Evaluation of Supply Chains and Post-harvest Losses of Selected Food Commodities in Ethiopia

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Abstract

Supply chain management practices and losses in food value chains of three major food commodities in Ethiopia (milk, *teff* and *warqe* or *enset*) were evaluated in this thesis. *Teff* is a cereal, while *warqe* is a perennial plant from which the food products *kocho* and *bulla* are extracted. T*eff, kocho* and *bulla* are staple foods for many Ethiopians.

In the three case studies, value chain analysis, questionnaire-based loss estimations and Likert scale-based loss factor evaluation were applied. Qualitative and quantitative primary data were collected using a semi-structured survey questionnaire and key informant interviews. The data were analysed using descriptive statistics, Tobit and Probit models in SPSS and Microsoft Excel software.

The study identified major chain actors and losses at each stage of the food supply chains. In the milk chain, estimated losses were 3.35%, 5.46%, 2.45%, 0.95%, 1.23% and 0.88% at producers, cooperatives/union, wholesalers, retailers, processors and catering institutions, respectively. In the *teff* chain, estimated losses were 8.18%, 1.67%, 2.85% and 3.58% at producers, wholesalers, retailers and catering institutions/consumer stage, respectively, while the corresponding values in the *kocho* chain were 5.8%, 15.2%, 24% and 5.8%, respectively. In the *bulla* chain, 1.4%, 3.1%, 12.6%, 28.8% and 4.5% losses were estimated to occur at producers, wholesalers, retailers, processors and catering institutions/consumer stage, respectively.

The loss hotspots identified were cooperatives, farmers, retailers and processors for milk, *teff, kocho* and *bulla*, respectively. Poor handling at collection points, the threshing process and poor packaging and processing facilities were among the major problems causing losses. Tobit model analysis identified distance to the nearest market as the most important factor for farmers' post-harvest losses, while Probit analysis identified attendance in formal education as most determining for value addition decisions in the *teff* chain.

Relationships among the chain actors were mostly based on spot transactions, lacking long-term market orientation and adequate mutuality and trust. However, application of supply chain management (SCM) practices could potentially improve the overall supply chains and reduce food losses.

Keywords: Ethiopia, Food Losses, Milk, SCM, *Teff*, Value Chain, *Warqe*

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Dedication

This thesis work is dedicated to my mother, Gure Wajwaji, who has devoted her whole life to shouldering all the challenges encountered by myself and my siblings.

You only have power over people so long as you don't take everything away from them. But when you've robbed a man of everything, he's no longer in your power - he's free again.

Aleksandr Solzhenitsyn

Contents

List of Publications

This thesis is based on the work contained in the following papers, referred to by Roman numerals in the text:

I Tadesse Kenea Amentae, Girma Gebresenbet, David Ljungberg (2015). Characterizing Milk Supply and Marketing Chains and Losses in Wolmera and Ejere Districts of Ethiopia. *Journal of Service Science and Management,* 8, 823-843

II Tadesse Kenea Amentae, Efa Gobena Tura, Girma Gebresenbet, David Ljungberg (2016). Exploring value chain and post-harvest losses of *Teff* in Bacho and Dawo districts of central Ethiopia. *Journal of Stored Products and Postharvest Research* 7(1), 11-28

III Ashenafi Cheka Tufa, Tadesse Kenea Amentae,Tesfaye Balemi Tufa, Girma Gebresenbet. Assessment of postharvest food losses of *Warqe* along its supply chain in the central part of Ethiopia (submitted)

The contribution of Tadesse Kenea Amentae to the papers included in this thesis was as follows:

I Planned the paper, performed data collection, made analysis/evaluations, and wrote the manuscript with the support from co-authors

II Planned the paper, performed data collection, made analysis/evaluations, and wrote the manuscript with support from co-authors

III Participated in paper planning, data collection, and manuscript writing

1 Introduction

1.1 Background

Feeding 9 billion people by 2050 may require food production growth of 70% above the current level (Godfray et al., 2010; Parfitt et al., 2010; Tomlinson, 2013). This is a global challenge that needs attention. Moreover, the existing situation in the global food sector is not encouraging. While there has been a continued decline in overall hunger, 842 million people, or one in eight of the world's population, were estimated to be suffering from starvation between 2011 and 2013 (FAO, 2013). The World Food Program (WFP, 2014) has released a hunger map indicating similar trend that about one in nine of the world's population goes to bed hungry each night. The intensity of food insecurity varies between global regions. Sub-Saharan African countries are among the most affected regions and this is projected to continue to be a very vulnerable region during the coming decade (Rosen et al., 2014). Ethiopia is one of the sub-Saharan countries where the food insecurity problem remains a threat.

According to the WFP (2014) hunger map, Ethiopia falls into the category of very high prevalence of undernourishment, with 35% or more of its population being food insecure between 2012 and 2014. This situation is exacerbated by causalities such as El Niño, which caused a drought in 2015 that resulted in about 10-15 million Ethiopians having to rely on emergency food aid (FAO, 2016).

These reports are clear calls for the scientific community to continue with investigations and provide solutions to food insecurity problems both locally and globally.

Significant amounts of food produced with scarce resources are lost before consumption. For example, a study by Kummu et al. (2012) on global food losses noted that 25% of the food produced was lost within the food supply chain before consumption. Similarly, Godfray et al. (2010) roughly estimated

global food losses to be between 30% and 40% and pointed out that such losses occur both in developed and developing countries, the main reasons being lack of infrastructure and knowledge in food supply chains in developing countries and human behaviour at the farming, retail and consumption stages in developed countries.

Food security may be discussed within three major categories, namely population, production including productivity, and food losses across food value chains. The food losses category is gaining more attention nowadays.

Inefficiencies and ineffectiveness in supply chain management practices are one of the major reasons for food losses. For instance, Kummu et al. (2012) argued that by making the food supply chain efficient, half of all food losses could be saved and that could feed one billion extra people. The author also claimed that efficient and effective food supply chain management is a crucial strategy if the world is to feed its growing population in a sustainable way.

1.2 Literature review and definition of terms

1.2.1 Post-harvest food losses and waste

Following the recognition that reducing food losses is an important element in the food security equation, the terms food losses, post-harvest losses and food waste are commonly used in scientific publications and other reports. However, unless specifically defined for a particular use, these terms may create confusion, as different sources use them to refer to somewhat different issues. The losses in the food supply chain are often broken down into type of loss, using the terms agricultural losses, processing losses, distribution losses and consumption losses (*e.g.* Gustavsson *et al*., 2011). Harris and Lindblad (1978) distinguished between pre-harvest, harvesting and post-harvest food losses using different periods of time in production and distribution of food commodities. According to those authors, losses that happen before harvesting, *e.g.* due to weeds, insects or disease, are 'pre-harvest food losses', losses during harvesting, *e.g.* resulting from pod shattering during harvesting, are 'harvesting losses', while losses that happen between completion of the harvesting process and human consumption are 'post-harvest losses'. Parfitt *et al.* (2010) points out that some studies distinguish between food losses and food waste, with: "*Food loss referring to the general decrease in food quantity or quality, which makes it unfit for human consumption while food waste refers to food loss at the end of food supply chains which generally results from human behavioural issues*." According to this distinction, food waste is part of food losses. However, Parfitt *et al.* (2010) opted to use the term "food waste" to mean both food losses and food waste. Hodges *et al.* (2011) referred to the

post-harvest system as "*interconnected activities from the time of harvest through crop processing, marketing, and food preparations, to final decision by the consumer to eat or discard the food product*" and post-harvest losses as "*measurable quantitative and qualitative food loss in the post-harvest system*", concluding that food losses are a subset of post-harvest losses and food waste is a subset of food losses that is potentially recoverable for human consumption. Rembold *et al.* (2011) considered post-harvest losses to include losses that occur at the time of harvest, though various post-harvest operations on the farm and on to the first level of market. The definitions of post-harvest losses by Hodges *et al.* (2011) and Rembold *et al.* (2011) are similar to that by Harris and Lindblad (1978) for post-production losses as losses occurring at all stages, starting from harvesting and movements of food down to the consumption point.

In this thesis, the term post-harvest loss is used because it is most often applied in the literature. However, post-harvest losses refer here to losses of food commodities both during the harvesting process and during all post-harvest activities throughout the supply chain in the process of reaching consumers. They include quantity, quality and economic losses as experienced by the food chain actors. The percentage estimates by chain actors at each stage of the food value chain represent losses relative to what they handle in an individual year. For farmers the percentage estimate is relative to their total production, while for other chain actors it is relative to the amount they handle through purchasing.

1.2.2 Value chain and value additions

A value chain is defined by Kaplinsky and Morris (2001, p.4) as *"the full range of activities which are required to bring a product or service from conception, through the different phases of production (involving a combination of physical transformation and the input of various producer services), delivery to final consumers, and final disposal after use"* The word 'value' in value chain may refer to *place values*, which means getting the product or services to the right place; to *form values*, which means getting the product or service in the right form (conversion of the product from one form to another), or to *time values*, which means getting the product or service at the right time. In a broader sense, value is what the customer is willing to pay for. Value addition refers to activities which serve to create or add these values, which include activities in improving product quality and convenience for chain actors downstream. A recent study (Deloitte, 2013) viewed the food value chain as the linkages and networking among the stakeholders and defined it as *"the network of stakeholders involved in growing, processing, and selling*

the food that consumers eat—from farm to table." According to that source, collaboration among these food value chain actors is a pivotal issue. The roles and key issues at these stakeholder stages of the food value chains were summarized in Figure 1.

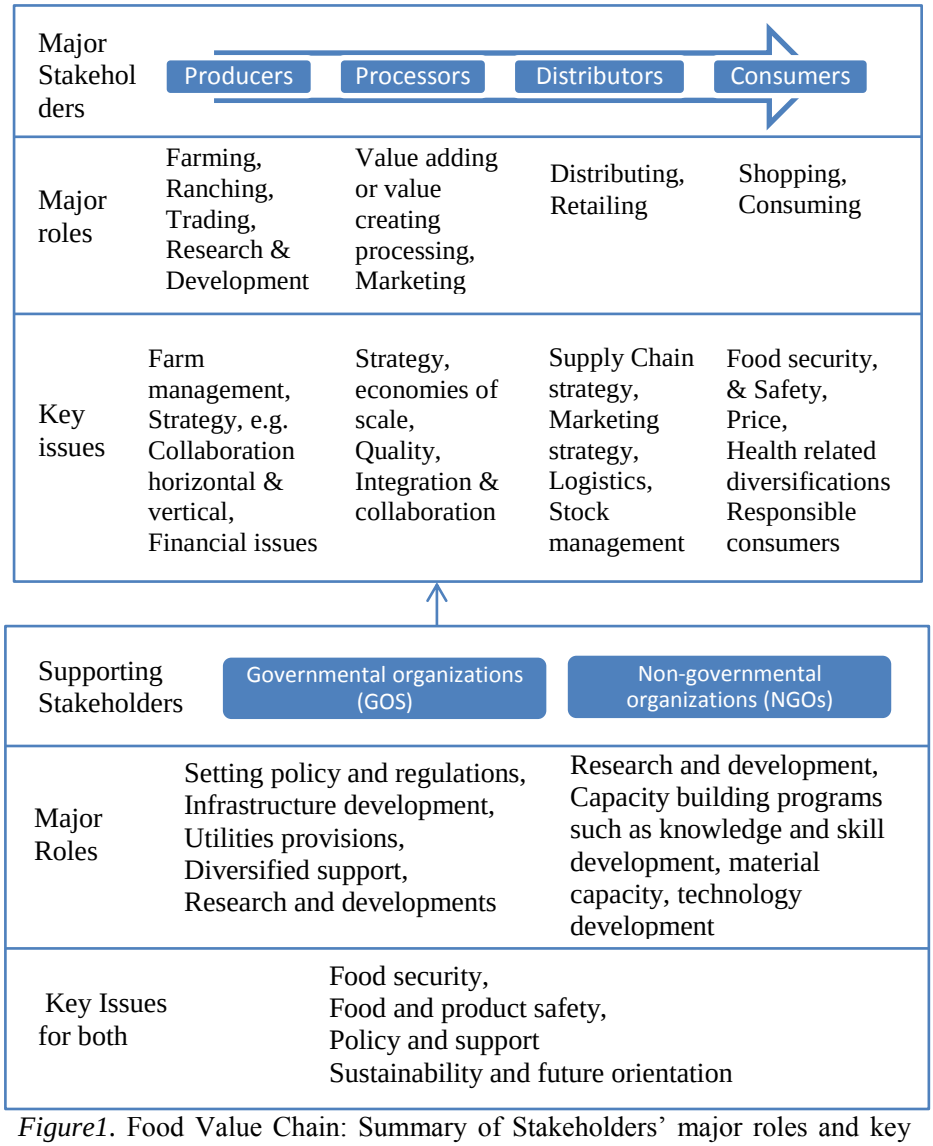

Figure1. Food Value Chain: Summary of Stakeholders' major roles and key issues (adapted from Deloitte, 2013)

The food value chain stakeholders listed in Figure 1 include: ***Producers*** involved in growing, searching for improvements and trading food commodities; ***processors*** involved in both primary and advanced value addition who process, manufacture and market value-added food products; ***distributors***, including wholesalers and retailers engaged in food commodity marketing, government (GOs) and non-governmental organisations (NGOs) involved in setting regulations that monitor and regulate the entire food value chain from producer to consumer and responsible for providing an enabling environment for value chain development; and end ***consumers,*** who purchase the food commodities and consume them.

Food supply chain management deals directly or indirectly with the key issues indicated in Figure 1, which are also related to the aims of this thesis. Issues in food supply chain management in each stage may include:

a) Producer stage: Improving farm management skills and knowledge, horizontal and vertical collaboration issues, access to market and financial services
b) Processor stage: Quality concerns, integration and collaboration issues, process or product specialisations to enhance economies of scale in processing
c) Distributor stage: Supply chain, marketing, inventory, logistics strategies
d) Consumer stage: Access to safe and nutritious foods that are produced and transported in socially and environmentally responsible manner.

1.2.3 Food supply chain

Food commodities are often produced thousands of miles away from their consumption point. This distance, be it short or long, between the point of production and the point of consumption is linked by a food supply chains. Vorst *et al*., (2007) defined supply chain as *"Supply chain is a sequence of decision making and execution processes and material, information, and money flows that aim to meet final customer requirements, that takes place between different stages along the continuum, from point of production to final consumption."* According to those authors, the supply chain includes not only producers and suppliers, but also the interactions of logistics, transporters, warehouses, retailers and consumers, which are interconnected within the total supply chain network.

The food supply chain can be defined in a similar way, where the word *material* in the above definition refers to food material. Any individual firm

belongs to at least one supply chain in the total network, as depicted in Figure 2.

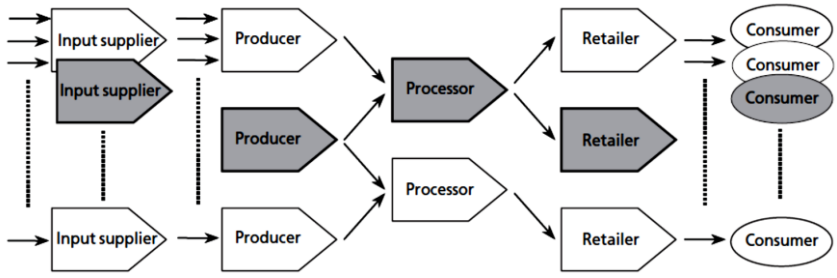

Figure 2. Supply Chain (shaded) within the total supply chain network (Vorst et al., 2007, p.7)

The management processes along the flows of the food commodity supply chains in order to achieve superior customer value can be referred as 'food supply chain management'. According to Christopher (2011), supply chain management (SCM) is *"the management of upstream and downstream relationships with suppliers and customers in order to deliver superior customer value at less cost to the supply chain as a whole"*, and is a process through which relationships between parties in the chain are managed to incorporate individual interests into common interest for the whole chain, with this common interest guiding the activities in the chain.

In terms of definition, food supply chain management may not be very different. It can be defined as the process of managing upstream and downstream relationships in food supply chains in order to deliver high quality and safe foods to consumers at a fair price. However, food supply chain management may require specific supply chain management practices not employed within industrial product supply chains. Mena and Stevens (2010) identified seasonality, concerns about health and safety, short shelf-life, volatile demand and consequences for the environment as the major points of divergence of food supply chains from industrial product supply chains. Seasonality concerns both demand and supply and agricultural produce has a short shelf-life and sensitive demand caused by different factors, thus requiring much more responsiveness and speed than industrial stock management. Quality, traceability, safety and food risk management are other important issues to consider. In addition, the high dependence of food production on natural resources such as water and its huge impact on environmental

degradation are major issues to be considered in agri-food supply chain management practices (Mena & Stevens, 2010).

Corporate social responsibilities such as animal welfare, biotechnology, environment, fair trade, labour and human rights are other challenges imposed by responsible consumers on agri-food supply chain managers (Maloni & Brown, 2006). These problems are further complicated by the fact that some agricultural products are only produced in specific locations or ecologies that may be geographically very far from consumption points.

Lambert and Cooper (2000) concluded that the era of autonomous standing in business competition is over and that businesses now are in the era of inter-network competition. In their words, "*instead of brand versus brand or store versus store, it is now suppliers-brand-store versus suppliers-brand-store, or supply chain versus supply chain.*" They viewed the ability of management to integrate their company's sophisticated network of business relationships in this emerging competitive environment as the key to ultimate success for businesses in the chain. There are three key decisions in SCM (Cooper *et al*., 1997). These are: i) decisions in choosing the supply chain network structure, ii) choosing what process to integrate with key supply chain members, and iii) choosing what level of integration and management should be applied for each process link.

The first decision deals with analysing and deciding on organisations that are part of the supply chain. The supply chain is a network of multiple businesses and relationships, not a chain of businesses with one-to-one, business-to-business relationships. Therefore, to choose the level of partnership for each particular chain member needs particular management based on the organizations' limited time and effort to collaborate with all networks (Vorst et al., 2007).

The second decision is about choosing the business processes that could be integrated among the selected chain members. Cooper *et al*. (1997) stated that SCM is "*the integration of business processes from end-user through original suppliers that provides products, services, and information that add value for customers*". They list eight business processes identified by the International Centre for Competitive Excellence (ICCE) as examples to be integrated among chosen supply chain members: Customer Relationship Management, Customer Service Management, Demand Management, Order Fulfilment, Manufacturing Flow Management, Procurement, Product Development and Commercialisation, and Returns Management.

The third key decision deals with choosing the level of integration required for the selected business processes to integrate in the second decision. Lambert and Cooper (2000) identified four fundamentally different types of business

process links between members of a supply chain, based on the degree of importance to the focal firm: Managed business process links, monitored business process links, not-managed business process links, and non-member business process links. Managed process links refer here to links that the focal company finds important to actively integrate and manage, while monitored process links are less critical to the focal company than managed process links. The focal company simply monitors or audits how the process link is integrated and managed. Not-managed process links are those links where the focal company is not involved in managing or monitoring. These are not critical enough to use resources for managing or monitoring. Non-member process links are links between members of the focal company's supply chain and non-members of the supply chain. These are not considered links of the focal company's supply chain structure, but have an effect on the performance of the focal company and its supply chain.

1.2.4 Important food commodities in Ethiopia

Ethiopian agriculture mostly comprises subsistence farming, dominated by smallholder farmers engaged in a variety of mixed farming activities. The Ethiopian national statistics agency (see Appendix A) lists the major food and economic crops and live animals in the country (CSA, 2016) using the local and FAO names and codes of these crops and animal species. According to that list, there are about fifty types of foods and/or commercial crops, nine types of economic live animals, five types of animals whose meat is used as food in the country, and two types of animals (cattle and camel) providing milk for human food. Eggs, as a food in the country, come from hens. The other food item listed is honey.

The economic crops in Ethiopia are further classified as cereals, pulses, oilseeds, vegetables, roots and tubers, fruit, stimulants and sugar cane. *Warqe* or *enset* is another class, which is categorised under roots and tubers by the FAO, but the commodity does not completely fit into that category. Ethiopian central statistics based on agricultural survey results (CSA, 2012/13) indicate that national crop production is dominated by cereals, in terms of both cultivated land acreage and volume of production (see Appendix B). They also show that cereals contribute to 78% of land under cultivation and 85% of total grain crop production.

Looking further to the cereals section in Appendix B, *teff*, maize, sorghum and wheat dominate land coverage, occupying 22.23%, 16.39%, 13.93% and 13.25% of the cultivated acreage, respectively. These cereals also dominate in terms of production volume, but with a slightly reshuffled ranking whereby maize, *teff*, sorghum, and wheat represent 26.63%, 16.26%, 15.58% and

14.85%, respectively, of total grain production in Ethiopia during the reporting period.

The economic live animal population in Ethiopia is dominated by cattle. According to CSA (2011/12), the top three livestock animals in terms of population in Ethiopia are cattle (about 53 million), sheep (about 26 million), and goats (about 23 million) (see Appendix C).

From these national data, it is apparent that Ethiopia has the potential to improve its agriculture if supported by appropriate policy. The diversity of crops and livestock and the large population of livestock, particularly cattle, are opportunities to be exploited. However, Ethiopia's agriculture sector remains unable to meet local food demands and therefore the country is highly dependent on imported food commodities, both through purchase and food aid (Adenew, 2004). Thus the food insecurity problem remains in Ethiopia.

To rectify this problem, efforts to achieve sound agricultural production performance play a vital role. However, achievements in agricultural production alone may not guarantee the availability of food crops. This is because besides low productivity, the agricultural supply chains and services across food chains in the Ethiopian agriculture sector are characterised by various problems.

Inadequate and inappropriate partnership in the food chains, underdeveloped and fragmented logistics management systems, poor or no transport or logistics infrastructure (roads, warehouses, cold chains *etc*.), poor information management systems, lack of an adequate financing system, lack of coordination of food transport, high losses resulting from damage to goods and quality deterioration due to inappropriate harvesting, storage, packaging and end transport are among the problems that are hindering the agriculture sector in Ethiopia. In particular, losses of major foods such as cereals (Hodges *et al*., 2011), dairy products (Steen & Maijers, 2014) and other foods are triggering factors causing food insecurity problems in Ethiopia.

The work presented in this thesis was designed to address these problems. In particular, the thesis deals with supply chains and post-harvest loss issues for three major food commodities, milk, *teff* and *warqe*. These commodities were selected based on national data indicating their importance in food security, observed problems during a pilot study and a review of the literature. Furthermore, there has not been sufficient previous research and analysis to identify solutions to these problems and guide policy directions in these food commodity chains. Therefore, this thesis may add value in this regard by not only serving as a policy guide, but also generating further studies in the area of food losses, food supply chain management practices and food value chains in Ethiopia in general and in the specific food commodity chains in particular.

Another aim was to contribute to the empirical knowledge of SCM in the food sector. Details of the selected food commodities examined in this thesis are further discussed in section 2.1.1.

1.2.5 Research questions

As noted previously, one of the major causes of food losses is inefficiency in food chains. In developing countries, particularly high food losses occur at the stages of the supply chain before the product reaches shops and consumers downstream (Aulakh *et al*., 2013). Therefore, this thesis focused on identifying possibilities for efficient and effective food SCM practices that could improve the food supply chains studied in terms of increasing profitability and food quality and reducing the quantity and quality losses of selected food commodities in Ethiopia.

Within the context of the above discussion, the following research questions were formulated:

- What do the value chains of certain selected food chains (milk, *teff* and *warqe*) comprise?
- What is the level of food losses across the stages of these food supply chains and what are the factors triggering the losses?
- Where are the loss hotspot points for the selected food commodities across the stages of their food supply chain?
- What are the factors affecting farmers' value addition decisions?
- Is there any potential for improvement of the selected food chains through food supply chain management practices?

1.3 Objectives

The main objective of this thesis work was to analyse selected food commodity supply chains in order to identify possibilities for improvements to reduce food losses through the application of efficient and effective food supply chain management systems in Ethiopia.

Specific objectives for the selected food commodities (milk, *teff* and *warqe*) in Ethiopia were to:

- Map and analyse the supply chains,
- Assess post-harvest food losses and factors causing these losses,
- Identify factors affecting farmers' decisions on value addition, and
- Evaluate the potential of SCM practices for improving food supply chain performance, including reduction of post-harvest food losses.

1.4 Scope and limitation of the study

The scope of this study was limited to characterisation in terms of production, marketing, food losses, relationships and logistics practices in the supply chains of milk, *teff* and *warqe*. No detailed analysis was made of the governance structure of the supply chains of milk, *teff* and *warqe*, but this could be a direction for future work. Moreover, dairy farmers included in the study were those commercially orientated and having dairy farming as a substantial contributor to their income and livelihood.

A lack of previous studies relating to supply chains and food losses, particularly in the cases of *teff* and *warqe*, were limiting factors. Moreover, loss assessments were based on subjective estimates made by the chain actors. Thus, the results obtained are not directly comparable to figures on losses reported in any earlier studies using other methods.

1.5 Structure of the thesis

The thesis structure was depicted in Figure 3. Acquiring sufficient knowledge on the selected food supply chains, determination of post-harvest food losses, identification of factors causing these food losses and assessment of the potential of SCM to improve food chains were the major challenges and tasks addressed in all three papers (I-III). Factors affecting farmers' value addition decisions were addressed only in Paper II. The work involved: characterising food supply chains, identifying levels of losses and loss hotspot points, identifying and ranking factors triggering food losses in the stages across the selected food value chains, identifying factors affecting farmers' value addition decisions, and determining the potential of SCM practices to improve these food chains. Based on these results, expected outcomes included: increased awareness through knowledge of the real food value chains, inviting prioritised interventions from stakeholders, and implementation of SCM among the chain actors, in order to ultimately reduce losses of food commodities in the value chains and improve the supply chains overall in terms of profitability, quality and reduced food losses. The ultimate goal is better food security.

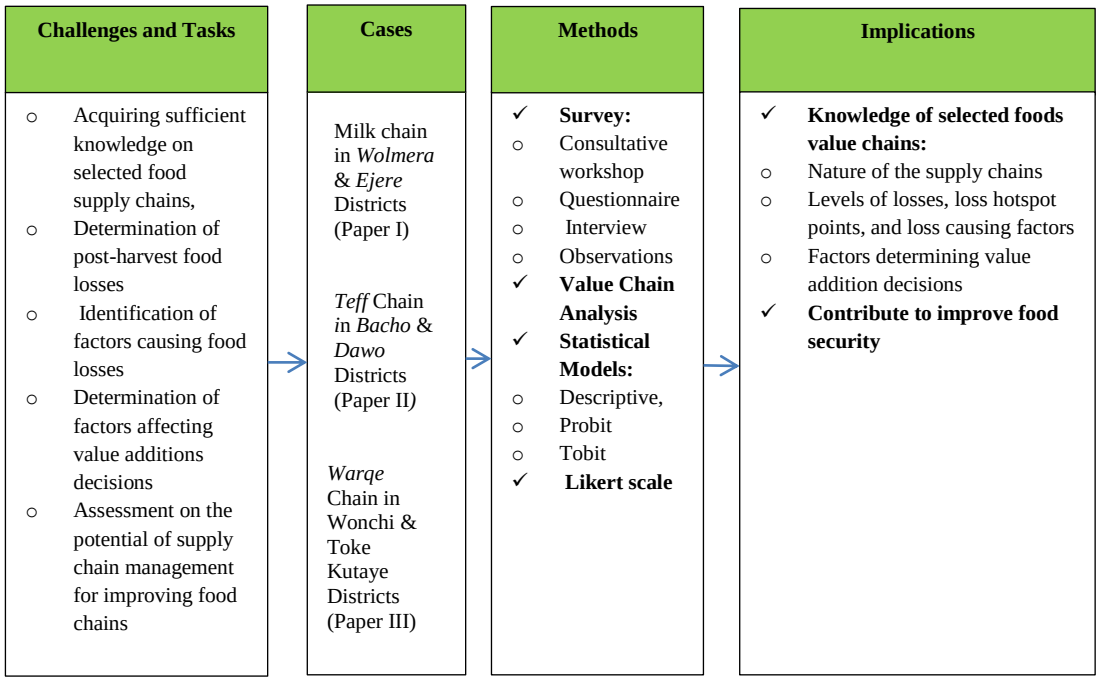

Figure 3. Structure of this thesis work

2 Materials and Methods

Value chain analysis, a questionnaire-based loss estimation technique, Likert scale-based loss factor evaluation and multiple case study methods were applied. Value chain analysis methodology was applied in order to make a stage-wise diagnosis for the value chain of the selected food commodities from production to consumption. In order to answer the specific research questions posed in section 1.2.5, a range of different kinds of evidence on issues in food value chains had to be investigated in different case settings.

2.1 Selection of study commodities and study sites

2.1.1 Study commodities

This thesis work concentrated on the food value chains of three major food commodities (milk, *teff* and *warqe*) in Ethiopia. The process of selection of the study cases, as discussed under section 1.2.4, was based on their importance for food security, the food loss problems associated with each product and the lack of previous studies particularly related to food losses across the supply chains that could indicate solutions to guide policy makers and stakeholders towards prioritised interventions.

***Milk*:** With about 53 million head of cattle (CSA, 2012), Ethiopia has high potential in milk production and consumption which could alleviate the food security problems of the nation. Despite this potential, the Ethiopian dairy sector remains incapable of meeting local demand and the country is losing large amounts of money through imports of dairy products. In Addis Ababa/Finfinnee, 8% of the dairy products consumed are imported (Francesconi *et al*., 2010). The country's imports of milk and milk products have shown a dramatic increasing trend in recent years, with the value of imports increasing by 142% from 49 million birr in 2005 to 119 million birr in 2010 (Land O'Lakes Inc., 2010). However, other reports indicate that a

significant proportion of domestic dairy production is lost in the value chain. For instance, a study by ILRI (2005) reported estimated dairy losses of 20-35% in Ethiopia in the movement of dairy products from farm to consumption, while Steen and Maijers (2014) reported milk losses as high as 35% in milk value chains in Ethiopia.

Teff: In Ethiopia, *teff* is an important cereal crop occupying 22% of all land under cultivation (first among all cultivated crops in terms of acreage) and contributes 16% to grain production, second next to maize in terms contribution to total grain production (CSA, 2012/13). Some reports indicate that *teff* is gaining wider acceptance in the international market too as a gluten-free cereal and as one of the 'healthy' grains (The Guardian, 2014). Regardless of its economic contribution and potential, *teff* is a very tiny cereal which is produced in a very laborious manual cropping system and has a number of problems in production and post-harvest management. Moreover, yield per unit area is among the lowest of all world cereals (Assefa *et al*., 2013). In addition, *teff* is a cereal that is subject to high losses particularly during the harvesting and threshing processes, mainly because of the tiny size of the seed. Farmers express their pain of the loss by a proverb in the Afaan Oromo language "*amman baddu osoo beekanii silaa nanqottan' jette Xaafiin*", which roughly translated it means the farmer knows how much is lost, so no-one wants to grow *teff*. This proverb indicates two important things, loss is serious problem of *teff* farming system and knowing the exact loss amount is difficult. Figure 4 shows a *teff* crop growing on an Ethiopian farm and a close-up view of a *teff* plant.

Figure 4. Teff crop growing on a farm (left) and close-up view of a *teff* plant (right)

***Warqe*:** *Warqe* is a perennial plants (see Figure 5) from which three important foods commodities are extracted: *kocho, bulla and amicho. Kocho* is produced after fermentation of the decorticated pseudo-stem and *bulla* is produced upon immediate squeezing of the inner soft part of the pseudo-stem,

which may be further processed to powdered *bulla*. *Amicho* is the root part of the plant and is consumed boiled fresh. *Warqe* means 'my gold' in the Afaan Oromo language, which indicates the multipurpose value of the plant. It is used as a staple food by 25 million Ethiopians and as a secondary food by more than 50 million in the country (Bezuneh, 2012). The plant is drought resistant and remains green throughout the year, and is therefore suitable as a supplement to crop residues when other animal feed materials are scarce (Nurfeta *et al*., 2008). It is also grown on small plots in the densely populated Ethiopian highlands, where the land is not suitable for other farming. There is a lack of previous research on supply chain and post-harvest losses of foods from the *warqe* plant. However, the responses of value chain actors and observations made during a pilot study before this thesis work revealed the very traditional and laborious procedures involved in getting the foods from this plant from farm to consumer, causing tremendous proportions of food losses which could be avoided.

Figure 5. *Warqe* crop growing on a farmyard (left) and close-up view of the *warqe* plant (right)

From a review of the literature, a consultative workshop and field observation made during the pilot study before the start of this thesis work, it was concluded that post-harvest food losses in the three food value chains were major problems. Moreover, it was apparent that there are almost no scientific studies addressing these problems. Therefore, in a first step to combat the problem of food losses, investigations on the value chains of these three commodities were deemed to be of paramount importance, in order to identify loss hotspot points and overall deficiencies in the value chains and necessary, high priority interventions by stakeholders.

2.1.2 Definition of chain actors in the selected food chains

For the selected food commodities, the major supply chain actors identified and the role these play are listed below. These terms are used thereafter in mapping and characterisation of the selected food chains.

Farmers/producers: Commercially orientated dairy farmers and *teff* and *warqe* growers engaged in producing these food commodities as a substantial part of their livelihood.

Cooperatives (co-ops): Farmers' associations which exist in the milk and *teff* chains. In both cases, the co-ops strive to alleviate marketing-related problems of the farmers.

Unions: Cooperatives of cooperatives. More than two cooperative associations may come together to form a union.

Processors: Those involved in processing these food commodities. In the milk chain, they are the small to medium-sized dairy plants engaged in producing value-added dairy products such as pasteurised milk. In the *teff* chain, processors refer to those businesses engaged in producing value-added products from *teff* cereal. These include bakeries, mill operators and *biddeena* sellers. In the *warqe* chain, processors are those businesses engaged in *bulla* processing. They purchase fresh *bulla* (dough) in large amounts and then process it into dried *bulla* (powder) and sell it in bulk or small quantities to their customers.

Wholesalers: Large traders who operate on large transactions. In the milk chain, the wholesalers buy a large volume of fresh milk from farmers and co-ops and sell it either to processors or down the central market to retailers and catering institutions. They also buy processed dairy products from processors and sell them to retailers and catering institutions. The milk chain wholesalers have their own transportation vehicles and they buy from farmers or from processing sites and transport the product to central market at Addis Ababa. In the *teff* and *warqe* chains, wholesalers are major traders operating in both the rural market and the urban market. They have a fixed establishment/site in the market place with a storage facility. They purchase large amounts of *teff* and *warqe* products from producers. They also buy from collectors in the *warqe* chain. They sell large amounts of *teff* and *warqe* to retailers and catering institutions.

Retailers and catering institutions: Businesses which sell the products to the final consumers. In the milk chain, these include supermarkets in Addis Ababa, kiosks selling milk or milk products such as *etitu/ergo*, cafeterias and hotels. In the *teff* and *warqe* chains, retailers are traders who have a fixed, established market facility in the market place. They purchase products in bulk

amounts from their suppliers (wholesalers and producers) and sell them in small amounts to consumers.

Collectors: (*Warqe* chain only) Non-licensed traders who run their business with wholesalers. They buy a large quantity of *warqe* products directly from producers in the vicinity of growers and sometimes at local markets and transport these to the marketplace to sell to wholesalers. Collectors usually use wholesalers' money collected ahead of time for purchasing.

Exporters: Retailers or wholesalers of various food products who also export processed *bulla* in the *warqe* chain. In the case of milk, *teff* and *kocho*, no exporters could be identified.

Consumers: Final users of these commodities as varieties of foods.

2.1.3 Study sites

The work was carried out in central Ethiopia. The value chains for the selected commodities start at producers in West Shewa and come through various market tiers to the capital city, Addis Ababa. The sites for each commodity were selected purposively from among high-producing areas for the commodities and areas with potential for value chain development. For each commodity, studies were made in two districts. *i.e*. in total six districts were covered by the studies. Districts are the second from bottom tier in the administrative structure of Ethiopia.

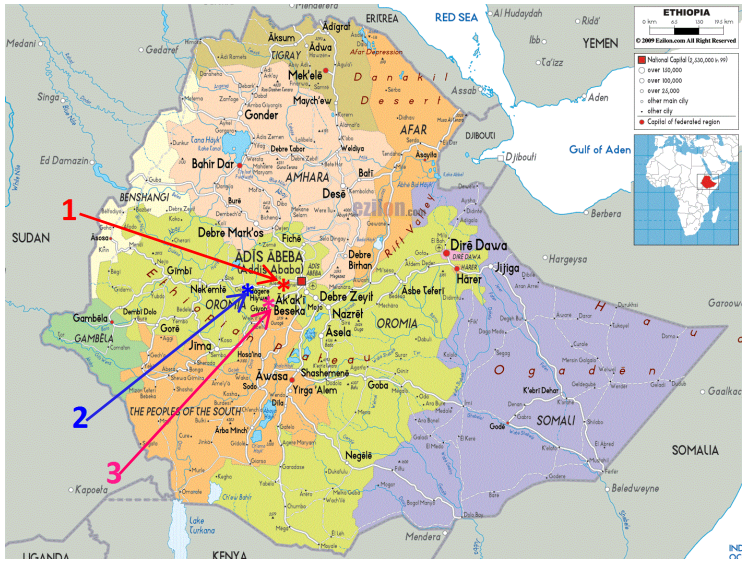

Figure 6. Location of study sites (adapted from http://www.ezilon.com/maps/africa/ethiopia-maps.html)

The general positions of the study sites within Ethiopia are shown in the map in Figure 6. The three dots indicated by arrows from numbers 1, 2, and 3 represent the general area of the case studies. Number 1 is the study area of the milk chain, Wolmera and Ejere districts, which are shown on the map as Genet and Addis Alem, the respective capital cities. Number 2 represents the case study area of the *warqe* chain, which was Toke Kutaye district between Ambo/Hagerehiyot and Gedo and Wonchi district near Ambo. Number 3 represents the study area of the *teff* chain, which was in Bacho and Dawo districts, between Addis Ababa and Woliso/Gihon (Figure 6). For more details of the study sites used for each food commodity, see Papers I-III.

2.2 Value chain analysis

Value chain analysis methodology was used to characterise the whole chains of the selected food commodities from source to market. In this characterisation work, elements of the stage-wise value chain analysis methodology developed by Taylor (2005) were applied (see Figure 7). However, the scope was limited to some elements of stages 2-5. Different aspects of the selected food chains, including production, marketing, relationships and trust-building among the chain actors, flow of information, levels of losses and loss hotspots points, were determined in order to characterise the chains. A brief explanation of what this thesis work covered at each stage of the value chain analysis is presented below.

Figure 7. Summary of value chain analysis methodology (Taylor, 2005)

Stage 1: Creating understanding of the business potential of value chain analysis.

This is the base phase of value chain analysis. It lays the foundations by making senior management of the organisations in the selected chains understand and commit to the concepts, implications and potential benefit of the development and integrated supply chains. In this thesis, an assessment was made on the existing understanding levels for integrated supply chains (as is). However, creating understanding and participatory value chain analysis was beyond the scope of this thesis and could be the policy direction for those stakeholders concerned with the selected food commodities.

Stage 2: Understanding supply chain structure and selecting a target value stream.

This is the process of identifying the companies and processes along the chain and the main linkages between the processes. It helps to clearly define the food supply chain structure by understanding the scope of the processes which make up the supply chain system. This stage also requires the selection of a specific value stream, which means a specific product or product family serving a specific customer or market segment, as a focus for analysis and improvement. In this thesis, milk, *teff,* and *warqe* were the selected value streams for which attempts were made to show the crude supply chain structures in the study areas.

Stage3*:* Analysing individual facilities along the chain.

This is a stage where the data needed to understand the whole chain are gathered by analysing the plants and facilities along the chain. Current-state maps of the value chains can be constructed from process activity data collected at this stage. There are three main flows in current-state maps of food chains: flows of physical materials, information and process time line (Taylor, 2005). In this thesis, the physical flow of materials among marketing channels was assessed and the information flow was also assessed, although not in depth, but the process time line was not addressed.

Stage 4**:** Developing the current-state map of the whole value chain.

The information gathered under stage 3 serves in development of the current-state map of the whole value chain. In this thesis, the current-state physical flows of the selected food products were plotted and assessed. One important element lacking from this thesis is the process time line, due to the limited scope of the study by the nature of the products selected, the nature of the processes involved and the business environment in which this study was

conducted. In other words, there were no defined process time and uniform processing across the food value chains of these commodities.

***Stage 5*:** Analysing issues and opportunities in the whole chain
This phase of the value chain analysis involves identification of issues and opportunities in the whole chain. It is the process of classifying the issues based on the basic elements for analysis as they relate to physical flows, information flows, and organisation, management and control of the whole chain. In this thesis, attempts were made to indicate various issues in the selected food value chains with emphasis on those which could potentially be alleviated through implementation of an SCM system.

2.3 Case study method

The case study method was used to make a detailed analysis of the cases of value chains of the three food commodities in Ethiopia. Case study-based food value chain analysis has been also employed by previous researchers (Taylor, 2005; Grunert *et al*., 2005; Keivan Zokaei & Simons, 2006; Aramyan *et al*., 2007).

Gillham (2010) defined the case study method as *"a study which investigates cases to answer specific research questions that seek a range of different kinds of evidence, evidence which is there in the case setting, and which has to be abstracted and collated to get the best possible answer to the research question."* According to that author, the case can be an individual, a group such as a family, an office, a hospital ward, an institution or a large-scale community such as a town, industry or profession. In the present thesis, the cases were the value chains of the three food commodities (milk, *teff*, *warqe*) at the selected study sites. Yin (2003) noted that the case study as one of the several ways of doing research, *i.e*. experiment, survey, archival analysis and history, which is preferred under three major conditions: a) When "*how*" or "*why*" types of research questions are being posed, b) when the investigator has little control over the events, and c) when the focus is on a contemporary real-life context. In earlier work, Yin (1981) noted that case study is a research strategy that attempts to scrutinise a contemporary phenomenon in its real-life context when the boundaries between phenomenon and context are not clearly evident.

The use of the case study research method is surrounded by debate. Those against the use of the method question its capacity in developing theory, its reliability and validity, and the very status of the case study as a scientific method. Supporters of the case study method argue that these are only

perceived problems and that a well-planned case study method is as useable as any other research method (Yin, 1981/2003; Voss *et al*., 2002; Flyvbjerg, 2006).

The case study method was chosen for this thesis work for the following major reasons: 1) The investigator has little control over the events happening in food value chains; 2) the focus of the work was to investigate the contemporary phenomenon in real food value chains; 3) the resources (finance, time, and logistics) required to make a food value chain analysis on a country or regional basis were lacking; 4) the complexity of relationships in the real world makes dealing with value chain analysis on a broader area like country or region confusing, with bulk data to be dealt with; and 5) most importantly, by examining more or less similar real agro-business environments in Ethiopia and performing precise, in-depth analyses on specific issues in the value chain, such as production, marketing, finance, logistics practice, losses and relationships in the chains, there is high potential to extrapolate the results of these case studies to similar contexts. This is further supported by the theoretical approaches this thesis followed, such as the value chain analysis methodology and the food supply chain management approach, which could be applied to the value chains of many kinds of food commodities everywhere, with the necessary contextualisation. However, as noted by Yin (2003) in case study research, the goal is extrapolation of overall ideas, not statistical generalisations.

2.4 Food loss assessment methodology

Despite the necessity of consistent measurement of food losses as a step towards food loss minimisation, introducing appropriate methods of estimating food losses across the food value chain remains a challenge. From the management point of view, clear measurement is needed to determine the amount of losses, *i.e*. "*we know it if we measure it*". However, as indicated by Hodges *et al*. (2011), the concept of measuring food losses is paradoxical: if food losses can be measured, this means that the losses are somehow known and if they are known, they can be avoided. However, despite this paradox and the difficulty of measuring food losses, there are two commonly used methods to estimate post-harvest food losses (Hodges *et al*., 2011).

The first method is measuring actual losses by following a particular food commodity from production to consumption, through measuring weight and/or quality losses at each stage it passes through. This approach, although difficult in particular for some commodities, provides a better estimate of food losses. An example is the grain loss assessment manual developed by Harris and

Lindblad (1978). The second method of measuring food losses is to use estimates by those who experience the food losses, using a questionnaire. This method is relatively easy to apply, but it is difficult to trust the subjectively estimated facts of food commodity losses. The second method was employed in this study.

2.5 Likert scale

The Likert scale is a widely used scaling approach used in surveys examining respondents' attitude or beliefs. The Likert scale was developed by Rensis Likert in 1932 as a five-point bipolar response scale that ranks group of categories, least to most, asking people to indicate how much they agree or disagree, approve or disapprove, believe to be true or false (Allen and Seaman, 2007). The Likert scale in most cases uses five-point scales that allow ranking of people's beliefs about certain phenomena. In this thesis, five-point scales were used to evaluate the chain actors' beliefs about factors that cause post-harvest food losses. Potential causes of losses were ranked by the chain actors from factors causing very low losses to factors causing very high losses of the respective food commodities. By looking at the factors which caused high and very high losses for most responding chain actors, the loss-causing factors were evaluated and presented in order of severity so as to enable prioritised interventions by stakeholders.

2.6 Sampling procedure

For farmers, based on lack of previous studies indicating the variance and proportions of the population with regard to the variables assessed, the general simple random sampling formula in such situations with probability (*P*) value of 80-85% and confidence level 95% was employed. The formula presented in equation 1 can be found in various statistics textbooks and was used by Olsson (2011). The n value can be estimated as:

$$n = \frac{z^2 pq}{e^2} \qquad (1)$$

where, n is sample size, z is the value of the normal curve, p is estimated population proportion, q is 1-p and e is an error term (5%).

In all, 262 dairy farmers, 196 *teff* farmers and 209 *warqe* farmers, in total 667 farmers, were included in the studies. The determined sample size was distributed to *kebeles* in each district based on stratification using the actual

number of households. The sample size for other chain actors was determined purposefully based on their willingness to cooperate and other particular factors associated with each chain's actors. Details of each sampling procedure can be found in Papers I-III.

2.7 Development of data collection tools and source of data

The data needed in case studies may come from multiples sources. Yin (1981) noted that *"Case study does not imply the use of a particular type of evidence. Case studies can be done by using either qualitative or quantitative evidence. The evidence may come from fieldwork, archival records, verbal reports, observations, or any combination of these."* With this notion, field observations, a pilot study, a consultative stakeholders' workshop, a semi-structured questionnaire translated into the local language, interviews with key informants and a review of secondary data were used in order to get the required data for this thesis. A brief explanation of how data collection tools were developed and sources of the data used in this thesis is given below.

2.7.1 Consultative workshop, field observation, and pilot study

As the first phase of value chain analysis requires, the studies began by identifying the chain actors in the respective food commodities chains through field observations and visiting various institutions dealing with the chains. These included district agricultural bureaux, business licensing offices, research institutions, markets and cooperatives. Moreover, important agricultural bureau personnel dealing with the food chains, such as the development agents who are supposed to interact on day-to-day activities with farmers were identified. In the company of the development agents and representatives from agricultural bureaux, various farmers, cooperatives, various traders and processors were visited. The overall ideas about the chains were identified by these means, combined with review of various reports by different organisations dealing with the selected food chains.

Interview-based data collection tools were then developed for the pilot study. The pilot study was conducted to serve three major aims:

1) To gain more knowledge about the chains than was obtained from field and institution observations, (more issues and from more sources)
2) To refine the data collection plan in terms of content of data and the procedures to be followed
3) To obtain results to be presented at the stakeholders' consultative workshop for discussion and setting the way forward.

Once the pilot study was completed, the stakeholders' consultative workshop was arranged at Ambo University, Ethiopia. Various representatives from all three food chain actors (milk, *teff* and *warqe*) were invited, specifically officials from various government and non-government organisations, producers, processors, traders, representatives from cooperatives and from catering institutions, leaders and elders of the local community, and researchers from Holeta, Bako and Ambo research centres.

In the workshop, the pilot study results were presented and researchers from the three research centres also presented a few previous findings of their own and their institutions' experiences. The chain actors were asked to share their experiences relating to what they are doing, what problems they have and what problems they wish to be researched further, and so on. The workshop participants discussed the issues of food losses and the nature of food supply chains in detail.

The workshop participants were then sub-divided into groups and further group-based discussions were held using a pre-prepared broad checklist of questions. The groups later came together and had a joint discussion where major issues that need further research were identified.

Major important points obtained from the stakeholders' consultative workshop were:

1) It helped the researchers explain and the chain actors understand the aim of the study, its scope, and its benefits
2) It gained the stakeholders' agreement to support and cooperate in the study
3) The results of the discussions helped to refine the final data collection tools.

Based on the results from the pilot study and consultative stakeholder workshop, a semi-structured survey questionnaire and interview questions were prepared for the detailed analysis of the value chains.

2.7.2 The survey questionnaire

A questionnaire can be defined as list of research questions posed to respondents in order to obtain specific information. Gray (2004) defined questionnaires as "*research tools through which people are asked to respond to the same set of questions in a predetermined order."* Questionnaires are one of the most popular and convenient methods of conducting scholarly research (Walonick, 1993).

In this thesis, a questionnaire was used to serve some basic purposes which included:

1) Collecting standardised and appropriate data from chain actors (data that satisfied stated targets during setting of the questionnaire)
2) Collecting data that were comparable and suitable for statistical analysis
3) Minimising bias in formulating and asking questions (pre-prepared set of questions for the same category chain actors).

As noted above, the semi-structured survey questionnaire was translated into the local language before being used in the studies.

Most of the respondent chain actors had literacy problems, which impeded them from understanding and responding to questions. Therefore, the researcher asked questions from the prepared list. However, with time limitations and faced with a large number of respondents, it became necessary to use trained enumerators to collect data using the questionnaire. The enumerators were trained in how to ask the questions without self-bias before they began data collection and were also supervised in the field while conducting the interviews.

2.7.3 Interview of key informants

According to Gray (2004), an interview is a dialogue between people in which one person has the role of researcher. In this thesis, semi-structured interviews were used. These can be defined as interviews where the interviewer has on hand a set of written, but non-standardised, list of issues and questions to be covered.

The aim of interviewing the key informants in this thesis was to obtain information that involved in-depth opinions and perspectives of a small number of respondents. The respondents termed key informants were believed to have relatively better knowledge and conceptual understanding of the respective food chains. These key informants were identified during the pilot study and consultative workshop, and also during the main survey. They included officials from government organisations, researchers, selected producers, processors and traders, representatives of cooperatives and local community leaders.

All the interviews with key informants were made and documented by the researcher.

2.8 Data analysis

Combinations of analytical techniques were used in analysis of the data obtained. These included mapping the product flows and characterisations of the selected food chains, descriptive statistics and Probit and Tobit models. The

analyses were mainly quantitative, but narrative-qualitative descriptions were also made regarding socio-economic characteristics, logistics practices and supply chain management issues in the selected food commodity supply chains, value addition decisions and the extent of post-harvest losses.

The Probit and Tobit models were used to investigate factors affecting value addition decisions and post-harvest losses, respectively, in Paper II. The Probit and Tobit Models were preferred for their advantages of solving the two major problems under the linear probability model (LPM), *i.e*. that the fitted probabilities can be less than zero or greater than one and that the partial effect of any explanatory variable is constant (Wooldridge, 2012). Using Probit and Tobit, which are limited dependent variable (LDV) models, overcomes these problems and the fitted probabilities under these models lie between zero and one. In this thesis, farmers' value addition decisions and farmer-stage post-harvest losses of *teff* were analysed using the Probit and Tobit models, respectively, as these were considered latent variables, unobserved variables that are measured by multiple observed variables or factors. The observed variables or the factors were elements of the questionnaire.

Probit model: The basic formula of Probit/ Logit (Wooldridge, 2012, p.586) is.

$$P(y = 1|x) = P(y* > 0|x) = G(\beta_0 + x\beta) \quad (2)$$

where P(y = 1|x), predicted variable or response probability in this case farmers' value addition decisions given the explanatory variable, in this case the factors (X_j); G is the standard normal cumulative distribution function (cdf), which takes values strictly between zero and one; beta (β_i) are regression coefficient which allow to assess the strength of the relationship between each predictor variable to the criterion variable; y* is an unobserved, or latent, variable.

The Probit model was preferred over the Logit model for the assumption and properties of normality distribution of disturbance terms (e) in the data. It was assumed here that the decision to add value is discrete, dichotomous and mutually exclusive. The goal was to explain the effects of the X_j (factors in this case) on the response probability P(y = 1|x) for farmers' value addition decisions. IBM SPSS Statistics Version 20 was used to compute the maximum likelihood estimation and the marginal effects results between factors (explanatory variables) and the percentage probability change of farmers' decisions to engage in value addition decisions or P(y =1|x) were analysed.

Tobit model: As stated by Wooldridge (2012), the Tobit model expresses the observed response (y), in terms of underlying latent variable. In this case the post-harvest losses of *teff* were an underlying latent variable relating to

factors determining these as independent variables to measure the latent variable. Equations 3 and 4 presented the basic Tobit model formula (Wooldridge, 2012), with lower limit censoring at zero:

$$y^* = \beta_0 + X\beta + \mu, \mu|x \sim Normal(0, \delta^2) \quad (3)$$
$$y = \max(0, y^*) \quad (4)$$

where δ^2 is variance μ is error term, and the other variables are as defined under equation 2.

In equation 4, the observed variable, y, equals y* when y* $\geq$ 0, but y = 0 when y* < 0. The Tobit model is one of the limited dependent variable models where there is a limit or boundary on the dependent variable and some of the observations hit this limit (which can be upper or lower). In the present case, the value of the dependent variable, *teff* post-harvest losses, for a rational farmer relating to particular factors believed to cause *teff* losses could never go beyond zero. Therefore, there was a lower limit. However, for some respondent farmers the losses as a result of some factors hit zero. Thus, maximum likelihood Tobit estimation was used in the analysis of factors affecting amount of post-harvest losses of *teff* (Tobin, 1958).

Note that equations 2-4 are discussed here to note the general formulas and ideas behind the Probit and Tobit models. The models were run by statistical package SPSS version 20 in order to get the necessary results required to evaluate the relationships between the variables with ease. Beside SPSS, Microsoft Excel was used in computing descriptive statistics and sketching graphics in this thesis.

3 Results

3.1 Mapping and characterisation of the supply chains

The flows of the selected food products in the supply chains in the study areas are presented in Figures 8 (milk), 9 (*teff*), and 11 (*warqe*). The chains involved a number of actors and networks. The flows started from producers/farmers, who had a number of alternative buyers for their products. In the milk and *warqe* cases, the supply chains were relatively closed chains and the flows of the products could be followed to consumer stage in the study areas. However, in the case of *teff*, the supply chain was open, which made tracking to consumption level difficult, *i.e*. there were flows of *teff* to and from the study area from other surrounding districts through traders for which the percentage distribution was not known.

In the case of milk, farmers had the option to sell their dairy products directly to consumers, cooperatives/union, wholesalers, processors, retailers and catering institutions. Farmers' milk sales distribution by customer category was dominated by cooperatives/unions, which bought 73% of the milk sold by farmers. The remaining 27% of milk sold by the farmers was distributed to wholesalers (18%), processors (6%), consumers (2%) and retailers (1%). Each of the other chain actors in this milk chain had important customers, based on the sales distribution. For example, for cooperatives/unions, wholesalers were important customers. For wholesalers, processors were important customers. For processors, retailers were major customers and for retailers, consumers were the sole customers. Note that the sales percentages for each actor were based on what was sold out from each stage, not from what entered the stage, as there were shrinkages due to losses at each stage.

The flow of dairy products between processors and wholesalers can be seen in Figure 8. This flow is bidirectional, where processors buy fresh milk from wholesalers and wholesalers buy processed milk from processors.

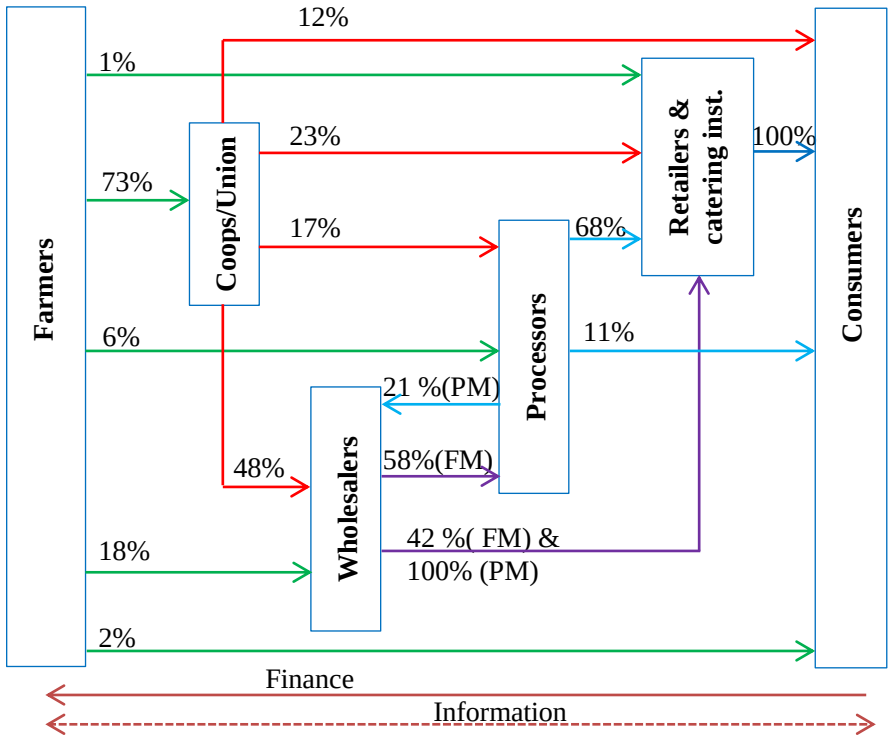

Figure 8. Dairy product flow in the supply chain, with sales distribution in the study area (distinct coloured arrows with percentages represent the sales distribution from each actor; FM and PM refer to fresh milk and processed milk, respectively)

A simplified flow chart indicating the flows of products, information and finance in the supply chain for *teff* is presented in Figure 9. The product flows sketched on the upper side of the diagram represent how the *teff* reaches from producers to consumers and how the inputs reach from the input supplier to the producers. The study revealed that producers sell their *teff* to processors, traders or directly to consumers in an open market. The boxes below each stage of the supply chain indicate the role players at each stage. The input suppliers were identified as cooperatives (farmers' associations), agricultural bureaux and the farmers themselves. Mills, bakeries and food factories (bread factories), *biddeena* or *enjera* (soft bread or pancake, which is daily food in most households with different types of dips in Ethiopia) producing and selling institutions and hotels and cafeteria were considered processors. There were

different types of traders operating in the chain. These traders were classified as wholesalers and retailers. The simplified flow chart in Figure 9 provides an overall insight into the major participants' categories in the chain, but in reality the chain was very complicated and it was difficult to assign a chain actor to any one category. For instance, the same person could be both wholesaler and retailer. It was also not uncommon to find a person engaged in wholesale or retail trade in *teff* and also engaged in processing *teff* to flour (having a milling operation). The majority of mills provided services to consumers on a fee basis, but a few were also engaged in buying *teff* cereal and selling the flour. The background triangles at input suppliers, processors and traders in Figure 9 indicate who played the major role at the stage. For instance, in the input supplier stage, the major input suppliers were cooperatives, followed by agricultural bureaux and farmers also supplied input for other farmers, particularly seed. Finance flows were identified mostly simultaneously with the product flows, where the payments were made immediately on transaction. However, it was also discovered that for a few transactions relating to input purchase by farmers, credit was granted when the farmer in question was judged to be in financial problems by the local administration. In that case, the payment for the input was made immediately after harvest and included calculated interest.

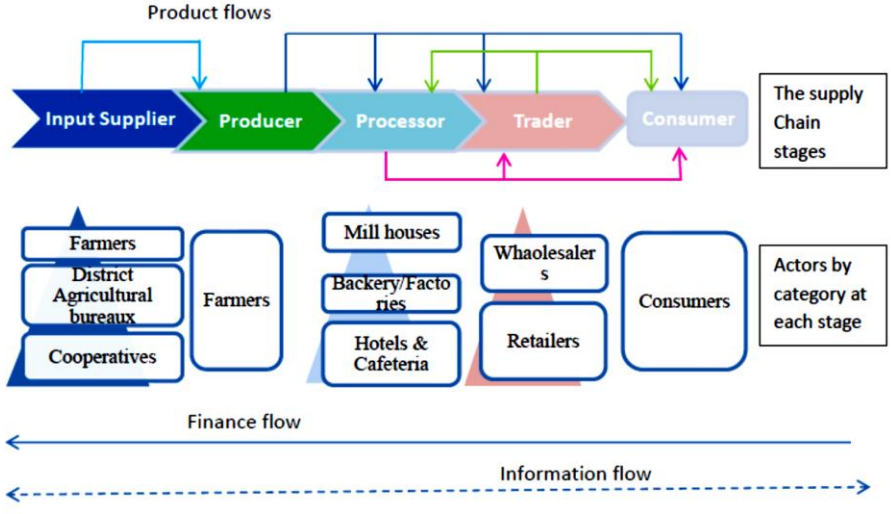

Figure 9. Simplified flow chart of *teff* in supply chains in the study area

As the data obtained from chain actors indicated, the information flow in the *teff* chain was very poor and the chain participants rarely knew what the

market was like ahead of the actual marketing time. Moreover, farmers claimed that the traders used oligopolistic power, particularly during the harvesting season, and offered lower prices using the advantage that farmers do not have price information from other markets down the chain, including the central markets. Moreover, farmers noted that they could not transport their *teff* to far markets due to their lack of transportation capacity and time constraints.

Warqe is a perennial plant with multiple uses, as illustrated in Figure 10. Three separate food commodities are extracted from the plant, namely *kocho*, *bulla* and *amicho.*

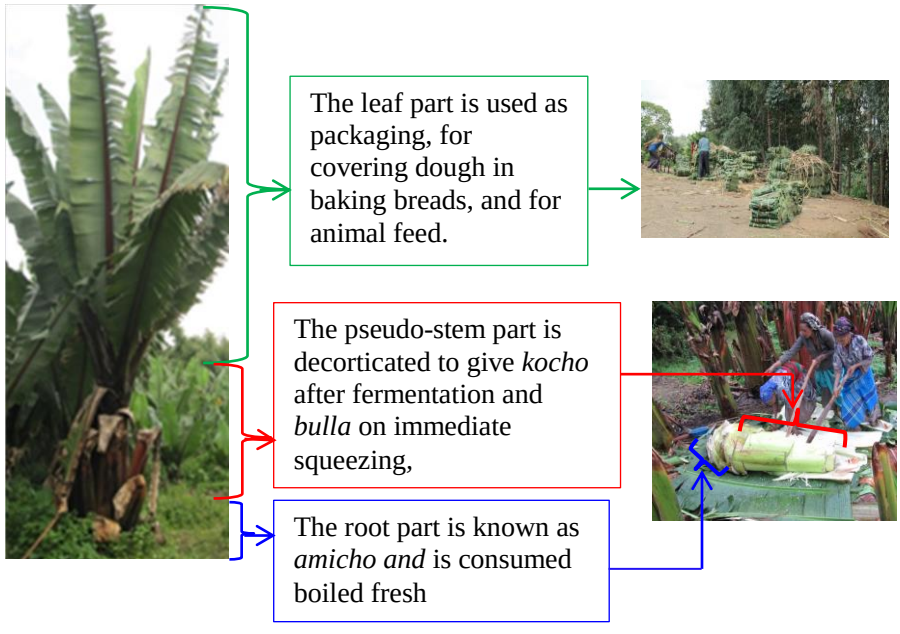

Figure 10. Major parts of the *warqe* plant and its main use

As *amicho* is consumed locally (not for sale to far markets), only the supply chains and losses of the products *kocho* and *bulla* were investigated in this thesis. The supply chain of these foods is illustrated in Figure 11.

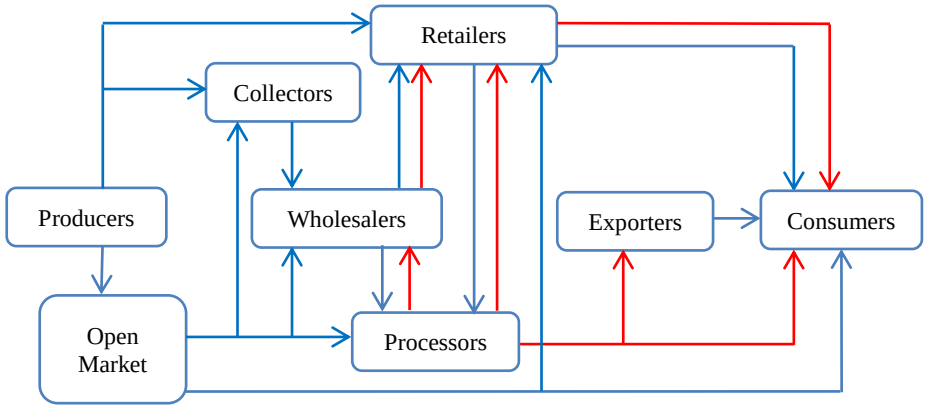

Figure 11. Simplified flow chart of *warqe* food products in supply chains in the study area (Blue lines represent the flow of *kocho and* fresh *bulla* and red lines represent the flow of processed *bulla.*)

At the time of this study, the *kocho* process ended at the farmer stage and no further processing was made, so processors could never buy the product. The *bulla* flows between wholesalers and processors and retailers and processors were bi-directional, showing that processors buy fresh *bulla* (wet dough) from wholesalers and retailers and sell them back processed (powder) *bulla*. Only processed bulla is exported.

It was observed that the *warqe* supply chain to the central market in Addis Ababa was long, involving a number of market tiers. The relationships between *warqe* supply chain actors were complex. Producers sold their products to wholesalers, collectors, retailers and consumers. Collectors purchased large amounts of *kocho* and fresh *bulla* from producers in the vicinity of farms and at local markets and sold directly to wholesalers. Wholesalers bought *kocho* and fresh *bulla* from producers and collectors and sold to retailers and processors. Retailers purchased *kocho* and/or fresh *bulla* from wholesalers and producers on the open market and sold to consumers and processors. These are simplified relationships by category, as otherwise the reality was complex and there were actors with mixed behaviour, *i.e.* it was not uncommon to find the same person who acted as wholesaler, retailer and processor.

3.2 Production and marketing

In the case of milk, as presented in Paper I, production was dominated by smallholders with a few cows producing a few litres of milk per cow and day. Figure 12 shows the average milk production per day for local and hybrid cows in the study area. As can be seen, the maximum milk production per day for a local cow was similar to the minimum milk production per day for a hybrid cow (5-7 litres). However, the majority of respondents (53%) reported that milk production per day for a local cow was 1-2 litres. For hybrid cows, 40% of respondents stated that milk production per cow per day was 8-10 litres and 34% said that it was 11-15 litres. Local cows mean cow breeds indigenous to Ethiopia, while hybrid cows are crosses between foreign milk breeds such as Holstein and Friesian and indigenous breeds. Figure 13 presents respondents' first choice of proposed solution to improve milk production per cow and day. As can be seen, the majority (71%) of the respondents indicated that improving cow breed was an essential means to improve production as their first choice solution.

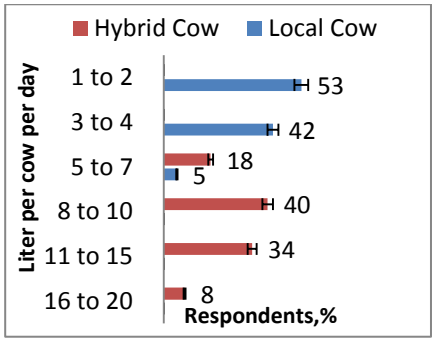

Figure 12. Average milk production per cow per day: Local versus Hybrid cows (5% error bar)

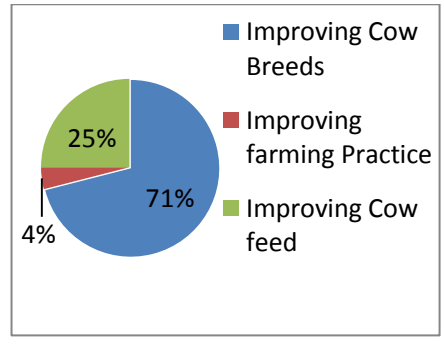

Figure 13. Farmers' first choice solution to improve milk production per cow per day

Based on the data collected at farmers, traders, cooperatives and union level, the main dairy product for sale was fresh milk. Information from the processors showed that they produced value-added dairy products such as pasteurised milk, butter, varieties of cream, varieties of cheese and yoghurt. The value addition varied among processors, however, with the majority of processors in the area engaged only in production of pasteurised milk. In catering institutions, minor value additions such as boiling and making traditional yoghurt (*etitu/ergo*) were common practices before selling milk to consumers

as a cup of boiled milk, yoghurt or 'makiyato'(milk mixed with coffee, similar to cappuccino). As Table 1 shows, most farmer respondents indicated that the demand for dairy products and prices had increased in the previous three to five years. This is an indication of potential for development of the dairy value chain. However, tough competition on inputs, increasing costs of animal feed and the dependence of the majority of farmers on external supplies as a source of supplementary animal feed were identified at farmer level as problems. The farmers indicated that they had not benefited from the increase in the price paid for dairy products as the increment in operating costs, particularly feed costs, had affected them.

In the case of *teff*, the study was made in an area where *teff* is the prime product, not only as a food crop but also as a cash crop providing the major income for the family. As noted in Paper II, about 89% of land owned by the farmers in the area was used to cultivate *teff* during 2013 and the farmers noted that their land allocation remained almost the same under normal conditions.

A few farmers indicated they had no land and they were engaged in farming by renting land. The land rent was reported by the farmers to be paid in cash in advance or paid in kind. Payment in kind is when the land owner shares the produce during harvest time. The farmer respondents reported that the common sharing ratio in the area was 1:2, where the land owner gets one-third and the farmer who produces the crop gets two-thirds of the produce. This sharing ratio agreement is locally known as '*siso*'.

Figure 14 presents the production and sales quantities of *teff* in the study area. The production of *teff* in the area was dominated by farmers producing small quantities of *teff* per year. The minimum production per farmer and year was 2.50 quintals (1 quintal = 100 kg), while the maximum production per farmer and year was 80 quintals. The total production during the year was 2882 quintals for the 150 sampled households. The average production per household and year for the sampled farmers was 19.21 quintals. The sales data showed the same situation with production, where sales per farmer and year represented smaller quantities.

Table 1. *Demand, price trends and nature of competition for dairy products and animal feeds in the study area*

Farmers' evaluation of overall dairy product demand trend during the previous 3 to 5 years			**Farmers' evaluation of dairy product price trend during the previous 3 to 5 years**		
Trend	Number	%	Trend	Number	%
Has been increasing	212	80,9	Has been increasing	211	80,5
Has been the same	11	4,2	Has been the same	-	-
Fluctuating, sometimes up and sometimes down	39	14,9	Fluctuating, sometimes up and sometimes down	51	19,5
Total	262	100	Total	262	100
Farmers' evaluation of competition from other dairy farmers when selling their dairy products			**Farmers' evaluation of competition for cow feed with other dairy farmers**		
Nature of competition	Number	%	Nature of competition	Number	%
Very tough	13	5,0	Very tough	71	27,1
Tough	86	32,8	Tough	157	59,9
Weak	75	28,6	Weak	23	8,8
No competition at all	88	33,6	No competition at all	11	4,2
Total	262	100	Total	262	100
Farmers' evaluation of the price trend in animal feed during the previous 3-5 years			**Farmers' source of cow feed**		
Trend	Number	%	Source	Number	%
Has been increasing	211	80,5	Own grazing land, plus home fodder production	15	5,7
Decreasing	-		Own grazing land, plus purchase of additional fodder from external supplier	153	58,4
No change	-		Home fodder production, plus purchase of grazing land from external supplier	11	4,2
Fluctuating	51	19,5	All purchase from external supplier	83	31,7
Total	262	100	Total	262	100

According to the results in Figure 14B, for most of the farmers (about 80%) the sales quantity was less than 10 quintals of *teff* per year. Total sales quantity from the sampled farmers was computed to be 798.33 quintals and the average sales quantity was 5.32 quintals of *teff* per household and year. However, regardless of whether the farmers produced a large quantity or small quantity, more than 90% sold more than 1 quintal (100 kg) of *teff* per year to get income to support their household. Relating sales quantity to production quantity for the sampled households, about 28% of *teff* produced in the area was sold off-farm by farmers. This is confirmation that *teff* is produced not only as food crop in the area, but also as a cash crop.

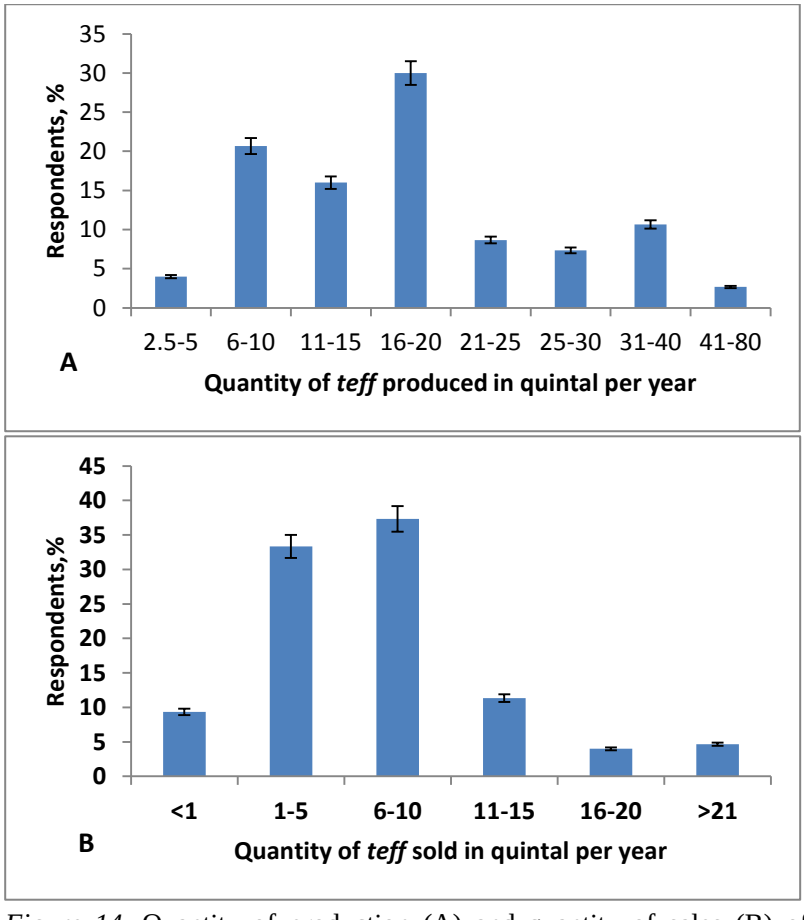

Figure 14. Quantity of production (A) and quantity of sales (B) of *teff* by producers in the study area during 2013 (5% error bar)

A significant proportion of respondents indicated an increasing trend in price and demand in the previous three to five years, as well as in the previous harvest year (Figure 15). According to the results, 64.7% of the respondents believed that demand and price over the previous three to five years was increasing, while 52% of the respondents noted that demand and price showed an increasing trend compared with the previous harvesting year.

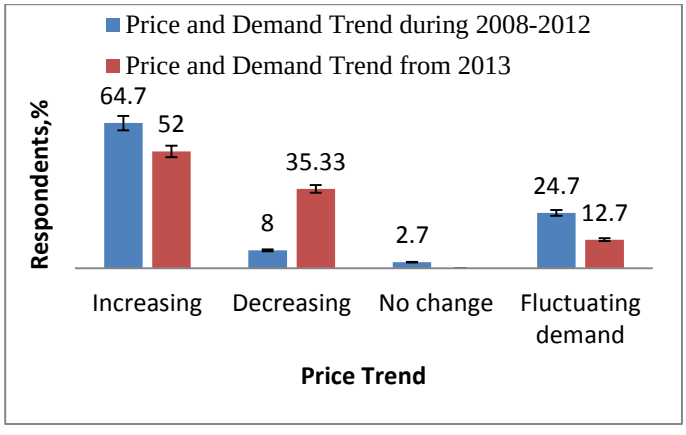

Figure 15. Respondents' perception of *teff* price and demand trends in the study area (5% error bar)

The study on the supply chain for *warqe* indicated that it is the major source of livelihood for the farmers surveyed (Table 2).

Table 2. *Average land area per family, warqe food production and sales quantities and percentage contribution to income*

Parameter	**Value**	
Warqe quantity produced (kg/family & year)	678	
Warqe quantity sold (kg/family & year)	275	
	% Contribution	Respondents, %
Warqe foods contribution to annual household income	16 to 30%	5.82
	31 to 45%	11.65
	46 to 60%	24.27
	61 to 75%	19.41
	More than 75	38.83

In the study area, on average a family produced about 678 kg/year of *warqe foods*, of which about 275 kg (41%) was sold. *Warqe* production was the main source of revenue for households in these areas, contributing more than 75% of their income for about 39% of farmer respondents.

3.3 Farmers' value addition decisions

In the *teff* chain, factors determining farmer-stage value addition decisions were assessed using the Probit model as a dichotomous response that the farmers either engaged in these activities (1) or not (0). The value addition decisions considered in the case were use of fertilisers, use of improved seeds and use of improved farming technology (*e.g*. new ploughing tools).

Table 3. *Probit results on factors influencing value addition at farmer level*

Variable	Coefficient	Standard error	Marginal effect
Sex (male)	-0.40	0.451	-0.091
Proximity to Nearest Market, km	-0.065*	0.0432	-0.015
Literacy Status of Household Head (Literate)	1.475***	0.204	0.11
Access to Credit _D	0.798**	0.320	0.186
Land Cultivated for Teff _C	0.14	0.305	0.0389
Perception on Post-harvest Losses _D	0.40	0.175	0.0273
Family size _C	-0.04	0.077	-0.013
Price_C	-2.391	3.890	-0.556
Non-Teff Farming Income _C	-0.018	0.116	-0.0042
Access to Extension Services	0.379*	0.485	0.088
Teff Farming Experience _C	0.037***	0.0136	0. 042
Constant	-19.67	27.77	
Observations	150		150

****, ** and * are statistically significant at 1%, 5%, and 10% probability level,* respectively

The factors expected to have an effect on value addition decisions were analysed using the marginal effect approach. As can be seen from the results in Table 3, farming experience and literacy status of household head were

identified as statistically significant factors influencing farmers' value addition decisions at 1% probability level, access to credit affected farmers' value addition decisions at 5% probability level and access to extension or advisory services and proximity to the nearest market were influencing factors at 10% probability level. At 1% statistical significance, an increase in *teff* farming experience of one year and access to formal education at any level increased the probability of farmer's participation in value addition by 4.2% and 11%, respectively (Table 3). At 5% statistical significance, access to credit increased farmers' probability of adding value by 18.6%.

3.4 Relationships in the chains

The relationships among the selected food chain actors at various major stages were assessed and a summary of the results is presented in Figure 16. In all three food chains assessed, there were no contractual or trust-based relationships between the chains actors to the level required.

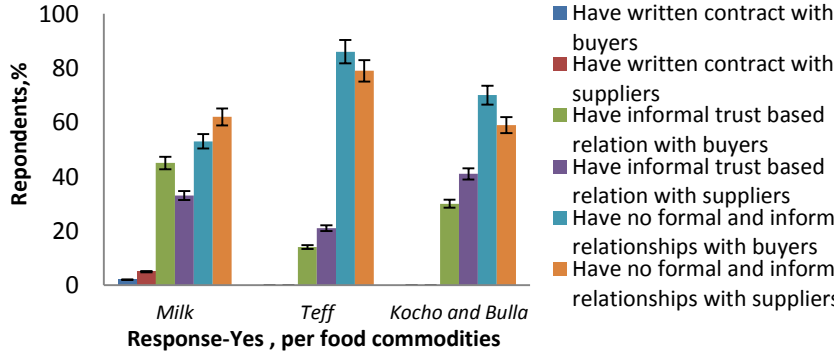

Figure 16. Formal and informal relationships between the selected food chain actors (% calculated average for all chain actors in all stages, 5% error bar)

As can be seen from Figure 16, it was only in the milk chain that respondents had written contracts with their buyers (only 2% of respondents) and suppliers (only 5%). Moreover, 45%, 14% and 30% of respondents in the milk, *teff* and *warqe* chains, respectively, had informal trust-based relations with their buyers. In addition, 33%, 21% and 41% of respondents in the milk, *teff* and *warqe* chains, respectively, reported they had informal trust-based relations with their suppliers (Figure 16). The majority of the chain actors in these food chains reported that they had no formal or informal relationships with both

buyers and suppliers. For example, in the milk chain 53% of respondents had no formal or informal relationships with their buyers and 62% had none with their suppliers; in the *teff* chain 86% of respondents had no formal or informal relationships with their buyers and 79% had none with their suppliers; and in the *warqe* chain 70% of respondents had no formal or informal relationships with their buyers and 59% had none with their suppliers. Overall, the relationships among the chain actors in the milk and *warqe* chains appeared to be better established than those in the *teff* chain.

3.5 Logistics practices

3.5.1 Transportation

The case studies showed that transport logistics was one of the major challenges in the food chains studied. Sample pictures showing the nature of modes of transportation in the case study food chains are compiled in Figure 17.

In the case of the milk chain in pre-urban and rural areas, milk was mostly (89%) transported by human labour and this resulted in delays in reaching collection points, physical losses due to falls by people carrying the milk and quality losses due to exposure to sun heat and microbial development. In urban areas, the transport logistics practice was relatively better; cars and animal carts were used for transportation. However, the milk transportation vehicles used were freight transportation vehicles without any cooling system or adjustment for standard milk transportation.

The majority of *teff* transport by farmers was by donkey, with 74%, 68% and 71% of *teff* transported from field to home, from home to market, and from home to mill, respectively, being performed by donkeys. Human labour-based transport was the next most frequent transport mode after donkeys, with about 20%, 25% and 25% of *teff* transport from field to home, from home to market, and from home to mill, respectively, being performed by human labour. Animal carts and hand carts were also reported as means of *teff* transport in the area, but an insignificant proportion of *teff* was transported by these means.

The *warqe* chain was similar to the *teff* chain in terms of modes of transport. For the majority of the farmers surveyed, human power was the basic mode to transport the products from field to home, but pack animals (donkey and horse) were used to transport *warqe* to the market place. In urban areas, the means of transport used by traders between various markets were identified as vehicles (39%), pack animals (34%), animal cart combined with pack animal (7%), vehicles and pack animals (7%), human power (7%), and pack animal combined with human power (6%). Processors mainly used vehicles (50%) to

transport their products, while others used vehicle and pack animals (25%) and pack animal and human power (13%), while the remaining 12% of processors used only human labour to transport their products.

Figure 17. A few pictures showing modes of transportation in the selected food chains

3.5.2 Storage/temporary cooling facility, packaging/ carrying tools

The storage facilities in these food chains were mostly traditional and had a number of problems resulting in food losses. For instance, no dairy farmer in the study area had a temporary cooling facility for evening milk. All farmers noted they milk their cows twice a day, once in early morning and once in the evening, but the milk is sold only once a day, between 9-11 am. Therefore, the farmers use cold water as a means of cooling the evening milk for a night, which is not successful during the warm season, according to the farmers.

Teff farmers use structures known as *gotara* and *gumbi/togogo* as the major storage facility (see pictures in Paper II). *Gotara* is made from bamboo and the inside part is varnished with cattle dung, while *gumbi/togogo* is made of

purpose-made matting made from glued *teff* straw. The advantages of these facilities are that both are locally made and involve less cost. The disadvantage reported by the farmers was that *teff* stored in these facilities is susceptible to damage caused by rats, floods, damp and fire. The chain actors in the area lack financial capacity to acquire small-scale metal silos that could potentially reduce such losses.

In the case of the *warqe* chain, similar problems exist as most farmers use either pits and/or their living space for storage purpose. Traders and processors downstream use an open room to store the *warqe* products *kocho* and *bulla.* With the easily perishable nature of *warqe* products, where exposure to air may result in total loss, the difficulty with storage was a serious problem identified in the *warqe* supply chain.

The existing carrying/packaging tools used in the selected food chains were also found to be associated with problems. In the milk chain, the use of plastic jars with a narrow opening was a major problem identified, particularly in relation to hygiene and milk quality. These types of jars, which were used by most farmers, are very difficult to clean inside due to the narrow opening. Moreover, they absorb heat easily, making the milk vulnerable to microbial development. In the case of *teff*, it was identified that different kinds of sacks were used as packaging material for the *teff* to be transported from threshing field to home and from home to market or mill. There were no significant problems associated with sacks. The packaging issue was more difficult in the *warqe* chain, where fresh and dry leaves of the *warqe* plant were used as packaging material. During long storage, transportation and marketing, these leaves may dry out and disintegrate, exposing the *warqe* dough to air, which means total loss of the product. The retailer stage was identified as a loss hotspot for *kocho* mainly due to this packaging problem, combined with a long waiting time in market due to lack of immediate buyers. With all its drawbacks as a cause of high food losses, the chain actors stick to using leaves because they are cheap and they believe that this keeps the *warqe* dough fresh and tasty as long as it does not get exposed to open air. The difficulties were with long storage and during transportation.

3.6 Post-harvest losses along the food chains

3.6.1 Estimated level of losses

Figure 18 presents the percentage losses of the food commodities studied across the stages in the whole value chains. The highest percentage losses were found to be happening at processors, with the commodity *bulla* suffering 28.8% losses.

Milk losses were highest at cooperative/union level, followed by farmer level. With estimated losses of 5.46% happening at the cooperative/union stage, it was the loss hotspot in the milk value chain. The major reason was reported to be inefficiencies at the collection points of the cooperatives/union.

Teff losses at farmer stage, which were estimated to be 8.18%, were the single highest losses for *teff* in the chain, indicating this as the loss hotspot for *teff* in the study area. *Teff* losses at farm level were mainly caused by problems during harvesting, threshing and transportation from harvesting site to home. Threshing was the severest problem identified as regards losses.

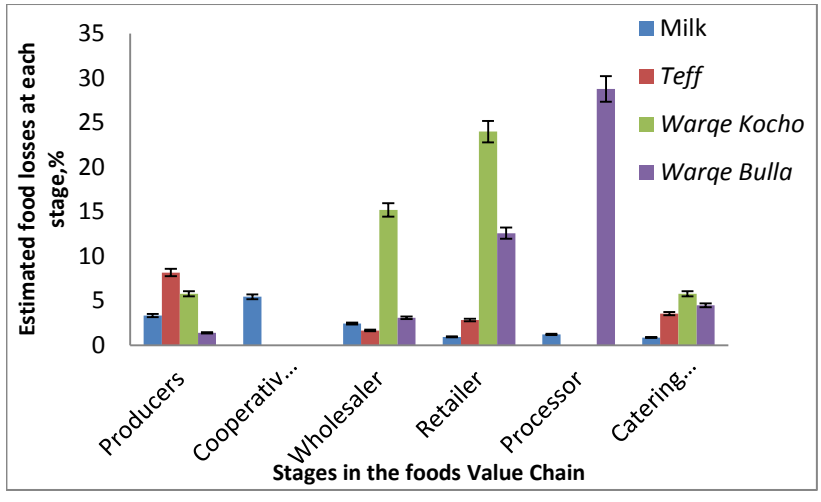

Figure 18. Percentage losses of the food commodities studied at different stages in the value chains (5% error bar)

In the case of *kocho*, the retailer stage was identified as the loss hotspot, with 24% of estimated losses. The main cause was reported to be packaging and storage problems, *i.e*. poor display and exposure to the air. In the case of *bulla*, processors suffered the most losses (28.8%) and were thus identified as a loss hotspot in the *bulla* value chains. The major reason for *bulla* losses at processor level was the very nature of bulla processing, with poor facilities including very old and traditional equipment.

3.6.2 Causes of losses

The chain actors believed that there were a number of factors causing food losses in these food value chains. Figure 19 and 20 present the reported causes of milk and *teff* losses in the value chains, respectively.

The major factors causing losses of milk in the area, expressed in order of severity as serious problems causing milk losses, included: milk handling practice at collection points, lack of immediate acceptor and long waiting time at collection points, milk carrying tools used, means of transport used and lack of effective communication with other partner in the chain (Figure 19).

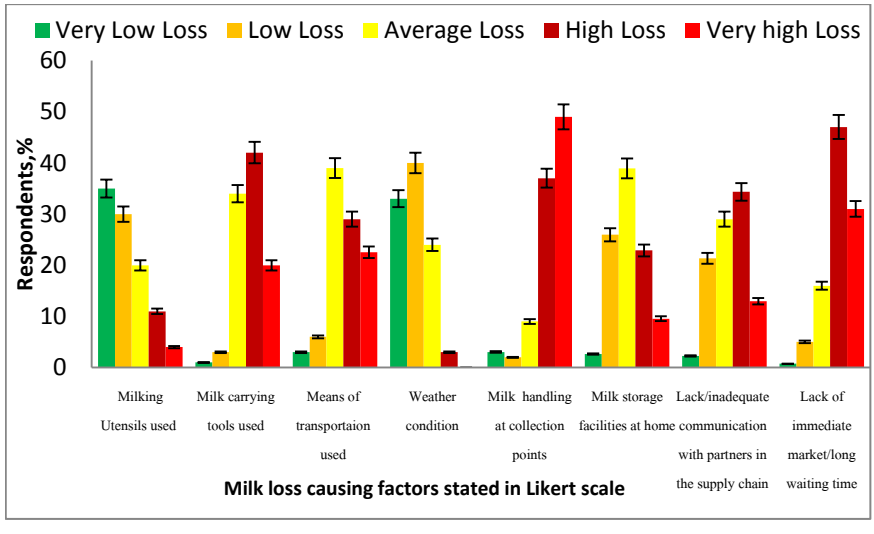

Figure 19. Factors perceived by chain actors as causing milk losses in the value chain of milk (5% error bar)

Farmers' perceived causes of post-harvest losses of *teff* in the area were presented in Figure 20. According to the result threshing process was listed as the top problem causing the losses.

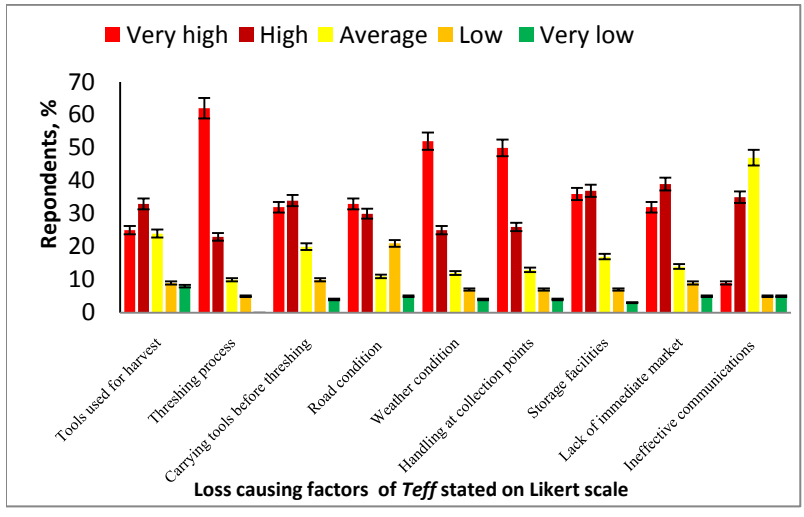

Figure 20. Factors perceived by farmers as causing post-harvest losses of *teff (5*% error bar)

Considering the cumulative of very high (red) and high (dark red) losses in Figure 20, the threshing process, weather conditions, handling at collection points, storage facilities, lack of immediate market, carrying tools before threshing, road conditions, harvesting tools used, and ineffectiveness of communication in the chain were factors causing *teff* post-harvest losses in order of severity (from harsh to lenient), according to the farmer respondents.

In addition to the Likert scale loss factors assessment (Figure 20), Tobit model analysis was used to assess factors determining post-harvest losses of *teff* at farmer stage in the area. According to the results (Table 4), six variables (Sex, Family size, Distance to the nearest market, Level of output, Weather conditions, and Storage facilities) included in the Tobit model significantly affected *teff* post-harvest losses.

As can be seen in Table 4, having a female household head resulted in an increase of *teff* post-harvest losses about 9%, when household size increased by one active labour person the amount of post-harvest losses decreased by 3.6% (note that in the model, family size between the age of 8-60 years were used, assuming these can be considered active labour in this context), an increase in *teff* production of one quintal increased the amount of post-harvest losses by 4.4%, the occurrence of bad weather during different post-harvest operations resulted in post-harvest losses of 1.53%, increasing the distance to

the market centre increased *teff* post-harvest losses by 11.3%, and post-harvest loss of *teff* were decreased by 6.9% if the farmer had a good storage facility. Note that according to statistical significance, distance to the nearest market (11.3%) and level of output (4.4%) were the factors affecting postharvest losses most significantly (P<0.01).

Table 4. *Result of the Tobit model analysis of factors affecting teff post-harvest losses*

***PHL* causing factors**	**Coef.**	**Std. err.**	**Marginal Effect**
Sex of household head	-0.0894**	0.0413	-0.0895
Age of household head	0.0008	0.0010	0.0076
Family size	-0.036*	0.0150	-0.0376
Distance to nearest market	-0.113***	0.0037	-0.113
Education status of household head	-0.007	0.0365	-0.0299
Farm size	0.00241	0.0158	0.00201
Output	0.044***	0.0012	0.0437
Weather	0.015*	0.0138	0.0153
Storage facility	0.069**	0.0147	0.0692
Transportation	0.0339	0.0150	0.0340
_cons	-0.144	0.0919	

***, ** and * are statistically significant at 1%, 5% and 10% probability level, respectively*

For *warqe* food products, poor harvesting and fermentation facilities, poor packaging, poor processing facilities including lack of appropriate place for processors of *bulla*, seasonality of market demand, long periods of storage, exposure to air and mould development were among the main factors reported by chain actors as factors instigating losses both for *bulla* and *kocho.*

3.7 Potential of SCM to improve the food chains

Factors behind losses reported in section 3.6 are summarised in Table 5 and compared against the ideal condition that could be achieved by implementation of SCM, in order to identify the potential of SCM as a means of improving these food supply chains. Details of how SCM can improve similar contexts are presented in the discussion section.

Table 5. *Summary of major problems in the studied food chains that could be solved by supply chain management (SCM)*

From cases	Major result/problems identified	How SCM could solve the problem
Loss factors		SCM could solve the facility-related logistics problems through enhancing collective investment in logistics tools and infrastructure and enabling coordinated and integrated use of existing facilities. SCM could also alleviate the milk handling practices at collection centres through creating awareness. With an effective SCM system, qualified and responsible operators across the whole chain could be achieved. SCM could also improve the communication between chain actors through creating effective relationships between chain actors. Effective and efficient sharing of information is integral to SCM system.
Milk chain	Poor milk handling practices at collection points: lack of appropriate facility and mismanagement	
Milk and *warqe* chains	Lack of immediate acceptors/waiting time at collection points	
Milk chain	Lack of cooling systems at home, at collection points and during transport	
All chains	Poor means of transportation	
Milk chain	Inappropriate milk carrying equipment- plastic, narrow opening difficult to clean inside	
All chains	Poor storage facilities	
All chains	Poor communication with other partners in the chain	
Production		Through effective SCM, the farmers could get support from downstream chain actors in terms of better access to improved cow breeds and improved production technology. There is potential for agricultural value chain financing with established chains that could solve the financing constraint.
Milk chain	Low milk production per cow per day Lack of access to improved cow breeds	
All chains	Lack of access to finance	
All chains	Lack of access to improved production technology	
Relationships		Through the SCM approach the relationships could be improved where all the chain actors focus on satisfying end customers and improving overall performance of the whole chain SCM creates system thinking where chain actors develop win-win partnerships and an attitude of winning the competition all together as a chain, not as individual businesses.
All chains	Relationships characterised by individualistic and opportunistic behaviour	
All chains	Focus on own profit or lack system thinking among the chain actors,	
All chains	No strong trust-based relationships among the chain actors and no ultimate customer conceptualisation	

4 Discussion

4.1 Production, marketing, and enabling environment

Efficient production and marketing at household level and an enabling/improved agri-business environment are among the prerequisites for value chain development (Donovan *et al.*, 2015). The assessments made in this thesis for the three food commodities identified both encouraging and challenging issues that need further work. The opportunities identified for value chain development in the studied food chains included:

- Households depend on the selected food commodities as a major part of their livelihood and engage in farming of these commodities not only for personal consumption, but also as a means of getting household income
- Market demand and prices for these food commodities are increasing over time, although this may be as a result of the nationwide inflationary trend (Headey et al., 2012)
- The gluten-free market could boost the global demand for *teff*, with subsequent integration into global agro-value chains
- The marketing role of cooperatives in milk and *teff* chains.

However, many challenges that need stakeholder attentions were also identified. These included:

- Poor farming practice and production technology
- Low productivity
- Lack of appropriate market infrastructure
- Lack of adequate market orientation, mutuality and trust,
- Poor logistics services
- Weak support from government and non-government organisations in facilitating an enabling agro-business environment.

In this regard, it is worth considering a proposed framework by Riisgaard and Ponte (2011), which describes three main interconnecting strategies that can facilitate agro-value chain development. These are improvement strategies in production and processing, strategies for improved coordination among the chain actors, and adding or changing of functions of actors across the chain, in order to improve institutional and economic frameworks for development of agro-value chains. The following points are among the major issues to consider in the present cases related to these strategies:

- Improving milk production per cow and day, which could be possible through improvement in cow breeds, feed supply, and farming practices
- Increasing and improving *teff*- and *warqe*-based food production through use of appropriate farm technology
- Strengthening and/or establishing farmers' cooperatives
- Improving market access and market-related facilities and institutions
- Collaborative coordination through the SCM approach
- Involvement of chain actors in additional functions such as food transport or primary value addition
- Achieving an enabling institutional and economic framework with the help of government and non-government stakeholders.

If stakeholders consider these points based on the opportunity assessed, there is potential for effective value chain development in ways that could benefit the stakeholders in the food value chains studied here.

4.2 Farmers' value addition decisions in *teff* chain

The Probit model was employed to assess farmer-level value addition decisions in the *teff* chain. Note that the value addition decisions for this case were defined as those activities by the farmers that improve *teff* quality and quantity available on the market. Some main activities considered were use of fertilisers, improved seeds, herbicides, and improved farming technology, *e.g.* new ploughing tools. These activities may not be considered value addition activities from a processing perspective. However, in this thesis the term was used with the justification that every organised activity that adds customer value to a product could be considered value addition. In the *teff* chain, use of improved seed, for example, would result in a better *teff* variety that is more demanded by consumers, which means consumers are ready to pay for it, and therefore it could be considered value addition.

The analysis showed that farming experience, literacy status of household head, access to credit and extension services, and proximity to the nearest

market were statistically significant factors influencing farmers' value addition decisions. Literacy status was the most determining factor among the variables analysed, with any attendance in formal education by the household head increasing the probability of farmers' value addition decisions by 11% (P<0.01). This may be attributable to the fact that education has the capacity to influence other factors like management skills, household income, household size and access to capital, which would all could have a positive effect on value additions. Similarly, Mamo *et al*. (2014) identified education status as a significant factor affecting milk value addition decisions in Wolmara district in Ethiopia.

4.3 Relationships and supply chain management

The relationship among the chain actors of the food commodities studied were poorly performing from SCM concept point of view. Assessments were made to evaluate the relationships between actors in the chain, *i.e*. farmer-to-next chain actor, farmer-to-input supplier, farmer-to farmer, and other chain actors-to-each other. The result showed that in all three food chains, there were no well-developed contractual or trust-based relationships between all chain actors; the majority of the chain actors in these food chains had no formal and trust-based informal relationships with either their buyers or their suppliers of the food commodities.

The farmers' relationships with chain actors appeared meaningful only with cooperatives in the milk and *teff* chains. Even with cooperatives, the relationships mainly focused on marketing, *i.e.* in the milk chain cooperatives/union were the major milk buyers, while in the *teff* chain cooperatives were the major input suppliers.

With other chain actors the relationships were transaction-based. Other findings that show chain actors' undeveloped relationships include:

- In most transactions the payments were immediate
- Farmers claimed buyers offer unfair prices
- Buyers blamed farmers for poor quality, including water adulteration, in the milk chain
- Farmers blamed input suppliers for poor quality of inputs
- Farmers blamed their cooperatives for weak transparency, inefficiencies and milk losses in milk chains
- Farmer-to-farmer relationships were limited to cooperation in farming activities
- The relations among the majority of the food commodity chain actors studied did not go beyond the instant buying-selling relationship.

In general, the food supply chains studied lacked both long-term market and supply chain orientations. Table 6 shows the meaning of market and supply chain orientations that could facilitates SCM process, compared against the findings of the present study. The proposed solutions could alleviate the problems and move the current situation towards the ideal state.

Table 6. *The ideal market and supply chain orientations and the findings of the present study*

Ideal situation	**Current situation based on thesis results**	**Proposed solution**
Market Orientation: Situation that goes beyond a particular actor and comprising the interaction among the value chain actors in creating value for the end user and the concept that profitability for a particular chain actor and for the whole chain is possible through focusing on customers down the chain or the end users (Grunert *et al*., 2005).	✓ Spot-market transaction ✓ Most transactions cash-based except milk sales to cooperatives ✓ No common goal established ✓ No awareness about overall profitability to the whole chain, instead silo mentality with chain actors worrying about self-benefit	✓ Establishing stakeholder platforms ✓ Awareness creation training for chain actors ✓ Facilitating an enabling environment by GOs and NGOs, ✓ Strengthening farmers' cooperative associations, particularly to improve their management aspects
Supply Chain Orientation: The extent to which there is a predisposition among chain members towards viewing the supply chain as an integrated entity. It is the overall positive attitude of chain actors towards cooperation with business partners in the upstream or downstream stages of the supply chain and the recognition of common goals of actors along the supply chain (Schulze-Ehlers *et al*., 2014).	✓ Opportunistic behaviour including exploitative trials, e.g. low quality input supply, milk adulteration with water, traders' oligopolistic price setting that exploits farmers ✓ No well-established cooperation among chain actors, except for the case of farmers with their cooperatives	✓ Investing in logistics including improving the flows of information

4.4 Food losses and supply chain management

In the three food chains studied, losses were a serious problem (see section 3.6.2). The major reason for the losses could be argued to be inefficiencies and ineffectiveness in the supply chains. Table 7 summarises the scant existing empirical evidence for developing countries where SCM improved the food chains. The relations to this thesis are indicated by identifying similar problems that could be alleviated. This shows the potential of SCM practices to improve

the food chains in general and to reduce losses in particular. The empirical evidence is mostly related to milk and evidence is lacking for the other two food commodities, *teff* and *warqe*. This may be due to the fact that both of these commodities are typical to Ethiopia. However, the similarities of the problems identified justify the relevance of SCM for these food commodities too.

The Tobit analysis in *teff* chain identified sex of household head, family size, level of output (production), bad weather condition, distance to the nearest market, and storage facilities significantly affecting *teff* post-harvest losses in the area. These factors mainly were related to labour time problems in harvesting activities and marketing problems.

Referring to the labour intensive *teff* farming practice, female headed family and lesser family size imply lesser time in harvesting leading to higher post-harvest losses. Similarly, due to the fact that as the amount of *teff* production increases, it became difficult for farmers to harvest on time the whole production due to lack of manpower therefore increase in production level was associated with high level of post-harvest losses. Higher post-harvest losses of *teff* were also reported associated with far distance of farmers' homestead from market centers. This may be due to the fact that long distance to market may be attributable to hassles during transport and time that may also discourage taking the produce to the market, hence higher losses. Different previous studies' findings confirm to the present study, e.g., Basavaraja *et al., 2007*, positive relationships between amount of post-harvest losses and amount of production, bad weather condition, and labour time; Ayandiji *et al., 2011*, high losses of produce with long distance to market.

Table 7. *Summary of empirical evidence from developing countries on supply chain management (SCM) in the food sector in relation to this thesis*

Empirical evidence -Major findings/role of SCM in food chains as noted from the literature	**Problem in the supply chains of the selected food commodities in this thesis that could be alleviated similarly**
The white revolution in India: The market opportunity established in different areas and preserving competences in rural areas converted inefficiencies and milk losses to profit to the whole chain actors. Smallholders' access to market near to their settlement, cold chain established for preserving milk, and the rural markets were integrated to the urban ones through linkages that resulted in Anand-pattern dairy cooperatives, today known as Amul dairy, a globally known dairy brand. In a nutshell, it is all about effective supply chain management. (Padmanabhan, 1978)	Establishing small markets near to the farmers' settlement could reduce the losses during transportation, microbial developments during transportation for milk, and also encourage farmers to be more genuine on provisions of quality products as in nearby market knowledge of each other and traceability is possible. But these market needs to be integrated to the urban markets through logistics services such as cold chains, integrated use of transport facilities and preservation of the products, particularly milk, in the collection points near the farmers' settlement. These are possible through SCM.
Kumar (2014) developed a SCM model for Andrhra Pradesh State in India with the emphasis on production and distribution activities within the supply chain. The results showed 9.8% cost savings with the SCM approach compared with the existing approaches without the SCM scenario	The inefficiencies as a result of non-integrated logistics activities in the studied food chains could be alleviated and overall cost could be reduced.
Lin (2005) listed the following as benefits of implementation of SCM in dairy chains in China: • Potential for overall improvement in logistics as a result of sharing logistics facilities among members of the supply chain, avoiding overlapping investments on logistics facilities, establishing information interchange platforms through cooperation of enterprises in the supply chain, and overall working efficiency improvement of logistics in the supply chain • Potential for reduction of transaction costs,	All points identified are relevant to the present study. Application of SCM could alleviate the self-orientated logistics service uses, hence reduce costs, improve the flows of information among chain actors and reduce transaction costs, reduce food losses resulting from these problems, and also increase customer satisfaction with quality product provision. Joint use of logistics facilities could reduce individual chain actors' investments in logistics costs and enable

particularly the information cost aspect • Potential for improving customer satisfaction.	them to invest more (pooled resources) on establishing better logistics facilities that will serve the whole chain.
Chen et al. (2014), made comparative analysis of two approaches of supply chain quality control: centralised versus decentralised approaches for supply chain quality control, using existing dairy chains in China, the 2008 milk adulteration incident as a case. The centralised quality control approach in the study was the situation of vertical integration where the dairy companies owned and controlled the whole functions in the chain while the decentralised version was a dismantled chain where dairy products were supplied by inexperienced and untrusted suppliers at different stages. After their investigations the authors identified the following points as important issues for consideration in food supply chain quality control: • Food product quality, particularly for emerging global markets, can be ensured by establishing right supply chains • The dependence on inexperienced and non-trustful suppliers of the food commodities could end with dangerous result in terms of food quality • Centralised food quality control is superior to decentralised situation for the causes of milk adulteration incidents in 2008 in China • However, the authors also noted the difficulty/impossibility of centralised or vertical integration type food supply chain and recommended establishing strong partnerships among legally independent organisations in the food supply chains instead.	This case is very relevant to the quality issues in the milk chain. This thesis identified the opportunistic behaviour that compromises quality, particularly in the milk chain. The farmers blamed the input suppliers for low quality of feeds that result in lesser density of milk, while the buyers blamed the farmers for water adulteration. Therefore, implementation of SCM could be a solution for such quality issues. Through SCM, it is possible to establish quality standards that will be monitored and controlled by the chain actors. The standards could be enforced by different methods. For instance the carrot approach such as providing bonus scheme for quality product provisions or the stick approach such as isolation from the chain could be possible in organised and integrated supply chains.
Francesconi *et al*. (2010) noted the potential emergence of supermarket-led dairy supply chain in Ethiopia, which may bring positive impacts to	This thesis provides an indication of the importance of comprehensive dairy SCM that includes and benefits the whole

the dairy sector such as expansion of dairy trade. However, the authors also noted the possible challenges of emergence of monopoly power by supermarkets and processors exploiting both farmers and customers.	chain, including the farmers. From this study it can be argued that unless a collaborative form of food supply chains is established with joint decisions among the chain actors, there are possibilities for the upstream chain actors and consumers to be exploited by downstream chain actors such as processors and supermarkets due to their financial power.
D'Haese *et al*. (2007) indicated improved production and productivity through cooperative-based networking and collective actions towards accessing markets and better negotiation capacity for small-holder farmers.	This thesis argued that collective actions based on negotiation and joint decisions need to be based on trustful collaborations among legally separate chain actors. The argument is based on the potential for access to market and the possibilities for smallholder capacity development programmes by the chain actors themselves through established SCM systems.
Steen and Maijers (2014) discussed the success story of one dairy business (Hiruth) in Ethiopia and showed that establishment of long-term win-win relationships between the dairy business and small-holder farmers as a key success factor. According to the authors' view, such a practice could alleviate the serious loss problem, estimated at about 20-35% losses in the milk value chain in Ethiopia as a result of problems in milk collection, cooling and transport.	The implementation of SCM in food chains can be viewed as implementation of such practices on a larger scale with many chain actors, establishing win-win relationships. The Hiruth dairy case could be taken as an example of supply chain management where both upstream and downstream chain actors were managed trustfully. The Hiruth dairy as a focal firm integrated the end-users' demand with producers and other chain actors' needs.

5 Conclusions and recommendations

In this thesis, the supply chains of three major food commodities, milk, *teff* and *warqe*, in six districts in central Ethiopia were analysed. The results showed that farmers, cooperatives/unions, processors, traders, catering institutions and consumers were the major chain actors.

In the milk chain, production was characterised as a system of smallholder farmers with a small number of cows and low productivity in terms of milk yield per cow and day. Similarly, the cases of *teff* and *warqe* also showed the dominant role of smallholder farmers engaged in farming activities as a major livelihood support.

Marketing relationships among the chain actors were characterised by lack of long-term market orientation and were transaction-specific. Opportunistic behaviour was common among the chain actors. Moreover, labelling and attributing the same problem to different causes were observed, such as farmers blaming poor feed quality for low-quality milk and buyers blaming farmers for water adulteration in the milk chain case study.

Significant amount of food losses were found along the commodity value chains. In the milk chain, 3.35%, 5.46%, 2.45%, 0.95%, 1.23% and 0.88% of losses were estimated for producers, cooperatives/union, wholesalers, retailers, processors and catering institutions, respectively. In the *teff* chain, 8.18%, 1.67%, 2.85% and 3.58% were estimated for the producers, wholesalers, retailers and catering institutions/consumer stage, respectively. In the *kocho* chain, 5.8%, 15.2%, 24%, and 5.8% estimated losses occurred at producers, wholesalers, retailers and the catering institution/consumer stage, respectively. In the *bulla* chain, 1.4%, 3.1%, 12.6%, 28.8%, and 4.5% estimated losses were found for producers, wholesalers, retailers, processors and the catering institution/consumer stage, respectively.

Loss hotspots were identified as taking place at the cooperative, farmer, retailer and processor stages for milk, *teff*, *kocho* and *bulla*, respectively. The

top problems causing losses at loss hotspot points were identified as poor handling practices at milk collection points in the milk chain, the threshing process in the *teff* chain, and poor packaging, display and processing facilities in the *kocho* and *bulla* chains. Using the Tobit model, distance to the nearest market was found to be the most important factor for farmers' post-harvest losses, while the Probit analysis identified attendance in formal education as most determining for value addition decisions in *teff* chain.

The results indicated the potential of supply chain management practices to alleviate existing problems and for overall improvement of the food chains in these cases. Implementation of SCM could more be easily done in the milk chain compared with the *teff* and *warqe* chains. This is because in the case of the milk chain, about 73% of the milk sold by farmers passed through cooperatives/union, so the cooperatives/union stage had influence over the chain in both upstream and downstream directions. Therefore, it can serve as the focal firm in improvement work. In the *teff* and *warqe* chains, traders had a strong influence in decision-making, such as determining the price. However, since the traders were different institutions or individuals, the possibility to serve as a focal firm is more difficult than in the case of the dairy chain. In the cases of *teff* and *warqe*, establishment and strengthening farmers' cooperatives might be more immediate direction than SCM.

The SCM approach, which is based on the principle of coordination through the formation of partnerships and trust among the legally separate chain actors through collective actions and decisions, can be part of the solution, as shown in this thesis. SCM could improve performance in the selected food supply chains in terms of improving profitability and reducing food losses across the whole chains. To achieve this, the requirements should be met for implementation of the SCM approach, such as supply chain orientation, trust-based partnership formation and long-term market orientations among chain actors.

6 Future Research

Although SCM has already evolved to the food sector, its implementation in food chains would not be possible without necessary preparations and commitment by concerned stakeholders. In food chains in particular, where self-profit at any cost (including exploiting others) may be the basic business notion, as in the food chains studied here, more preparations and activities by stakeholders are required. One of the major prerequisites is detailed knowledge of the chains. This thesis contributed to this task by characterising some sample chains. However, the detailed governance structure and performance measurement and management methods for these food chains need further assessment. The relationships between variables in factors for governance structure choice (*e.g.* environment, transaction-specific investments, transaction cost, *etc*.) and the choice of governance models (formal contractual vs relational or trust-based) and the effect of these on supply chain performance (cost, quality, food losses, *etc*.) should therefore be the subject of future studies.

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Appendixes

Appendixes A-C contain major food and economic crops and livestock data in Ethiopia