and *E. coli* as described in detail elsewhere (Joseph 2013; Shija 2013). To quantify the total viable count and coliform count 25 samples from Lushoto and 25 samples from Handeni districts were randomly selected from the total number of samples collected (of the 25 samples per district, 15 were boiled milk samples from the consumers, restaurants and vendors, and 10 were un-boiled milk samples from farmers, vendors and collection centre); around 25 samples each were also tested for Mvomero and Kilosa districts. Ten-fold serial dilution of the milk samples from 10^{-1} to 10^{-10} in sterile normal saline solution was done before mixing 1ml of the inoculum with MacConkey agar for total coliform count and Nutrient agar for total viable count in a sterile Petri dish and incubating it at $37^{o}C \pm 1^{o}C$ for 24 hours to allow for bacterial growth.

By using a bacterial colony counter, the number of colony forming units (CFU) was counted. Two consecutive plates with countable colonies were considered to calculate the number of bacteria using the following formula:

$$\text{Number of bacteria} = \frac{\text{Number of colony forming units (CFU)}}{\text{Volume plated (ml)} \times \text{total dilution factor}}$$

Conventional uniplex PCR was used to identify *B. abortus* and pathogenic *E. coli* (0157:H7) in milk samples using their specific primers (BRU P5 and BRU P8 for *B. abortus* and O157-3 and O157-4 for

E. coli). A total of 166 samples from Lushoto and Handeni districts and 109 samples from Kilosa and Mvomero districts were analysed for the presence of *E.coli* 0157:H7. A total of 87 samples from Lushoto and Handeni districts and 82 samples from Kilosa and Mvomero districts were analysed for *B. abortus*. The samples analysed for *B. abortus* were selected by simple random sampling from the total milk samples available (Joseph 2013; Shija 2013).

Food consumption score (FCS)

The FCS is a composite score based on dietary diversity, food frequency, and relative nutritional importance of different food groups; it is a measure of food security. To calculate it, the guidelines given by the World Food Programme were followed (World Food Programme 2008): First, data were cleaned to exclude the households with missing data. Next, all the food items from the 7 day recall were grouped into specific food groups as listed in Table 4, then the sum of consumption frequencies was made and recoded with a maximum value of 7 days/week for each food group. Next, the value obtained for each food group was multiplied by its weight to create new weighted food group scores (weights are given in Table 4). Finally, the sum of the weighed food group scores was made, thus creating the FCS.

$$FCS = a_{staple}x_{staple} + a_{pulse}x_{pulse} + a_{veg}x_{veg} + a_{fruit}x_{fruit} + a_{animal}x_{animal} + a_{sugar}x_{sugar} + a_{dairy}x_{dairy} + a_{oil}x_{oil}$$

Where

x_i Frequencies of food consumption = number of days for which each food group was consumed during the past 7 days

a_i Weight of each food group

Table 4: Food groups and their weights used to calculate the food consumption score (World Food Programme 2008):

	Food Item (examples)	Food groups (definitive)	Weight (definitive)
1	Maize, maize porridge, rice, sorghum millet pasta, bread and other cereals	Main staples	2
	Cassava, potatoes, other tubers, plantains		
2	Beans, peas, groundnuts, cashew nuts	Pulses	3
3	Vegetables, relish, leaves	Vegetables	1
4	Fruits	Fruit	1
5	Beef, goat, poultry, pork, eggs, fish	Meat and Fish	4
6	Milk, yogurt, other dairy	Milk	4
7	Sugar and sugar products	Sugar	0.5
8	Oil, fats and butter	Oil	0.5
9	Spices, salt, fish powder, small amounts of milk for tea	Condiments	0

4 RESULTS AND DISCUSSION

The tools and methods applied in this scoping study aimed to identify research opportunities for improving nutrition and decreasing health risks in informal value chains, such as new technologies, development of institutions, social and marketing innovations. In this section, the findings from the value chain analysis, situational analysis, participatory assessments, consumer surveys, biological sampling, and key informant interviews are drawn together to discuss the key research questions described at the beginning. For detailed findings of the focus group discussions and participatory appraisals please refer to the full reports in the appendices.

4.1 Description of respondents and study sites

In each district, five out of 25 villages identified in the selection of study sites described above were selected. Per village, one consumer PRA, one producer PRA and one FGD were conducted, complemented by interviews with key informants (e.g. extension officers). The total number of participants in the producer PRAs ranged from 10 to 17 with male participants dominating in all groups (proportion of men 64-80%), apart from one group, where men only represented 40% of participants. The total number of participants in the consumer PRAs ranged from 13 to 19 with female participants representing more than half of the participants (proportion of women 53-76%), apart from one group where women only represented 42% of participants. The number of women participating in the FGD ranged from 5 to 13.

Table 5 describes the characteristics of the 157 respondents interviewed in the consumer survey. Of the 157 respondents, 98 (62%) were women and 59 (38%) were men. The mean number of respondents per village was 15.7, with the lowest number of people interviewed (6 respondents) in Wami Dakawa and the highest (22 respondents) in Kidudwe. Two thirds of respondents (61%) reported to be Muslims, 38% Christians, one person (1%) was Jewish and one person (1%) did not give an answer. There were 31 different ethnicities among respondents, of which the most frequently mentioned one was Msambaa (44%). In all villages, for the majority of people, crop farming was the primary activity. Animal keeping was also mentioned in all villages apart from one (Lusanga). The mean number of members per household was 6 (min 2, max 19, standard deviation 3.17). Most respondents (75%) had a primary school education, 8% each had secondary or no education, 4% reported an informal education, and 4% did not give an answer.

Table 5: Summary of participants in the consumer survey. The villages highlighted in blue are in Mvomero district, the villages highlighted in green are in Lushoto district.

Village	No. of males	Mean age males	No. of females	Mean age females	Predominant religion	Predominant ethnicity	Crop farming and animal keeping
Kidudwe	12	51	10	41	Christian	Mixed	Crop farming: 19 Animal keeping: 10
Lubungo	7	37	6	34	Islam	Luguru	Crop farming: 9 Animal keeping: 4
Lusanga	6	60	9	33	Islam	Mzigua	Crop farming: 8 Animal keeping: 0
Mlandizi	3	27	14	51	Christian	Mixed	Crop farming: 12 Animal keeping: 6
Wami Dakawa	1	60	6	31	Mixed	Mixed	Crop farming: 3 Animal keeping: 3
Handei	8	49	3	37	Islam	Msambaa	Crop farming: 10 Animal keeping: 3
Manolo	3	21	13	37	Mixed	Mixed	Crop farming: 14 Animal keeping: 5
Mbokoi	11	47	5	41	Mixed	Msambaa	Crop farming: 13 Animal keeping: 4
Mwangoi	4	41	15	39	Islam	Msambaa	Crop farming: 12 Animal keeping: 4
Ngulwi	4	56	17	41	Islam	Msambaa	Crop farming: 15 Animal keeping: 2

Table 6 describes the characteristics of the 150 respondents interviewed in the producer survey. Of the 150 respondents, 100 (67%) were men and 50 (33%) were women. The mean number of respondents per village was 15, with the lowest number of people interviewed (6 respondents) in Wami Dakawa and the highest (23 respondents) in Mwangoi. Ninety-three respondents (62%) reported to be Muslims, 56 (38%) were Christians and one person did not give an answer. There were 14 different ethnicities among respondents, of which the most frequently mentioned one was Msambaa (57%).

Table 6: Summary of participants in the producer survey. The villages highlighted in blue are in Mvomero district, the villages highlighted in green are in Lushoto district.

Village	No. of males	Mean age males	No. of females	Mean age females	Pre-dominant religion	Pre-dominant ethnicity	Pre-dominant education
Kidudwe	5	47	3	31	Muslim and Christian	Mixed	Primary
Lubungo	1	29	10	49	Christian	Maasai	None
Lusanga	7	49	8	47	Muslim and Christian	Mixed	Primary
Mlandizi	7	36	0	n/a	Christian	Maasai	None
Wami Dakawa	5	48	1	38	Christian	Maasai and Mchaga	Mixed
Handei	20	45	0	n/a	Muslim	Msambaa	Primary
Manolo	16	38	5	35	Muslim and Christian	Msambaa and Mpare	Primary
Mbokoi	13	47	7	54	Muslim and Christian	Msambaa	Primary
Mwangoi	13	46	10	46	Muslim	Msambaa and Mpare	Primary
Ngulwi	13	54	6	52	Muslim	Msambaa	Primary

The type of cattle used most frequently by producers was cross-breed cattle; they were owned by 123 respondents and kept by 35 respondents. Local cattle were owned by 34 respondents and kept by 14 respondents. Exotic cattle were owned by 5 respondents and kept by 1. The median number of cross-breed cattle owned was 2 (range 1-11, SD 2). The median number of local cattle owned was 15 (range 1-400, SD 90). The median number of exotic cattle owned was 8 (range 1-10, SD 4). The median of the average daily milk production reported across all cattle types was 6 litres per day (range 1-70, SD 10). The median of the best cow milk yield reported was 4 litres per day (range 0.5 to 14, SD 3).

There were some **critical differences** among districts and between some villages; these are described in the following paragraphs.

In **Mvomero district** it proved more challenging to find producers, because the district is dominated by the Maasai, a Nilotic ethnic group of semi-nomadic people inhabiting Kenya and northern Tanzania whose lives revolve around their cattle for food and status (one of the Maasai herders interviewed is portrayed in Figure 7).

Figure 7: Timo, one of the Maasai cattle herders interviewed with a group of his calves. (Photo by Barbara Haesler)

At the time of the interviews (between November 2012 and January 2013) they were trekking their animals in the search of pastures and therefore absent from the homesteads and villages. The predominance of Maasai producers characterised the dairy production system in this district causing important differences in feeding and breeding practices, disease knowledge, the way of selling milk, and milk prices. Maasai pastoralists pursue 100% extensive farming (grazing) with local breeds. In most Maasai families, there is a long-standing tradition of cattle rearing and keeping, and knowledge is passed down from generation to generation. The measure of a man's wealth is in terms of cattle and children. His cattle herd represents social status, income, wealth, a source of food, and social security. Maasai cattle herders tend to grow up with their animals and acquire an advanced understanding of their cattle's needs and diseases. Their animals produce generally low quantities of milk, which is prioritised for the calf, and the rest either used for the family and/or sold.

Two villages in Mvomero districts, **Mlandizi and Wami Dakawa** villages are located close to main roads and show some particular characteristics: The main road promotes trade in these villages, which has an impact on job diversity, income, the availability of shops and restaurants and food variety.

In contrast to Mvomero district, **Lushoto district** is dominated by intensive and sometimes semi-intensive milk production. In intensive livestock production systems, the cattle do not go outside and are being fed by the farmers using grass, hay and sometimes molasses and minerals as supplements. Almost all villages (which are predominantly Msambaa and some Mpare people) sell milk to the only collection centre in the district, which is in Mwangoi and pays a price of TSH 450/litre. Unlike the Maasai that are experienced cattle keepers, many producers in these intensive systems are new to cattle production, have limited disease knowledge and are largely dependent on the advice of extension officers and training provided by the government and non-governmental organizations (NGOs). Farmers mentioned lack of basic livestock keeping skills among the most serious constraints which limit milk production. They are using improved breeds, but all producers interviewed mentioned the lack of pure dairy breeds as the number one or two constraints in production (see Section 4.9).

4.2 Food safety: what are the main hazards likely to be present in the dairy value chain?
4.3 Food safety: what risks do the main hazards pose to value chain actors?

The full extent of zoonotic disease is hard to establish due to a lack of baseline surveys, surveillance systems and peer-reviewed publications. The WHO (2008) estimated that food and waterborne diarrheal illnesses contribute to 2.2 million deaths annually, 1.9 million of the deaths being children. In Africa, diarrhoea contributes to over 40% deaths in children below five years (WHO 2008). In a study conducted to attribute causes of diarrhoea in hospitalised children in Dar Es Salaam by Moyo et al. (2007), *E. coli* was found to be the cause of 22.9% of diarrhoea cases. Occurrence of multiple other zoonotic and foodborne hazards that can be linked to the dairy value chain has been confirmed in various studies, including tuberculosis, brucellosis, anthrax, antimicrobial residues and resistance, salmonellosis, and campylobacteriosis.

These diseases can result from contamination of a number of food sources, including milk, with pathogens or through direct contact with animals. This knowledge is to some extent reflected in the population. For example, the Maasai homestead in Lubungo was aware of tuberculosis and said that it could be transmitted from the "cow's hair in the milk" (reflecting food-borne transmission) or that grazers could get it from "the dust of the cow" (reflecting direct contact).

Apart from occupational hazards, people are likely to be purchasing milk contaminated with pathogens or antibiotic residues. The analysis of the 50 milk samples from Lushoto and Handeni districts found a mean log10 CFU/ml for total coliform count of 4.8 for farmers, 4.8 for vendors, and 3.6 for restaurants and a mean log10 CFU/ml for total viable count of 5.3 for farmers, 5.8 for vendors, and 4.9 for restaurants (Shija 2013). Microbiological quality was found to be poor, as 87% of the samples from farmers and 93% of the samples from vendors had total plate counts above the stipulated East African community standards of raw cow milk and all samples were above the recommended level for coliform plate counts (Shija 2013). Coliforms are used as indicator microorganisms and their presence implies a risk of contamination with other enteric pathogens and therefore a safety risk. Contamination can for example stem from poor housing conditions (e.g. dirty bedding that contaminates teats, tail or coat and gets into milk during milking), contaminated water, containers, tools or hands. These findings were corroborated by the second study where 50 samples from Mvomero and Kilosa district were tested. The mean natural log CFU/ml for total coliform count was 8.98 for farmers, 12.23 for vendors, 14.68 for collection centres, and 2.44 for selling centres and a mean natural log CFU/ml for total viable count of 9.72 for farmers, 12.18 for vendors, 14.56 for collection centres, and 7.88 for selling centres (Joseph 2013).

None of the 328 samples analysed by PCR for *E. coli* 0157:H7 was positive. For *B. abortus*, 17/45 (37.8%) of samples were positive in Lushoto district and 20/42 (47.6%) were positive in Handeni district (Shija 2013). Of 82 investigated samples for *B. abortus* in Morogoro, 25.8% of samples were positive in Kilosa district and 11.8% were positive in Mvomero district (Joseph 2013).

Importantly, contamination levels in raw and pasteurised (boiled) milk were not significantly different ($p > 0.05$), suggesting poor quality of raw milk, insufficient pasteurisation, and/or a high level of recontamination post-pasteurisation (Shija 2013). Only a small minority of people interviewed in this study were familiar with the term pasteurisation. The risks posed by **milk-borne microbiological hazards** are greatly reduced during **boiling**. Temperature is the most important factor to influence bacterial growth; both freezing and chilling lower the temperature to a level that retard or cease microbial growth. **Heating > 60°C** denatures proteins which causes microbial death (milk commonly boils just above 100°C) for most bacterial pathogens including common milk borne pathogens such as salmonella, *Yersinia enterocolitica*, *Campylobacter jejuni*, *Staphylococcus aureus*, Brucella *spp.*, and *Escherichia coli 0157: H7* (Buncic 2006). However, some forms of *Listeria monocytogenes* are known to be thermoresistant (Rowan and Anderson 1998) and may occasionally survive pasteurisation temperatures (Doyle et al. 1987). Hence, insufficient heating of the milk or improper handling after heating and potential (re-)contamination may lead to ingestion of foodborne microbial pathogens.

In all 10 consumer PRAs, milk was bought fresh between 7am and 9am in the morning, then filtered and boiled for 5 to 30 minutes. In most cases, some of this milk is then consumed as fresh boiled milk or chai (tea with milk) or less frequently mixed with porridge. The milk that is not consumed in the morning is generally stored in a thermos for consumption later in the day. Using the example of Mlandizi village, Figure 8 represents a common pattern of milk preparation and consumption in the villages visited.

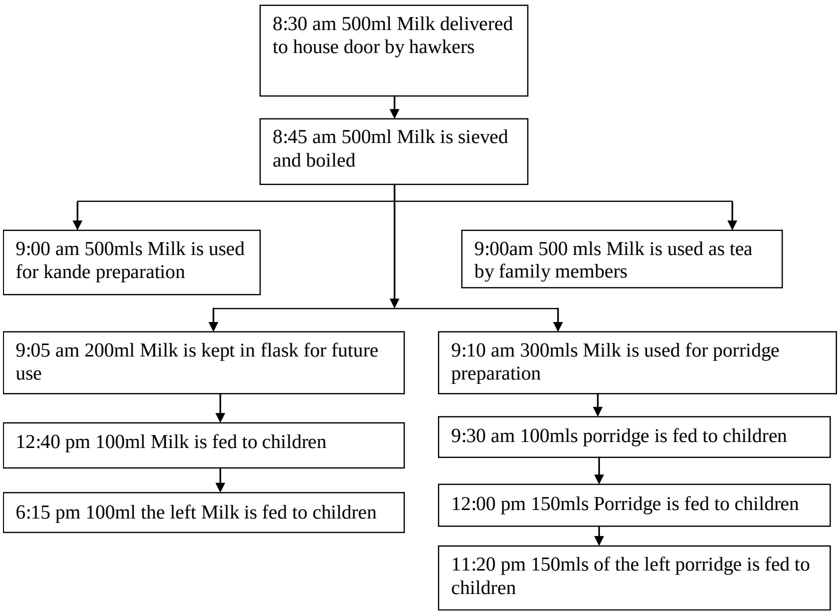

Figure 8: The common preparation and consumption of milk reported by the PRA in Mlandizi village. Kande is a dish made of maize and beans.

This habit of boiling milk and consumption on the same day was also confirmed in the consumer survey, where the median boiling time was 13 min (range 3-180 min, n=140) and 121/157 (77%) respondents reported to drink boiled milk (Figure 9).

In some households it is also common practice to consume **raw or raw fermented milk** (Figure 9). The most common practice in Tanzania to produce fermented milk is to filter the milk, put it in a clean pot and let it stand overnight at room temperature. In some cases, a starting culture is added, but more frequently, nothing else is added to the milk.

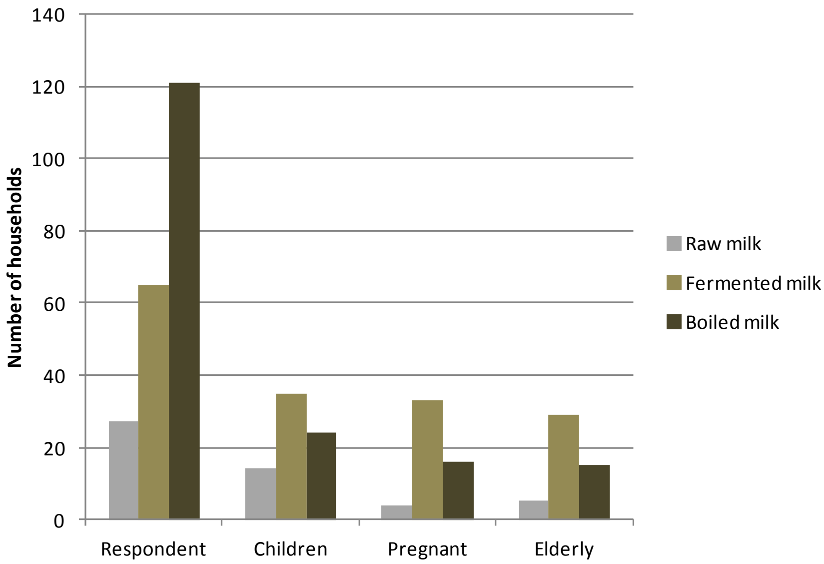

Figure 9: Raw, fermented and boiled milk consumption in the households surveyed (n=157)

Raw milk consumption was reported for the respondents, children, pregnant and the elderly (Figure 9). Further, a considerable number of households (hh) indicated that respondents (65 hh, 41%), children (35 hh, 22%), pregnant women (33 hh, 21%) and the elderly (29 hh, 18%) drink fermented milk (Figure 9). In the FGDs it was described several times that pregnant women and children were either more or less likely to drink **fermented milk**. Mothers mentioned that children were less likely to consume fermented milk, because they were not used to it and could throw up or develop diarrhoea. The consumption of fermented milk in pregnant women could be increased or decreased depending on cravings or aversion due to hormonal changes. **Raw milk** was mentioned in several FGDs as a detoxifying agent that could clean the system in particular after ingesting any form of poison.

Antimicrobial residues in milk constitute another hazard that may jeopardise people's health if they lead to the development of resistance genes that render antibiotic treatments ineffective. Of the 156 producers interviewed, 98 (63%) said that they administered antibiotics. Of those, 80 (52%) and 81 (52%) producers, respectively, gave an answer as to whether they discarded the milk during or after administering antibiotics. Fifty-six percent of respondents indicated to discard the milk while administering antibiotic treatment (42% said they did not discard), while 34% said that they discarded the milk after antibiotic treatment (64% said they did not discard). Only a few producers mentioned that they would use the milk for the calves (Figure 10). Specific withdrawal times were mentioned by 23 producers: 11 producers stated 1 - 3 days; 11 producers stated 4 - 7 days and one producer stated 14 days. Moreover, 4 producers each said that it depended on the veterinarian's advice or that they would wait until recovery, respectively. Overall, this indicates that antimicrobial residues are highly likely to get into the food chain.

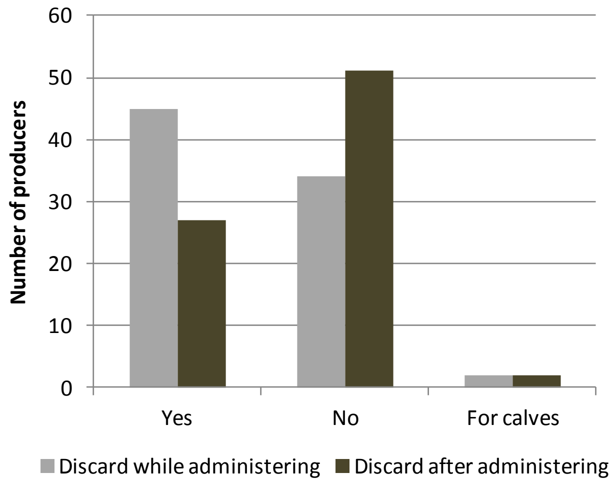

Figure 10: Number of producers stating whether they discarded milk during or after administration of antibiotics

Apart from this, consumers and producers may be put at risk of foodborne pathogens when milk from sick animals is sold or consumed at home. When asking producers what they did with milk from sick animals (multiple answers were possible), 143/156 (92%) provided an answer. They said 54 times that they would consume it at home, 24 times that they would give it to other animals, 22 times that they would sell it, and 16 times that they would not milk the animals (Figure 11). All other answers had less than ten counts.

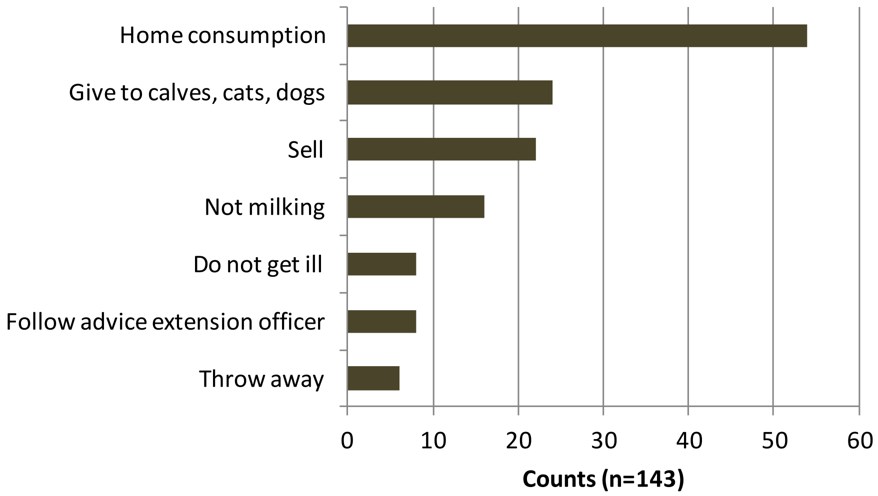

Figure 11: Answers given by producers when asked what they would do with milk from sick cows

When looking at the answers given by producers to the KAP statements in the survey, it was shown that about half of producers thought that milk and dairy products from sick cows would not affect consumers (Figure 12). This indicates a generally low awareness of the potential of disease transmission through milk and dairy products. Further research would be needed to understand why many producers do not consider milk from sick cows to be a food safety hazard.

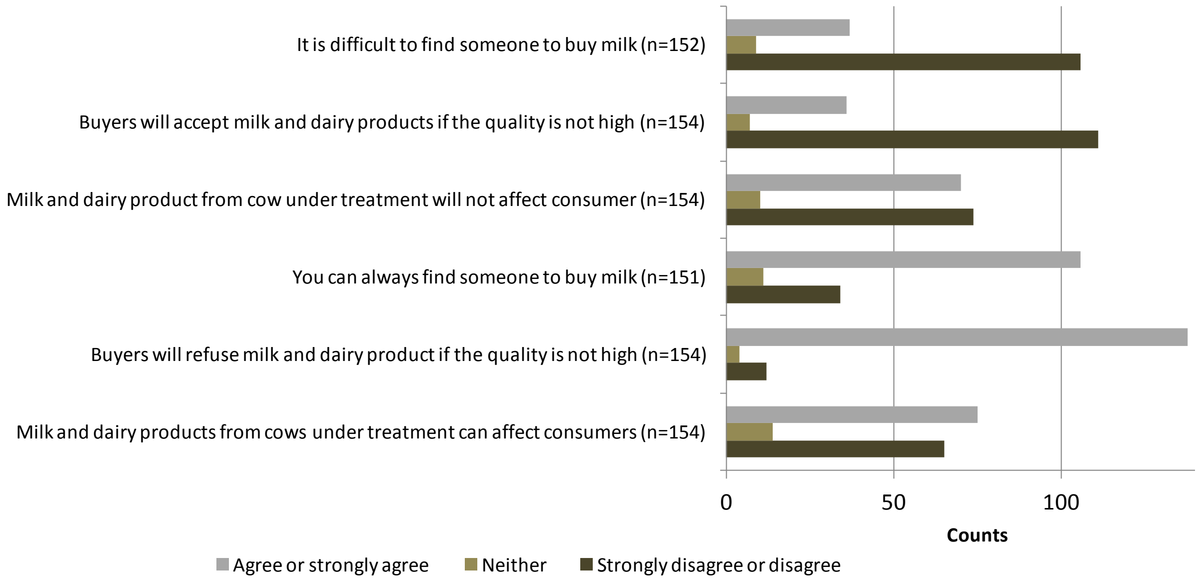

Figure 12: Attitudes and perception stated by dairy producers when asked about buyers and milk quality

To summarise, coliform colonies had a mean value between 3.6 and 4.8 log10 CFU/ml at various points in the dairy value chain and 42.5% of milk samples tested positive for *B. abortus* in the PCR thus indicating contamination and poor hygiene practices. Such bacteria constitute a source of spoilage and food borne disease. This is of concern, as the use of raw or fermented milk is observed in all population groups resulting in potential exposure and development of disease. Further, there is a risk of exposure to zoonotic pathogens through direct contact with infected animals.

Suggested research questions:

- What is the level of contamination past-boiling and is it due to re-contamination or insufficient heating?
- What effect does fermentation have on the presence of foodborne zoonotic hazards?
- What is the knowledge of producers about occupational zoonotic hazards and preventive measures?

4.4 Food and nutrition security: what is the role of dairy products in diets of poor farmers and consumers?

Animal-source foods are considered an important component of a nutritious and balanced diet. Meat and milk contain high levels of energy, readily-digestible protein and bio-available micronutrients such as zinc, iron, calcium, Vitamin B_{12}, Vitamin B_2 (riboflavin) and Vitamin A. However, in sub-Saharan Africa, animal-source foods make up only 5-10% of the total daily energy intake; in developed countries, this is over 25%.

When calculating the food consumption scores (FCS) for the households interviewed and applying a cut-off of 35 as suggested by the World Food Programme (a national, context-specific cut-off point would be preferable, but the 35 is used here in the absence of a more specific cut-off), all households were classified as adequate, with only one household being close to the cut-off point (with a FCS of 36) and therefore the borderline group. All other HH had scores of 53 or more (Figure 13).

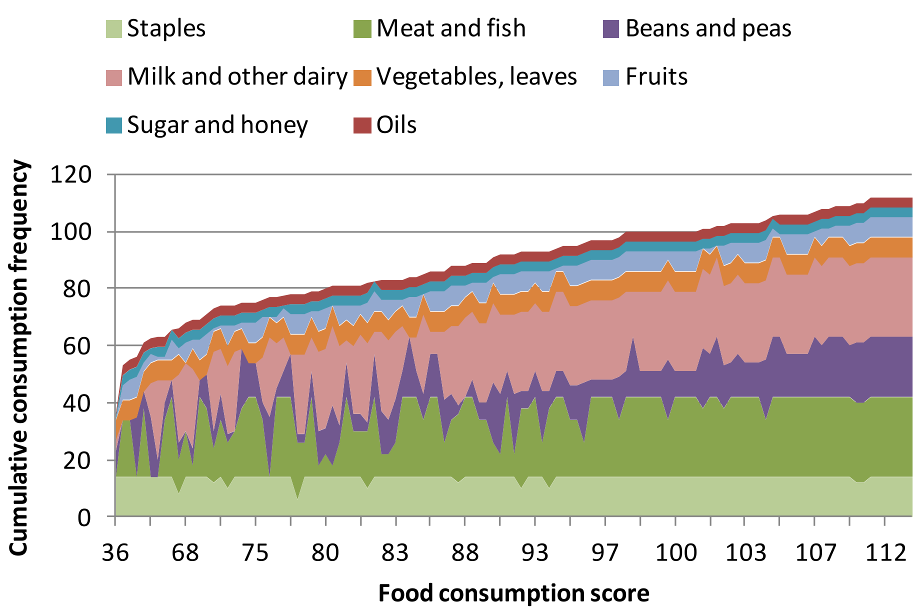

Figure 13: Weighted cumulative food group scores in 115 rural households in Tanzania

The unweighted consumption frequencies (Figure 14) showed that the products consumed daily by the majority of respondents were staples, vegetables, fats, and sugar. More than half of the households reported consuming fresh milk, fish, pulses/beans and chai three times or more per week. Potato and red meat was reported to be consumed two times or more per week by about two thirds of households. Food items least frequently consumed were canned meat, pork, game, cheese, yoghurt, powdered milk and infant formula.

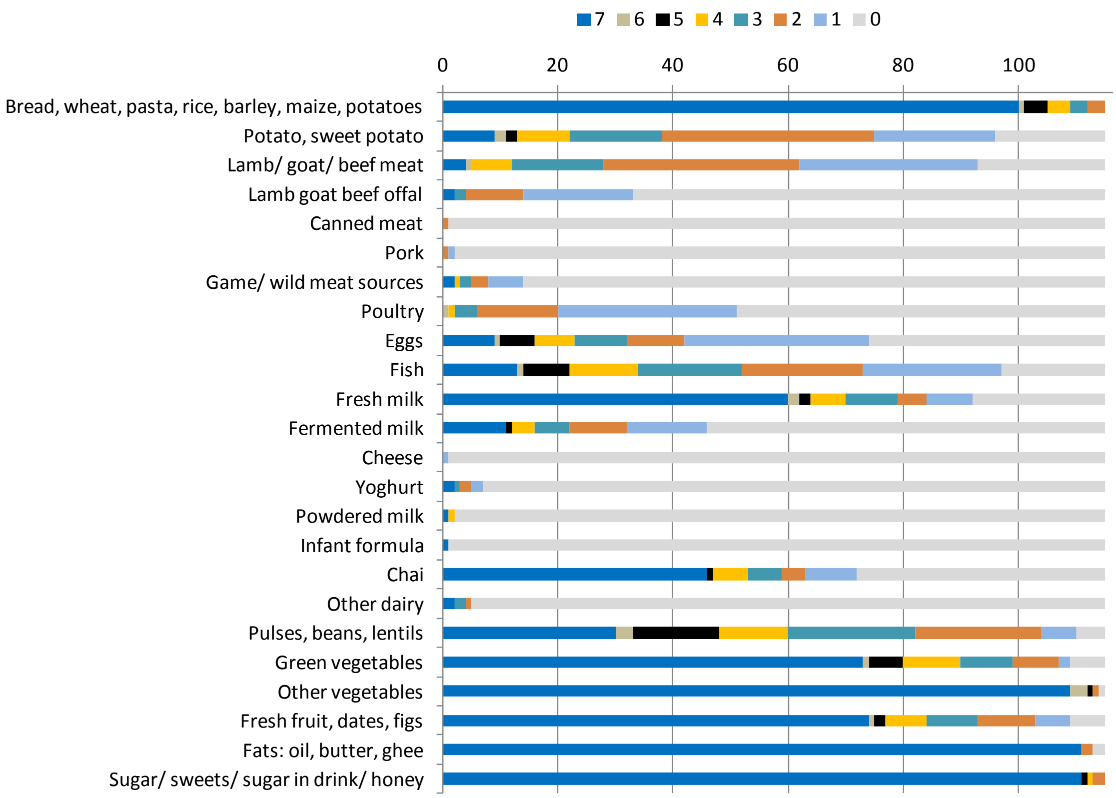

Figure 14: Frequency of consumption (number of days consumed in the previous seven days) of different food items in 115 households interviewed in rural Tanzania

The same pattern was reflected in the mean frequencies calculated across all households. The highest mean frequencies of consumption (consumed on 7 days in the previous seven days was the maximum) were found for sugars (6.9), other vegetables (6.9), fats (6.8), staples (6.6); green vegetables (5.6), pulses/beans (4.1), fresh milk (4.6); and chai (3.6). Of the two most popular dairy products consumed, twenty-three households said that they had not consumed fresh milk in the past seven days and nine households said that they had not consumed chai in the past seven days (Table 7). Fish was consumed frequently in the households interviewed; it is hypothesised that these are either freshwater fish from lakes (such as tilapia) transported to the study areas, sardine or farmed fish. Sea fish may also be available.

Table 7: Frequency of consumption (number of days consumed in past seven days) of dairy products in 115 rural households interviewed in Tanzania

Frequency in days	Fresh milk	Fermented milk	Cheese	Yoghurt	Powdered milk	Infant formula	Chai	Other dairy
7	60	11	0	2	1	1	46	2
6	2	0	0	0	0	0	0	0
5	2	1	0	0	0	0	1	0
4	6	4	0	0	1	0	6	0
3	9	6	0	1	0	0	6	2
2	5	10	0	2	0	0	4	1
1	8	14	1	2	0	0	9	0
0	23	69	114	108	113	114	43	110

While the food consumption scores give a favourable picture of food security, it is important to keep in mind that this was a cross-sectional survey and that the situation may change during the year. The survey was conducted between December and February, when food availability for some villages may be low, but high for others. In the consumer and producer PRAs, participants reported strong seasonal fluctuations of food in general as well as fresh milk and other dairy products. The availability of food was reported to closely follow the rainfall pattern. Focus group and PRA participants stated that in the dry season there was general low production, which reduced the amount of products available on the market. At the same time, people reported less income due to low production, which negatively affected the affordability of food. Consequently, large parts of the population may be affected by a general food shortage in the low season (people reported that there were no or limited substitution possibilities), which in some households is made worse by reduced income during the same period and may cause food insecurity in poor population groups. The FCS reflects household food access and consequently intake, but it does not take into account quantities (therefore does not provide information on how much food is lacking in the diet) and individual nutritional requirements or seasonal variations.

Figure 15 illustrates food availability throughout the year as reported by producers in Mvomero district in the PRAs using proportional piling. Lubungo, Kidudwe, Lusanga, and Wami Dakawa show very similar patterns, which – according to producers - closely follow rainfall patterns. Producers explained that they begin preparation of fields from January up to February, when the planting season for the main crops (in particular maize) begins with early harvesting in May then continuously increasing until the main harvest peak in July (followed by a gradual decline). In October, November and December there is little or no food in the study area due to drought. Some (staple) food becomes available early in the year which results from short rains between October and December commonly known as “vuli” rainfall. While the reported rainfall pattern for Mlandizi was very similar to the other villages, its harvesting peak was earlier in the year, which was explained by the production of maize after “vuli” and the production of beans during/after the long rains.

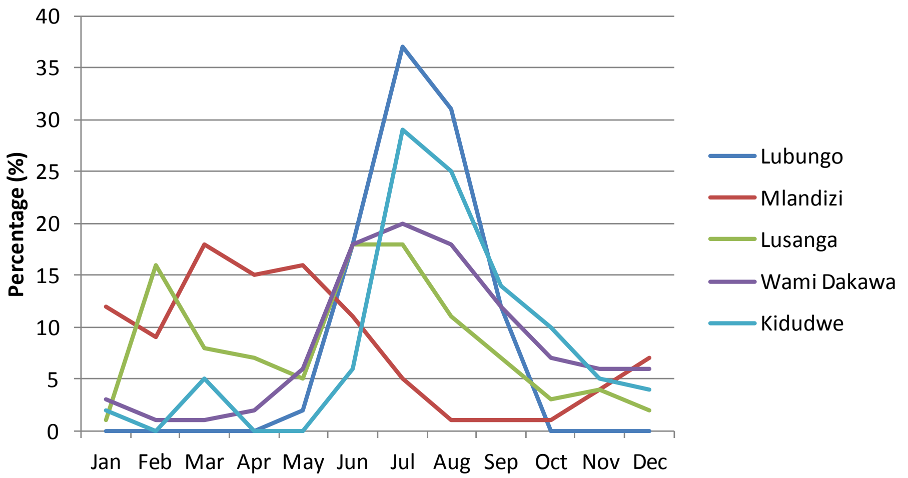

Figure 15: Food availability reported by producers in PRAs in Mvomero district (results from seasonal calendar)

Figure 16 illustrates food availability during the year as reported by producers in Lushoto district in the PRAs using proportional piling. The food availability patterns in Manolo and Ngulwi are similar to those observed in most villages in Mvomero district, which is explained by similar seasonal rainfall patterns and production of the same crops. Mwangoi and Handei follow similar patterns as Mlandizi, which may indicate production of similar crops. A different pattern was reported by producers in Mbokoi, where there are three planting seasons following three rainy periods (“masika”, “muruati”, and “vuli”).

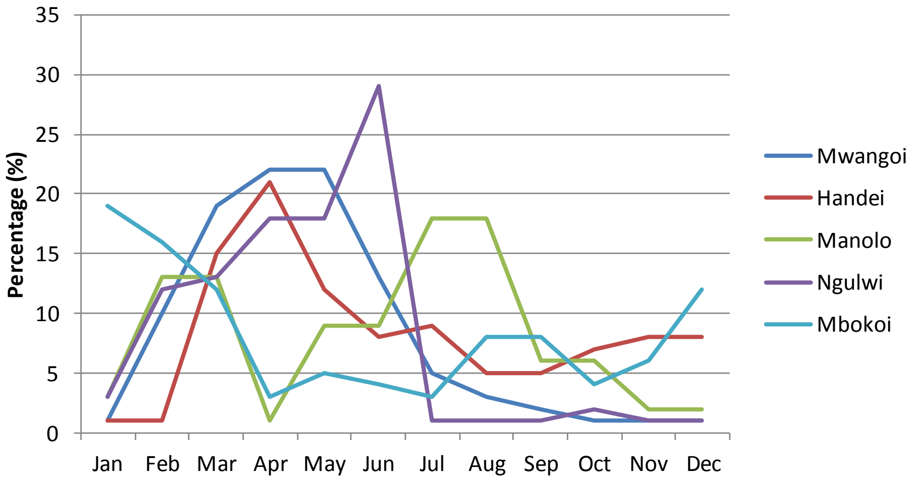

Figure 16: Food availability reported by producers in PRAs in Lushoto district (results from seasonal calendar)

In the months of low food supply, farmers tend to import food from other areas, in particular from urban centres and other, more fertile districts. However, various people described poor marketing and supply chains and that in period of low production not enough food was available in the marketplace.

Fresh milk consumption was influenced by the availability of milk which fluctuates strongly according to rainfall patterns and therefore pasture availability, as well as the availability of by-products from crop production (e.g. maize stalks). In Maasai communities, which depend on pastoralism for their livestock, a strong hierarchy of consumption was reported: First, milk would be given to the calf; second, milk would be used in the household, and third, any surplus would be sold on the market.

In summary, fresh milk and chai are frequently consumed by most households in rural villages in Tanzania, whereas other dairy products are consumed less often. The FCS showed that the majority of households had adequate food access. However, because the study was conducted after the season of lowest food supply, these figures may be over-estimated. Moreover, the FCS does not provide information on quantities consumed. Strong seasonal patterns for general food supply and availability of milk and milk products were reported with sometimes associated reduction in income.

Suggested research questions:

- How does food security evolve throughout the year?
- What are the drivers of food availability and affordability throughout the year?
- What are supply chain mechanisms that impact on food availability and affordability?
- How could milk supply become more stable over the year and less dependent on rainfall patterns?
- What are cropping patterns in the study area?
- What proportion and type of food consumed is purchased or produced?
- What are malnutrition levels in the study areas?

4.5 Food and nutrition security: what is the relationship between livestock keeping and livestock eating?

The value chain analysis showed that there are both very short food chains and some more complex chains that involve collection centres and processors before the final produce gets to the consumer. Mainly non-pastoralist, semi-intensive systems deliver to collection centres, while Maasai pastoralists tend to use the milk for their calves and their families first and then sell the surplus either to collectors that bring the milk to selling points or sell the milk directly to consumers.

Consequently, Maasai are one important group of producers that at the same time are consumers of their own product.

In the consumer survey, 50 of the 156 people interviewed (32%) indicated owning cattle. The minimum number of cattle mentioned was 1 and the maximum was 55. Of those, five people said they never consume milk from their own animals, while 10 said that they would consume the milk sometimes, and 26 said always; thus demonstrating that home produced milk is an important source of consumption of animal protein. Comparing the food consumption scores (FCS) of cattle holders and non-cattle holders showed a median FCS for non-cattle holders of 88 (36-112, SD 16.6) and for cattle holders of 97 (63-112, SD 11.99); the two sets of scores differed significantly in the Mann-Whitney U test (z=2.10, p=0.017). Of the 50 consumer households that kept cattle, 29 were Msambaa (58%), 10 (20%) were Maasai, and the other 11 were from various other ethnic groups.

Of the 107 consumers that did not keep cattle, 83 (78%) always purchased milk, 8 (7%) said sometimes, 4 (3.7%) said rarely, nobody said zero and 12 (11.2%) did not give an answer. The most popular place to purchase the milk was by far the neighbour followed by street vendor (Figure 17) thus highlighting the importance of local production for the purchase and consumption of milk.

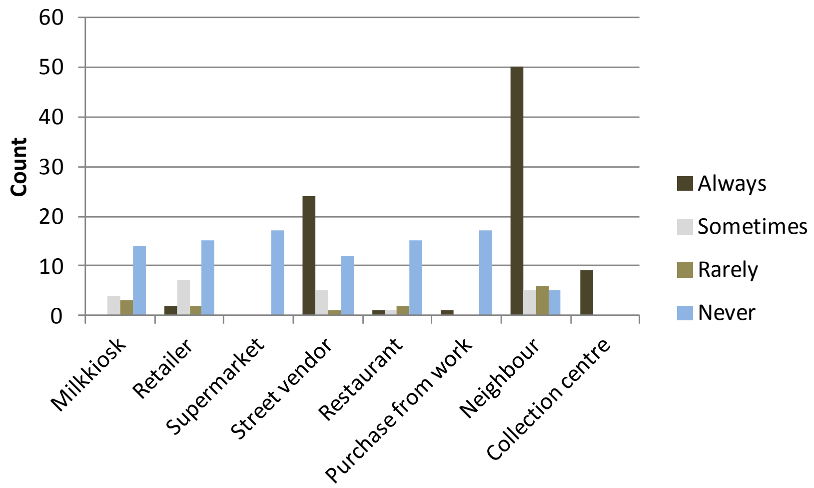

Figure 17: Places most frequently used to purchase milk by consumers who do not keep cattle

To summarise, the majority of people who keep cattle consume the milk from their own animals. This may be a reason for the better food security between people who keep cattle and those who do not. Further data analysis is necessary to correct for factors such as education, socio-economic status, etc. There seems to be a strong dependency on local milk production and availability, as people most frequently buy from their neighbours.

Suggested research questions:

- Do people who keep cattle have better food security, because they consume their own milk?
- How resilient are local supply chains?
- What can be done to ensure stable supply with local supply chains?

4.6 Food safety and nutritional issues: how does nutritional quality and food safety change along the value chain?

The FGDs, PRAs, and consumer survey revealed that the use of fresh milk was most popular, followed by fermented milk. Other dairy products are only rarely or very rarely consumed. Most people relied heavily on fresh milk and the consumption of industrially pasteurised milk in the rural villages was unknown. The Tanzanian 2007 Household Budget survey from the National Bureau of Statistics revealed that less than 1% of households consume processed milk (www.nbs.go.tz). However, most people reported that they boiled the milk, which would deactivate most heat-labile microorganisms, as milk – similar to water – boils around 100°C. Some thermophile bacteria may survive temperatures of 85°C (Buncic 2006), i.e. may persist in the milk if the milk is not heated enough. At the same time, most households reported long boiling times and frequent re-heating later in the day was also popular. This carries a risk of sporulation of *Bacillus cereus* endospores causing diarrhoea, severe nausea and vomiting as well as affecting heat-labile nutrients. *Bacillus cereus* endospores may survive when food is not properly heated, germinate in non-refrigerated conditions and produce enteroxins.

Milk is an important source of A, D and group B vitamins. The fat soluble vitamins are reportedly thermostable and their level is not lowered by heat treatment. On the other hand, Vitamin C and some of the group B vitamins, particularly VB12 may be affected by heat treatment. Casein, the major protein in the milk is not denaturable. Most amino acids are heat stable up to 120°C (Weder and Sohns 1983). In a study that examined the effect of overheating on calcium it was found that consumption of a diet based on overheated milk led to a negative calcium balance in mice under laboratory conditions (Seiquer et al. 2010). They concluded that processing conditions of milk may cause impairment of dietary calcium utilization, which could be especially important in situations in which milk and dairy products are the main staples of the diet.

While bio-availability of certain micronutrients in yoghurt may be higher than in milk (Goldin 1989), the importance of these products in the diet was found to be limited. There was limited commercial processing of milk in the study areas. Further, milk was most commonly consumed boiled fresh as a standalone product, i.e. there was no further addition of nutrients. One exception to this was porridge, which was described by many mothers as an important food for young children.

Unhygienic harvesting and handling practices described by PRA and FGD participants indicated that contamination of milk with pathogens can occur along the chain thus creating risks of foodborne disease. The biological samples showed high coliform counts and contamination with *B. abortus* in multiple points in the dairy value chains (Joseph 2013; Shija 2013), thus indicating contamination through exposure to infected animals or people, unclean equipment and handling practices.

Multiplication of microbial pathogens along the chain is highly likely, because there is no cold chain, and transport times can be substantial between production and selling point as well as between selling point and consumption. A further concern mentioned was the addition of water to increase the quantity of milk to be sold (adulteration). This is of particular concern in the dry season when production is low. Boiling of milk is expected to decrease food safety risks for heat sensitive microbial pathogens, but does not have an impact on most chemicals. Moreover, there is limited information available on contamination past boiling.

4.7 Food safety and nutritional issues: what are trade-offs between food safety and nutrition?

In the dairy value chains in Tanzania, food safety and nutrition are interconnected. To be able to understand the trade-offs and/or co-benefits of food safety and nutrition, it is important to identify the **direction of effect/impact** and ideally determine unidirectional effects that either both improve or decrease food safety and nutrition. In some instances, it will not be possible to find such unidirectional factors and it will be necessary to provide a qualitative or quantitative estimate about which effect is more likely to have a beneficial impact on human health.

The example of **adulteration** is used to describe this concept and illustrate relationships between food safety and nutrition:

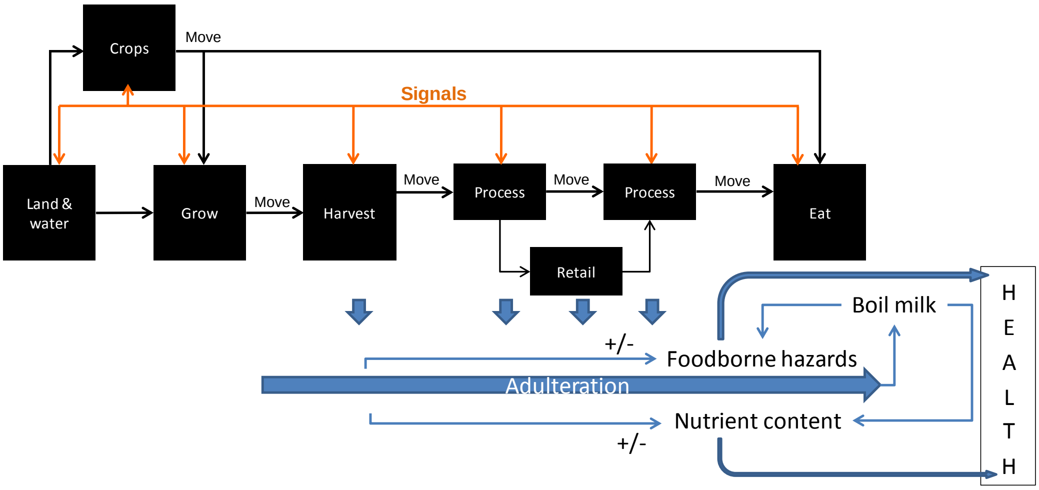

Figure 18: Illustration of the impact adulteration can have on foodborne hazards and nutrient content

1. Adding water to milk can happen at any level along the food chain and can have a positive or negative effect on food safety depending on the water quality. If there is clean water and contaminated milk, the **pathogen load** is diluted and **nutritional content** decreased. If there is clean water and non-contaminated milk, the nutritional content decreases and there is no food safety issue. If dirty (contaminated) water is added to non-contaminated milk, contamination occurs and nutritional content decreases. If dirty water is added to milk already contaminated, there is an increase in contamination, while the nutritional content decreases. Biological sampling would be necessary to determine whether 1) the milk is adulterated, and 2) whether the adulteration caused a (further) contamination of the product and would therefore constitute a potential food safety hazard for consumers.
2. Consumers indicated both in the PRAs and the survey that **adulteration** is one of their top concerns in terms of food quality and described various ways they test milk. All of the 11 consumer PRAs mentioned adulteration as an important quality attribute; it was ranked top one

time, second seven times and third three times. Explanations about what comprised this quality attribute included reduced nutritious value (mentioned four times), stomach ache (mentioned twice), taste (mentioned twice), diarrhoea, vomiting, and reduced milk quality. Of the eight groups that provided a frequency of finding this issue in the market, all of them said that it was observed "sometimes". Six groups said that adulteration would not make the milk less safe to drink; two groups said that it would and two groups did not give an answer. Remarkably, nine groups said that they would consume the milk despite adulteration (one group did not answer); indicating that they may not be aware of the potential risks or believe the nutritional benefits outweigh the risks (see Point 5 below). Several groups offered descriptions of how to check for adulteration visually. For example, they mentioned dispersion on a table or the ground, blowing milk on the palm, and the match stick test, where a match is dipped into the milk and the dripping off observed. One group also mentioned that adulterated milk would behave differently when boiling or cooling. The issue of adulteration was also mentioned frequently in the producer PRA groups who said that many poor farmers added water to the milk to increase the quantity.

3. The milk quality attribute ranked number one in all ten PRA groups was **hygiene**, which was described as **cleanliness** of utensils and personnel and sometimes included the colour and smell of the milk. People said that they associated cleanliness with good preparation and consequently less contamination. All groups associated the absence of hygiene/cleanliness with disease transmission in general and mentioned diarrhoea (four times), stomach ache (twice), vomiting (once), poor health of children (once), and tuberculosis (once). Eight groups said that it would make the milk less safe to consume (two groups did not provide an answer), and that they would not consume it. The issue of lacking hygiene in the market was observed often by one group and sometimes by seven groups (two groups did not provide an answer).
4. The importance of **proper boiling of milk** was mentioned frequently in the consumer PRAs and FGDs. The duration of boiling mentioned varied from 5-10 min (2 groups), 15 min (1 group), 20 min (1 group), to 30 min (four groups). All groups reported to buy the milk fresh in the morning, then filter and boil it soon after buying. Nobody mentioned what temperature they used to boil the milk, but some people said that they would boil it until the milk started frothing and rising in the pan. Very high temperatures may be of concern as it can cause the destruction of heat labile nutrients as described above. In the KAP questions in the consumer survey, about 2/3 of people indicated that one cannot get sick from boiled milk (Figure 19). This common belief may lead to overheating of milk and therefore affect the nutrient content of the milk.
5. The common **perception** consumers had of milk quality was corroborated by the answers to the KAP questions in the survey (Figure 19). Eighty-eight of 153 respondents (58%) agreed with the statement "The milk you drink may be contaminated", while 51 disagreed (33%) and 14 (9%) said "don't know". Further, 88/153 respondents (58%) agreed with the statement that "milk safety can be judged by sight and taste", while 49 (32%) disagreed and 16 (10%) said "don't know". These answers stand in stark contrast with the answers given when presented with the statement "You can get sick from drinking milk?", where 44/153 (29%) respondents agreed, 99/153 (65%) disagreed and 11/153 (7%) did not know. This contrast between awareness of contamination level and milk related illness may be explained by a general strong belief that milk is good for people's health and that milk is highly nutritious (Figure 19) and the perception that one cannot get sick from boiled milk as described above.

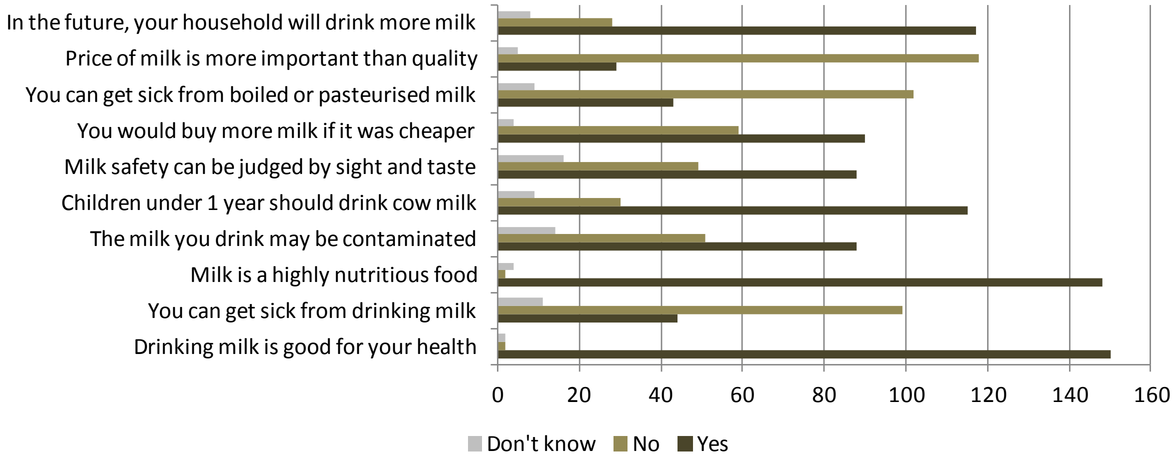

Figure 19: Answers given by respondents to statements presented in the consumer survey (n=153)

6. The **request for quality** from consumer side was known to producers. Forty-eight of 58 (83%) producers agreed or strongly agreed with the statement "Buyers will refuse milk and dairy product if the quality is not high", 6/58 (10%) disagreed or strongly disagreed, and 4/58 (7%) were neutral. Nevertheless, the strength of these market signals was doubtful, as there seems to be a high demand for milk and more often a shortage than a surplus (in particular in the dry season, see above). This was underlined with the statement "You can always find someone to buy milk", with which 64% of respondents agreed or strongly agreed thereby implying that it is not difficult to sell the milk.

Using the example of adulteration and milk quality attributes in general, some of the complex relationships between food safety and nutrition are illustrated. It is important to understand people's knowledge, beliefs and awareness to be able to determine consumer demand, which in turn gives signals to producers who may react to this information. Also, there is a need to further look into people's practices about treating milk to make sure that a balance can be achieved between minimising the risk of foodborne pathogens without jeopardising the nutrient content.

There are also higher level trade-offs between food safety and nutrition, when for example production is promoted without taking into account food safety considerations. This is described in more detail in Section 4.9.

Suggested research questions:

- What is the level of milk adulteration?
- Does adulteration contribute to foodborne disease and/or does it have a negative effect on nutrition?
- What is the level of foodborne illness stemming from milk?
- How can correct boiling of milk and hygienic handling after heating be ensured?
- What is the potential of consumer demand to drive the production of nutritious and safe milk?

4.8 Food safety and nutritional issues: are there trade-offs, synergies, between feeds and foods?

Five of the ten producer PRA groups described issues relating to the **availability of land**, namely heavy competition between crop producers and livestock keepers, and pasture and water shortage in general. These land/pasture related constraints were ranked top twice, and 2, 3 and 4 one time each. Pastoralists in particular reported to be highly dependent on grazing land and pasture. Some schemes to manage land use were described, but often they are not respected and fights over land are common and sometimes fatal. Further, there are initiatives in place to reduce the number of cattle Maasai keep, but this finds strong resistance among the pastoralist community who have been practicing this way of livestock keeping for centuries. Tensions seem to be getting worse with climate change and an associated reduction in rainfall and consequently water availability. These problems are further exacerbated by competition for land by human settlements and hunting practices that include burning of land.

Table 8 summarises the **pasture/grazing constraints** described in more detail by four villages that ranked them among the top three concerns. The issues reported evolve around lack of grazing land, lack of pasture, water shortage and lack of knowledge about how to conserve feed. Producers requested more land or better management thereof, access to training and the construction of dams or reservoirs to store water. They thought that this was something to be addressed by the government, NGOs and farmers.

Table 8: Production constraints reported in the PRAs by four villages with regards land use

	Wami Dakawa	Mbokoi	Lubungo (grazing land)	Lubungo (pastures and water)	Mlandizi – pastures and water
What is the problem related to?	Little land that is currently available for grazing Climatic change	Weather condition determines the availability/unavailability of pastures. Shortage of pastures is a result of lack of rainfall.	Living area is small compared to the number of livestock Large areas are privately owned by investors Land separated for livestock is small	Burning of the grasses due to the hunting activities Seasonal variation whereby there is shortage starting from July	Climatic variability (drought) Small land available for grazing
What is already being done (in the past)?	Requested land from the government for grazing animals Were trained on animal feed production Only farmers with improved cattle were trained by "Tan Dairies Co. Ltd".	Nothing has been done.	MKURABITA trained farmers the proper use of land, separation of grazing and settlement areas. Farmers were given area for grazing and settlement	Government has built water reservoir (RAMBO) Digging of the well by Seventh Day Adventist (SDA)	Farmers were given a piece of land for grazing in MERA.
What more can be done & how it can be done	To plant grasses within the small available piece of land Harvesting of water to be used during drought /shortage of water To be trained on how to conserve suitable	Provision of technical skills to farmers on how to preserve pastures so that they can keep longer and become suitable for use in dry seasons.	Government should intervene and allocate new location for grazing	More water reservoir should be constructed	Construction of Dams (MARAMBO) to simplify availability of water especially during drought/summer

	Wami Dakawa	Mbokoi	Lubungo (grazing land)	Lubungo (pastures and water)	Mlandizi – pastures and water
	grasses for their animals Government should discuss with producers on how to end-up the conflicts between livestock keeper and crop cultivators				
Who has to do	Farmers themselves Government NGOs	Government NGOs	Farmers themselves Government	Government NGOs Farmers	Farmers themselves Government NGOs
How it can be done	Work under partnership	-	-	-	-

Competition for water and land causes a trade-off between production of animal source foods and crops, in particular staples. Further, low feed implies low milk production, which may increase the risk of adulteration of milk or unhygienic production to save on production costs. These issues become more urgent with increasing population growth, a higher demand for meat, and increasing animal populations. Some farmers in intensive systems reported feeding **crop residues to their cattle** (e.g. one focus group reported feeding livestock with maize bran as a by-product of the milling machines), which may be an option to ease some of the pressure created by competition for land.

Apart from the major issues reported regarding land use, one focus group reported a practice of feeding livestock with waste food, in particular *ugali* (a stiff maize porridge eaten as staple food), and green vegetables. They also observed that this feeding practice can have a negative effect on the milk, i.e. cause rancidity. However, in most groups people reported that no feed supplements were given to cattle apart from pastures. This once again highlights the dependence on the natural environment of most farmers.

Suggested research questions:

- What are the trade-offs between crop production and cattle production in terms of their health impacts?
- What are sustainable strategies to manage land use given the fierce competition?
- What are sustainable strategies to manage water use (to facilitate crop and animal production)?

4.9 Food safety and nutritional issues: how is dairy value chain development (lengthening, complexity, adding value, processing, etc) likely to affect nutrition and food safety?

4.10 Trends and possible interventions

4.11 How could investments enhance consumption of nutrients and decrease risks?

Findings demonstrated that there are substantial fluctuations of **milk supply** (in some cases combined with a decrease in affordability) during the year, which is likely to have an impact on food security throughout the year. Consumers indicated that they like milk because of its nutritional value and 74% of respondents in the consumer survey thought that they would consume more milk in the future. The value chains that supply milk to rural populations were found to be rather short, i.e.

people depend on their own milk or local supply (e.g. milk from neighbours) and milk is commonly purchased fresh for filtering and boiling at home. With increasing population growth (the 2011 population was 46.22 million and the population growth rate was 3%, Figure 20), the demand for milk is expected to stay high. Many milk collection and processing centres operate below capacity. Previous work and data collected in this study indicate that there is a shortage of milk supply and that there are strong seasonal fluctuations. Further value chain analysis should aim to capture not only the most important routes in terms of flow of milk and money, but also take into account high and low season flows. These would be useful in identifying which routes are constant or variable. In variable chains there may be a potential risk of relying on casual labour with relatively inexperienced or untrained staff members.

Seasonal patterns are also expected to be of relevance when looking at inputs in the different dairy production systems, i.e. grazing, grains, stover and fodder. Some systems (e.g. LGH, see Section 2.2) show a high ratio of density to milk production and a lower amount of feed compared to other systems. Moreover, to better understand the context, the VCA should detail data on beef cattle and dairy cattle, ideally broken down by breed and purpose (indigenous breeds may be double purpose).

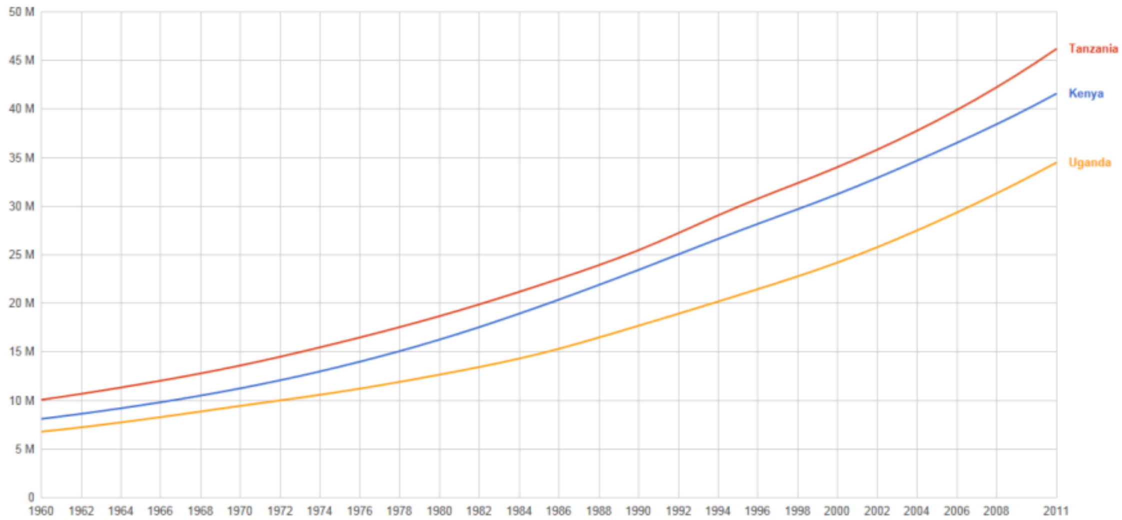

Figure 20: Human population in Tanzania over time in comparison to neighbouring countries[2]

Apart from the land constraint mentioned above, producers in the PRAs listed a range of factors that limited their production; the issues most frequently mentioned were lack of dairy breeds, limited technical knowledge and know-how, unreliable markets, lack of capital, and diseases (Table 9). All PRA groups that reported **technical knowledge/know-how** to be an issue described the lack of training seminars and/or education opportunities (e.g. education centres in villages) and required regular provision of training for livestock keepers by government, NGOs, veterinary officers and livestock holders. Low productivity because of **lack of dairy breeds** was also of concern. After the Soil Erosion Control Project (SECAP) in 1979-80, which gave pure dairy breeds to villagers, they continued with the same breed, but could not afford pure replacements and so started to breed with local cattle which resulted in crossed breeds. Since the early 1980s, various dairy development projects have been implemented by the Tanzanian government and development partners. Many of

[2] Source: http://www.google.co.uk/publicdata/explore?ds=d5bncppjof8f9_&met_y=sp_pop_totl&hl=en&dl=en&idim=country:TZA:KEN:UGA

these projects followed a model known in Kiswahili as **“Kopa Ng’ombe lipa ng’ombe”**, which means “Borrow a Cow; Keep a Cow” and is known in English as Heifer-In-Trust (HIT) scheme. The basic principle is to provide access to relatively high-value female livestock through a loan "in kind" agreement. A farmer is given a pregnant heifer or cow (i.e. foundation heifer) on the condition that he or she repays to the project the first (and sometimes also the second) heifer calf born to each animal. These heifer calves are usually passed on to other farmers in the group who must also repay the loan in the same manner. This scheme can continue for a very long time and can be seen as a type of revolving credit scheme (Afifi-Affat 1998). Heifer Project International (HPI) promoted the concept in Tanzania at large scale in collaboration with the government of Tanzania. Other projects that used similar approaches were the Southern Highlands Dairy Development Project (SHDDP) funded by the Swiss Government in Iringa and Mbeya regions; the Tanga Dairy Development Project (TDDP), and the Kagera Dairy Development Project (KALIDEP) – both sponsored by the Dutch government - which later changed to the regional trusts Tanga Dairy Trust (TADAT) and Kagera Dairy and Development Trust (KADADET) (Njombe and Msanga 2007). All PRA groups would welcome the provision of dairy cattle through a “*kopa ng’ombe lipa ng’ombe” scheme.*

Lack of capital was associated with poverty in general, dependency on rainfall cultivation and difficult loan terms for farmers. Solutions suggested were the creation of livestock unions or associations, special funds for livestock keepers, and provision of loans (cash or in the form of live cattle as in *kopa ng’ombe lipa ng’ombe*). **Diseases** were commonly associated with lack of basic knowledge, the natural occurrence of diseases in the area, **high input prices** (feed, drugs, vaccines), and climatic variability. Solutions suggested included training, a higher number of livestock officers with effective communication, health insurance schemes, and the provision of free or subsidised drugs, vaccines, and/or services.

Many groups also mentioned that there were too few or unstable markets for the milk. Given that there was rather a milk shortage than a surplus, the problem is likely to be associated with a lack of infrastructure, and contract systems.

Table 9: Rank of constraints to production listed by cattle holders in the PRAs

	Wami Dakawa	Lusanga	Ngulwi	Mbokoi	Manolo	Lubungo	Kidudwe	Handei	Mlandizi	Mwangoi
Lack of pasture	1			3		2			1	4
Lack of capital	3	2	5		2			2		2
Limited knowhow	2	1	1		3		2	3	5	1
High input prices	4	5				3			2	
Diseases	5	3	2				3		3	5
Lack of dairy breeds		4	3	1	1		1	1		2
Unreliable markets			4		4	5	5	4	4	
Low quality feeds				2	5		4	5		
Grazing land						1				
Lack of dip tanks						4				

With regards milk quality, producers were aware of the importance of milk hygiene and commonly reported measures such as washing hands, utensils, containers, or filtering the milk to remove dust and dirt. Most producer PRA groups reported the need for training on appropriate milking procedures as well as hygiene during and after milking.

Consequently, there are many potential **intervention points to increase the production** and therefore the supply of milk. These interventions could be targeted at various points in the value chain, for example at farm level to provide better breeds, veterinary support and technical knowledge or higher up in the chain to create stable markets, by for example promoting contract schemes with collection and processing centres or retailers (Figure 21, interventions 1 and 2). **Increased efficiency** of the value chain could result in higher supply. If this increase in supply outpaces demand (which does not seem to be very likely given the current increase in population growth and demand), a decrease in price might be seen which may make milk more affordable for poor population groups.

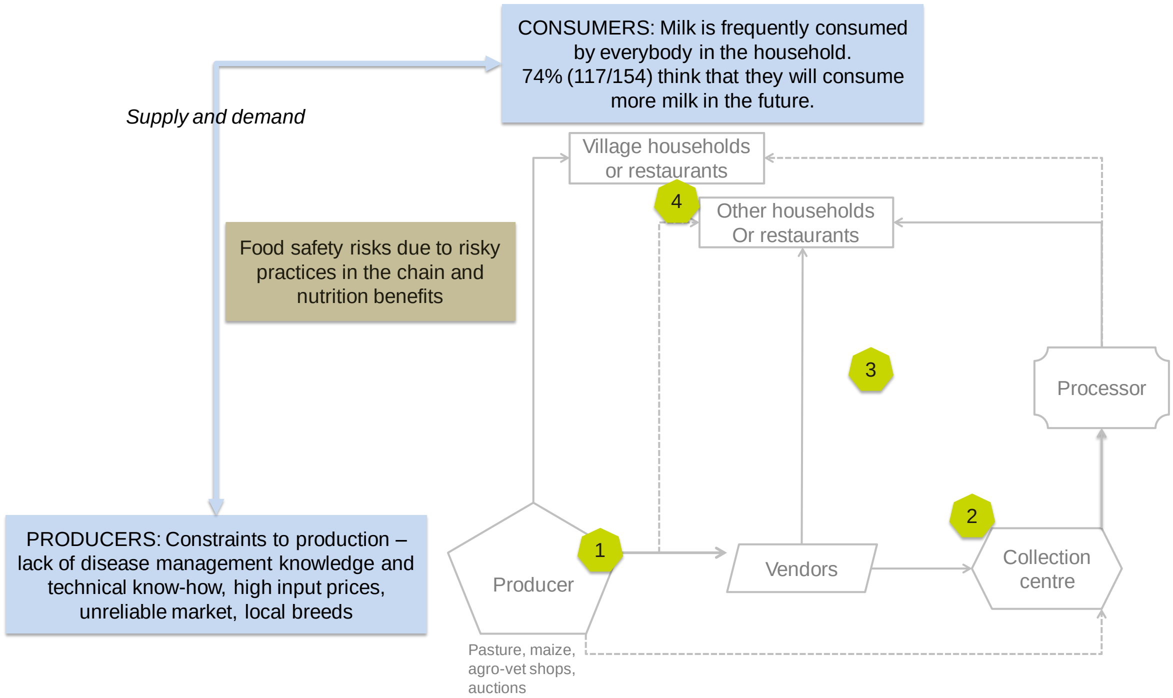

Figure 21: Relationship between demand, supply and food safety. Constant or increasing demand for milk could be covered by addressing production constraints. However, this should be accompanied by milk hygiene and safety measures to avoid an increase in foodborne disease. The green hexagons are intervention measures described in the text.

Such measures would allow an increase in milk production and hopefully reduce the shortages experienced in the dry season. However, given the risky practices along the chain and the reported contamination and hygiene issues, such an increase in production could constitute a major food safety risk if it was not accompanied by intervention measures to promote milk hygiene and safety in the value chain. This becomes particularly important in settings where smaller and smaller proportions of the population work in farming and provide milk for the larger part of the population (consumers); in other words the often observed pyramid shape of production and consumption.

Given that only 8% of households interviewed in the survey had constant electricity, it is likely that in the short to mid-term the fresh milk chain without refrigeration will continue to be an important source of animal source nutrients. Further, fresh milk is the dairy product consumed most frequently in the households interviewed. Consequently, **intervention measures** to promote food safety in the existing system could be:

- **Regular education campaigns, training seminars or workshops** to inform producers, processors, retailers and consumers about the risks related to adulteration and unhygienic production and handling of milk as well as to teach best practice. This would need to be based on scientific evidence to ensure a balance between nutritional value and food safety.

- Such campaigns could be supported by the promotion of **quality control mechanisms,** such as **quality assurance schemes.** In milk collection and processing centres this could, for example, include the measurement of the water content using lactometers, organoleptic checks, inhibitor tests to check whether the product is free from residues, and Resazurin test to assess the bacterial load in milk. These could be supported by incentives (e.g. higher price for high quality milk) and disincentives (e.g. penalties for adulteration or residues). However, penalties can be detrimental for food safety if producers and retailers tend to sell adulterated milk through informal channels to avoid penalties instead of improving quality. One of the problems reported with such schemes in the past was that rejected milk was sold privately to households or restaurants. To avoid this happening, collection centres could keep the milk at a low price and find uses that would not require highest quality (e.g. production of animal feed after heat treatment).
- Achieving higher standards in direct sales between producers and consumers would be more difficult to achieve. One option may be to have a **producer quality label** established by for example the government or the dairy sector that would include regular assessments of the milk quality. Because consumers clearly appreciated good quality and 78% of consumers in the survey stated that quality was more important than price, it is likely that many consumers would be willing to pay a **price premium for certified milk**.
- Official **rules and regulations** and **effective enforcement** would need to accompany many of these intervention measures to give them a legislative foundation and promote their success.

In the longer term with economic growth, increase in income, and urbanisation, it is likely that there will be an increase in demand for processed products. Consumers are currently not familiar with pasteurised milk and - apart from butter, ghee, and fermented milk - other dairy products such as cheese are very rarely consumed. Many preservation and processing steps would have a positive impact on food safety, but they often lead to high-density, high caloric products, which may contribute to overnutrition in the longer term.

Suggested research questions:

- What is the predicted demand for milk and other dairy products over the next decades?
- What are seasonal patterns in the dairy value chains, which flows are constant or variable?
- What are the flows in the dairy value chains broken disaggregated by production type, breed and purpose as well as associated input use?
- What is the practicality, acceptability, feasibility and cost-effectiveness of suitable intervention packages in the milk value chain?
- What is the willingness of the consumer to pay premium for safer milk and dairy products?

4.12 Social and gender determinants: Who gets the nutritional benefits and bears the health risks of ASF? How do gender roles and poverty influence health and nutrition risks?

4.13 Social and gender determinants: How do cultural practices affect health and nutrition risks (consumption raw food, withholding food during illness)

Milk and other ASF were commonly perceived as something beneficial and frequently given to children, because of the perceived nutritional benefits (“milk is a highly nutritious food”, “meat is good for growth”). Benefits from ASF consumption mentioned in the FGD included the following:

- Good/rapid/increased growth
- Increased body weight
- Good energy
- Improved health; children do not get ill often
- Children have good mental capacity, learn fast

When asked why milk would sometimes not be consumed, the following answers were given:

- Allergic reaction upon consumption such as skin rushes or inflammation.
- Vomiting upon milk consumption.
- Children who vomit or suffer from diarrhoea or stomach ache after consuming fresh milk
- Some children dislike dairy products and prefer other foods.
- Some women crave milk, in particular fermented milk during their pregnancy, while others are completely put off by dairy products and avoid them.

Generally, there were no dairy products that were not eaten at all and no community reported that there were any beliefs that would restrict the consumption of milk. However, there were some beliefs for other ASF that prevented the consumption: For example, fish was reported not to be eaten by the Maasai, because they are like snakes and in some communities eggs were not given to pregnant women, as they were believed to cause bearded babies. In one village there was a taboo against egg consumption for the young children who has not started to speak yet, it was said that if such children eat egg they will be dumb. In one village, young children were not given sheep's milk because it was said to be sticky and most of the children did not like it.

One village reported that they gave women after delivery a mixture of ghee, honey, milk and eggs as medicine to treat stomach aches; in the ratio of 1/8 litre ghee, 1/8 litre honey, 1 litre of milk and 2 eggs to be used twice per day. Similarly, milk was mentioned by various people as a treatment to clean the system, for example after having ingested something poisonous.

The main factor limiting consumption of dairy products was the purchasing power of the households. This implies that p**oor people may be excluded from milk consumption** in particular when milk is scarce, prices high and income low. There is a risk that poor people may drink milk even if it is low quality, i.e. their consumer choices are likely to be restricted.

Other points referring to consumption practices are discussed above.

5 FURTHER DISCUSSION POINTS

5.1 Feedback on tools from enumerators

Enumerators reported that the tools generally worked well in the Tanzanian context. Engagement with people and enjoyment of the participatory methods was universally noted, and helped counteract 'research fatigue', which was explicitly raised by respondents at every site. There were positive reactions regarding the selection of sites, response rate, training of enumerators, and team collaboration. Proportional piling was perceived as a highly effective and informative technique, as it was easy to understand for both enumerators and participants.

In terms of difficulties encountered, enumerators reported that Maasai farmers were often afraid to disclose the real number of cattle they owned. Apart from that, enumerators did not think that people would give answers to please them or feel uncomfortable with certain topics, apart from questions related to diarrhoea and sickness, which sometimes embarrass people. A commonly described problem was that participants had high expectations of something in return for their participation, ranging from money to gifts, training and support.

The consumer questionnaire was found to be too long. It took about 30-45 min per interview and people were exhausted after a while and responded too slowly or too quickly. In particular the food diversity question was perceived as too time consuming and it contained many foods that people do not commonly consume. For many respondents it was difficult to record milk quantities in L/ml, as mothers use other types of measurements (e.g. cups). Commonly, the PRAs and FGDs were reported to last quite long, in general about 3 hours for one PRA. For the consumer PRAs and FGD there was an additional issue in that there were not enough people available in the village, which led to people participating in both groups. Hence, the same participants were exposed to very similar questions; this was perceived as tedious by some. In terms of logistics, the enumerators recommended to make better use of the support and knowledge of extension officers and involve them more closely in the data collection process. Moreover, they recommended translating the documents into local language so that all enumerators could use exactly the same questions. Supervisors reported that for them it was sometimes difficult to supervise all ongoing activities at the same time (both producer and consumer groups ran in parallel).

It was stressed multiple times that participants would like to hear about the results of the study and get some payback in the form of information and/or training.

6 CONCLUSIONS AND RECOMMENDATIONS FOR RISK MANAGEMENT

Milk and dairy products are commonly perceived as highly nutritious and beneficial foods in Tanzania and consumed very frequently by all household members. There is large demand, which cannot be covered by the current production, which is particularly evident in the dry season, when there is a reported shortage of milk.

Many **constraints** to production have been reported, which indicates that there is considerable potential for increased supply that could be unlocked. Future studies could investigate which intervention measures would be most effective, practical, economic and acceptable to increase productivity of dairy farmers in Tanzania. This should include an assessment of options at various points in the value chain as described above.

With increased productivity and marketing channels, the availability of milk on the market throughout the year should improve and hopefully become more stable over time.

It is currently unclear what such an increase in milk supply would mean in terms of **nutrition**. All households in the survey were found to be food-secure, but no information was available on seasonal fluctuations or micronutrient intake. Therefore, a longitudinal design and the collection of individual dietary diversity data, for example based on a 24h recall should give more accurate information on nutritional status of people in rural areas in Tanzania. This would then allow assessing the impact of increased milk consumption on nutrition. Given the frequency of consumption, it is recommended to assess the impact milk and dairy products may have in the future in terms of overnutrition.

Consumers mentioned many quality attributes that were of importance to them, such as taste, normal appearance, viscosity/heaviness, fresh smell, clean, white colour, absence of pus/dirt/blood, and various people said that they would reject milk if it was of insufficient quality. The main quality issues mentioned were hygiene and adulteration. However, despite the awareness of the importance of good hygiene, the belief that milk was "good" seemed to outweigh any concerns about food safety both in producers and consumers. Given the results from the biological sampling and testing that showed contamination with coliform bacteria and *B. abortus* along the dairy value chain, this has important consequences for any interventions targeted at nutrition.

If production is increased without addressing food safety issues along the chain, risks of food borne disease in consumer groups may increase. Consequently, **incentive**s**/disincentives for improving food safety** along the chain should be created. These can be targeted at any point in the chain as described above (e.g. testing in collection centres, correct heat treatment at home, chance in practices, such as discarding of milk from sick animals, etc).

Importantly, any risk management measures need to take into account both food safety and nutritional aspects and ideally tackle points in the chain that have **a positive impact on both food safety and nutrition**.

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8 APPENDICES

Appendix 1: Participatory rural appraisal for producers

PRA producers.docx

Appendix 2: Participatory rural appraisal for consumers

PRA consumers.docx

Appendix 3: Focus group discussions mother and children

FGD mothers and children.docx

Appendix 4: Consumer and producer questionnaires

Consumer household survey.docx

Producer survey.docx

Appendix 5: Participatory rural appraisal and focus groups discussion reports

Microsoft Office Word 97 - 2003-Doku

Lubungo_7.12.12_consumers.doc

Kidudwe_11.12.12_consumers.doc

Kidudwe_11.12.12_producers.doc

Lubungo_7.12.12_producers.doc

Lusanga_13.12.12_consumers_FGD.doc

Manolo_9.1.13_consumers.doc

Manolo_9.1.13_producers.doc

Mbokoi_13.1.13_consumers.doc

Mbokoi_13.1.13_producers.doc

Mlandizi_3.12.12_complete report.doc

Mlandizi_3.12.12_consumers.doc

Mwangoi_7.1.13_consumers.doc

Ngulwi_14.1.13_consumers.doc

Ngulwi_14.1.13_producers.doc