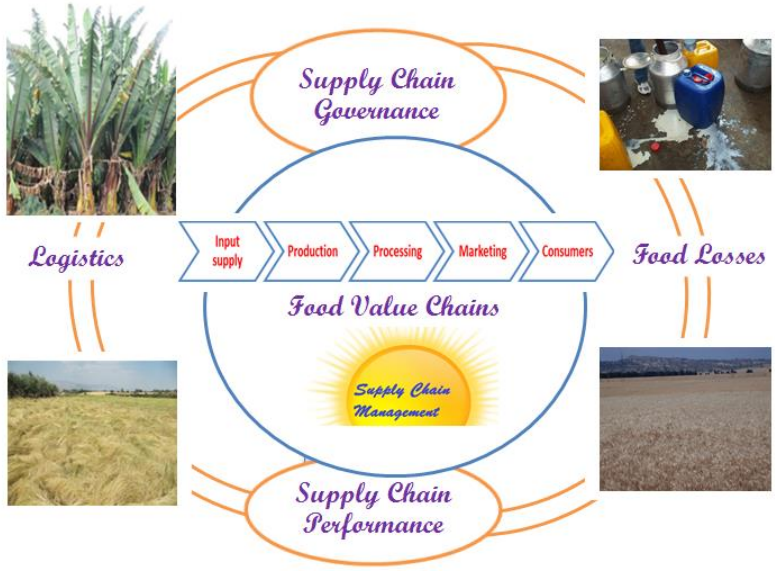
Supply Chain Management Approach to Reduce Food Losses

Empirical Results of Selected Food Commodities in Ethiopia

Tadesse Kenea Amentae
Faculty of Natural Resources and Agricultural Sciences
Department of Energy and Technology
Uppsala



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Description of cover picture: The cover picture shows major topics the thesis covered. It also shows the major food commodities discussed: *warqe*, *teff*, wheat, and milk in anticlockwise direction, respectively, starting at top-left.

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Abstract

Food loss is one of the heavy challenges to food security in low income countries. Inefficiencies and ineffectiveness of management in supply chains are considered as the major reasons for postharvest food losses. Therefore, this thesis sought to increase the knowledge base for reducing postharvest food losses using efficient and effective food supply chain management approach.

The supply chain management and postharvest losses of four nationally important food commodities (milk, wheat, *teff*, and *warqe)* in Ethiopia were analysed. *Teff* is a cereal, while *warqe* is a perennial plant from which the food products *kocho* and *bulla* are extracted. 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, Probit, and Structural Equation Modelling (SEM) in SPSS, AMOS, and Microsoft Excel software. Value chain analysis, questionnaire-based post-harvest loss estimations, Likert scale-based loss factor evaluations, and SEM have been applied for the analysis.

The study reported significant food losses at each stage of the food supply chains. The sum of the reported estimated losses from the total marketed products along the whole chains were 14%, 16%, 39%, and 50% for dairy, *teff*, wheat, and *warqe* foods (both *kocho* and *bulla*), respectively.

Poor handling practices at milk collection points, the threshing process in the *teff* chain, harvesting problems and bad weather conditions in the wheat chain, and poor packaging, display, and processing facilities in the *kocho* and *bulla* chains were the forefront factors causing the losses. For farmers, the Tobit model indicated the distance to the nearest market and level of production were the most important factors triggering post-harvest losses in the *teff* and wheat chains, respectively.

The Probit analysis identified attendance in formal education as most determining for value addition decisions in the *teff* chain.

Using the SEM, it was found that transaction costs, trust, and uncertainty significantly predicted chain actors' supply chain governance choice ($p < 0.001$). On the other hand, chain actors' supply chain governance choice significantly predicted efficiency, flexibility, and level of dairy losses at ($p < 0.001$) and level of integrations at ($p < 0.05$) in the dairy chains.

The supply chain management approach was found relevant in reducing the food losses and alleviating many other problems along the food chains.

Keywords: Dairy, Ethiopia, Governance, Losses, SCM, *Teff*, Value-chain, *Warqe*, Wheat

Author's address: Tadesse Kenea Amentae, SLU, Department of Energy and Technology, P.O. Box 7032, SE-750 07 Uppsala, Sweden
E-mail: tadesse.kenea.amentae@ slu.se

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 as a widow bearing all the pains caused by the loss of my father when I was six.

Live as if you were to die tomorrow. Learn as if you were to live forever
Mahatma Gandhi

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 Tadesse Kenea Amentae*, Tura Kaso Hamo, Girma Gebresenbet, David Ljungberg (2017). Exploring wheat value chain focusing on market performance, post-harvest loss, and supply chain management in Ethiopia: the case of Arsi to Finfinnee market chain. *Journal of Agricultural Science, 9(8), 22-42*

IV Ashenafi Cheka Tufa*, Tadesse Kenea Amentae,Tesfaye Balemi Tufa, Girma Gebresenbet (2017). Assessment of Postharvest losses of *Warqe* Food Products in Central Ethiopia. *African Journal of Agricultural Research, 12(9), 750-763.*

V Ashenafi Cheka Tufa*, Tadesse Kenea Amentae,Tesfaye Balemi Tufa, Girma Gebresenbet (2016). Analysis of the Supply Chain and Logistics Practices of *Warqe* Food Products in Ethiopia. *Journal of Food System Dynamics*. 7(3), 213-228.

VI Tadesse Kenea Amentae*, Girma Gebresenbet, David Ljungberg. Examining the interface between supply chain governance structure choice and supply chain performance of dairy chains in Ethiopia. *Submitted Manuscript*

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* Corresponding author.

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 input from co-authors

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

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

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

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

List of Publications that have not been included in the thesis:

I **Tadesse Kenea Amentae**, Girma Gebresenbet (2015). Evaluation of Performances of Intermodal Import-Export Freight Transport System in Ethiopia .*Journal of Service Science and Management*, 8, 57-70

II Ashenafi Chaka Tuffa, **Tadesse Kenea Amentae**, and Girma Gebresenbet (2017). Value Chain Analysis of Warqe Food Products in Ethiopia. *International Journal of Managing Value and Supply Chains (IJMVSC) 8, 23-42*

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Abbreviations

CA	Collaboration Advantages
Co-ops	Cooperatives
CSA	Central Statistical Agency (Ethiopia)
E	Efficiency
EGTE	Ethiopian Grain Trade Enterprise
F	Flexibility
FAO	Food and Agricultural Organization of the United Nations
FM	Fresh Milk
GC	Governance Choice (supply chain)
GHI	Global Hunger Index
GO	Governmental Organizations
ILRI	International Livestock Research Institute
L	Level of Losses
LI	Level of Integrations
NGO	Non-Governmental Organizations
PHL	Post-harvest Loss
PM	Processed Milk
QS	Quality and Safety
RELOAD	Reducing Losses and Adding Value
SCM	Supply Chain Management
SCOR	Supply Chain Operations Reference

SEM	Structural Equation Modelling
SP	Selling Price
T	Trust
TC	Transaction Costs
TotC	Total Costs
TCE	Transaction Cost Economics
TSI	Transaction Specific Investments
U	Uncertainty
WC	Willingness to Collaborate
WFP	World Food Programme

1 Introduction

1.1 Background

Food security has been a serious question in the recent decades. Related to this, the relational view of competitive advantage in food supply chains is getting higher attention and acceptance in academia and practice. This is based on the idea of transforming businesses through networking and trustful partnership in supply chains (Lambert and Cooper, 2000). The supply chain management has already been evolved to the food sector. However, there are lots of concepts which need empirical evidence in order to understand and practice these concepts, particularly in less developed agro-value chains. One of the important topics that need investigations is the interface among food security, food supply chain management practices, and food losses.

Whenever the issue of food security is discussed, three important challenges that may come to mind are: challenge of meeting future food demand, the current food insecurity problem, and food loss and waste. The first challenge is concerned with all parts of the world. It is global concern to feed its ever-increasing population that is expected to exceed 9 billion by 2050 *(Godfray et al*., 2010). Tomlinson (2013) discussed the fact that increasing food production by about 70% from the current was becoming a universal agreement among many scholars in order to feed global people by 2050. The author believed on the importance of increasing food production to meet the challenge but rejects the statistical exaggerations of 70%. The second challenge, the current food insecurity problem, is more relevant to some part of the world. Currently, about 13 percent of the world's population is undernourished (K. von Grebmer *et al*., 2017).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). The third challenge is food loss and waste exacerbating the first two challenges. The study made by Kummu *et al.* (2012) on global

food losses reported that about 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. This resulted in not only the losses of the food but also the losses of the scarce resources that could be used to produce the food and also exposing the globe to additional economic and environmental costs *(Kummu et al., 2012; Godfray et al*., 2010; Parfitt *et al*., 2010; Hodges *et al*., 2011; Rembold *et al*., 2011). According to these sources, the main reasons of losses were 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.

As mentioned previously, Sub-Saharan African countries are among the most food insecure regions and this region is expected to be vulnerable to food insecurity problem during the coming decade. Ethiopia is one of these countries, where food insecurity remains intact. According to the 2017 hunger index report (K. von Grebmer *et al.,* 2017), with 32.3 Global Hunger Index (GHI) score, Ethiopia falls into the category of countries with serious undernourishment problems. This situation is exacerbated by causalities such as El Niño (irregular alters in the weather pattern), which caused a drought in 2015 and forced about 10-15 million Ethiopians 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.

Food security may be discussed within three major conceptual categories, namely: population growth, production including productivity, and food losses across food value chains. The population dimension deals with limiting the population growth to the limited resources as well as to use the growing population as means of increasing production and productivity. The production and productivity concept in food security issue is one of the most discussed topics that deal with how to increase production and productivity of resources to feed the growing global population. The food losses category, which is gaining more attention nowadays, deals with how to reduce the significant amount of food losses in food chains economically.

Inefficiencies and ineffectiveness in supply chain management practices are among 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.

This thesis work examined the potential role of supply chain management in order to improve supply chain performances and reduce food losses in food value chains by using empirical evidence from case studies of selected food commodities' (dairy, *teff*, wheat, and *warqe*) value chains in Ethiopia. *Teff* is a cereal, while *warqe* is a perennial plant from which the food products *kocho* and *bulla* are extracted. These food commodities are among the very important food commodities in Ethiopia.

1.2 Literature review and research questions

1.2.1 Post-harvest food losses and waste

Following the recognition that reducing food losses is an integral element in the food security equation, the terms food loss, post-harvest loss, 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 divided into types of losses, 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, p. 3066) 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.*" 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 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". The authors concluded 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.

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. Post-harvest losses 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 each 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 during the year in the marketing process.

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, form, and time values*, which means getting the product or services to the right place, in the right form (conversion of the product from one form to another), and 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 study by Deloitte (2013, p. 3), 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.

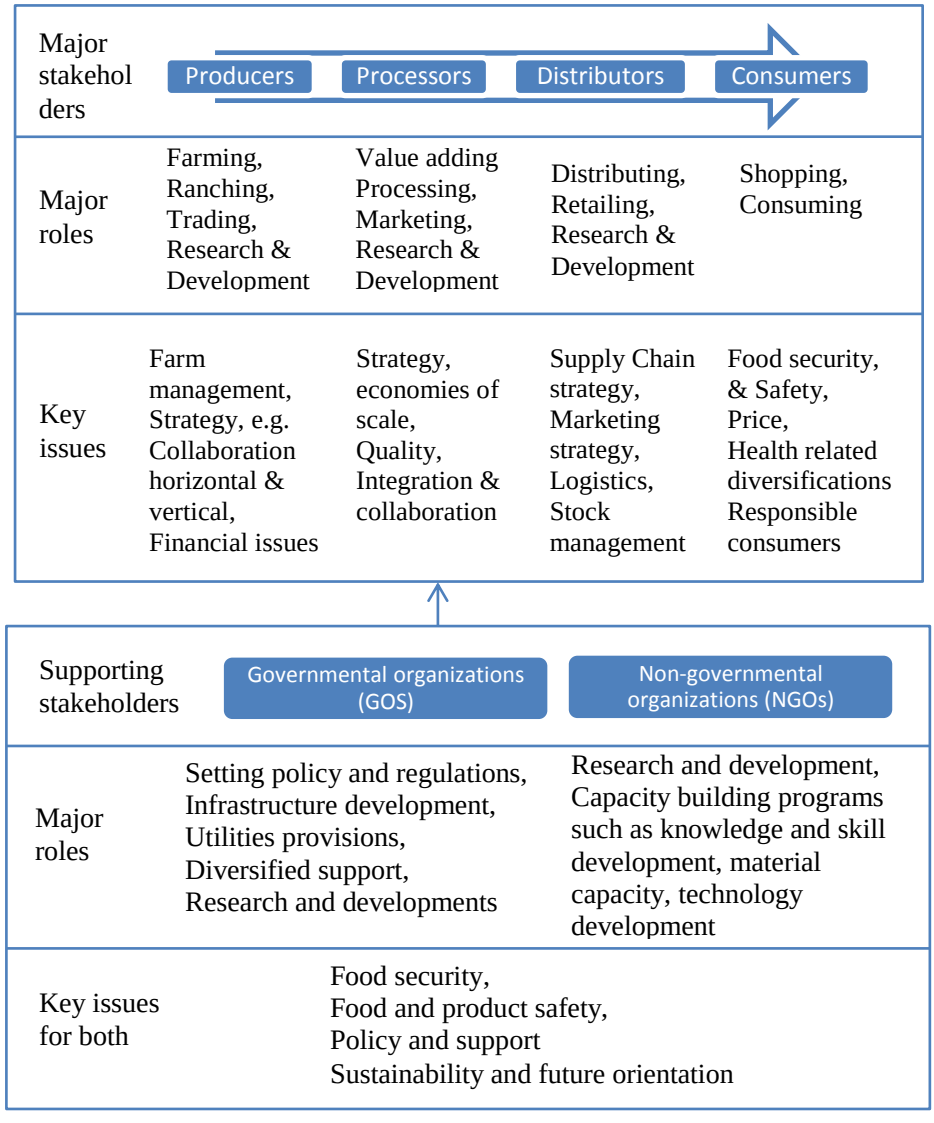

Figure1. Food value chain: summary of stakeholders' major roles and key issues (Adapted from Deloitte, 2013)

The food value chain stakeholders listed in Figure 1 includes:

(a) ***Producers*** involved in growing, searching for improvements and trading food commodities;

(b) ***Processors*** involved in both primary and advanced value addition who process, manufacture, and market value-added food products

(c) ***Distributors***, including wholesalers and retailers engaged in food commodity marketing,

(d) ***Support actors,*** government organizations (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

(e) ***Consumers,*** who purchase the food commodities for final consumptions.

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 the food supply chain management in each stage may include:

a) Producer stage: Improving farm management skills and knowledge, post-harvest loss reducing mechanisms, 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 produced either locally or 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. Van der Vorst *et al*., (2007, p. 7) defined supply chain as *"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 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, p. 3), 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." SCM 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 on the environment as the major points of divergence of food supply chains from industrial product supply chains. Seasonality concerns both demand and supply. Agricultural produce has a short shelf-life and sensitive demand caused by different factors. Thus, it requires 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 agro-food supply chain management practices (Mena and 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 agro-food supply chain managers (Maloni and 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.

1.2.4 Governance issues in food supply chains

Lambert and Cooper (2000) concluded that the era of autonomous standing in business competition is over and businesses are now 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.*" The authors viewed the ability of management to integrate company's sophisticated network of business relationships in this emerging competitive environment as the key to ultimate success for businesses in the chain. The institutional framework which governs the

transactional interactions among the businesses in the supply chain may be termed as food supply chain governance.

Supply chain governance refers to the institutional framework in the supply chain where transactions are negotiated and executed (Zhang and Aramyan, 2009). Humphrey (2001, p. 22) defined supply chain governance structure as, "*the inter-firm relationships and institutional mechanisms through which nonmarket coordination of activities in the chain is achieved*." According to the author supply chain governance structure refers to a situation when some firms in the chain work according to parameters set by other firms in the chain. The parameters may include about the product itself (what to produce), the production process (how to produce), the time it is needed (when to produce), the volume (how much to produce), and the price.

According to Humphrey (2001), improvements in governance of value chains, particularly global food value chains, is important for: enhancing access to market, fast track of productions, fair distribution of gains among chain actors, providing leverage points for policy initiatives, and providing convenience for technical assistance to the food chain from stakeholders.

1.2.5 The theoretical building-blocks of governance structure choices

When governance of food chains is discussed, important theoretical building blocks that come to picture include concepts in transaction cost economics such as bounded rationality, opportunism, transaction-specific investments, information asymmetry, and contracts. These are important theoretical bases for explaining governance structure choices.

According to Zhang and Aramyan (2009), governance forms could be explained under two major business relationships, namely contractual and relational governance. According to the authors, the former refers to written and/or oral agreements reached by parties to reduce risk and uncertainty in exchange relationships while the latter refers to parties' informal embedded relationships and social norms. Thus, concepts in Transaction Cost Economics (TCE) particularly contract issues play a major role in formal contractual governance model while relationship management theory particularly, trust, comes to immediate picture to explain the relational governance model. These theoretical bases of governance are briefly discussed in the following paragraphs.

Transaction cost economics (TCE)

According to Williamson (1999b, p. 1088), *"Transaction Cost Economics (TCE) states that the transaction is the basic unit of analysis and an economizing response to the commons triple in governance: conflict, mutuality,*

and order." TCE refers to the basic idea that the nature and level of transaction costs (search costs, bargaining/negotiation costs, and policing/enforcing costs) are determinant factors for supply chains governance structures. Transaction costs are also the bases for contract theory as transaction costs are the primary motives for vertical coordination in the supply chains (Hobbs, 1996; Frank and Henderson, 1992).

In this study, effort has been made to analyze the situation of transaction costs in the food chains and how that is related to the supply chain governance structure choice and performances across the chains (Paper VI).

Bounded rationality

Although human beings are assumed to have intention of making rational decisions their ability to evaluate correctly all possible decision alternatives that lead to rational decisions may be limited in reality, and this limitation is known as bounded rationality. According to an online business dictionary (BusinessDictionary, 2017), "*bounded rationality is a concept that decision makers, irrespective of their level of intelligence, have to work under three unavoidable constraints.*" These constraints are:

a) information constraint: only limited, often unreliable, information is available regarding possible alternatives and their consequences,
b) human brain capacity: human mind has only limited capacity to evaluate and process the information that is available at a time, and
c) time constraint: only a limited amount of time is available to make a decision.

Therefore, according to the source, individuals who intend to make rational choices are bound to make satisficing instead of optimizing or rational choices in complex situations. In food supply chains, the governance choice is highly affected by bounded rationality. Particularly, in less developed food chains, the information and time constraints can be argued as the most constraining factors.

Opportunism and information asymmetry

According to Williamson (1999), opportunism is a risky situation that businesses and individuals seek exploiting the situations to their advantages. It is self-interest seeking, which lacks honesty.

Hobbs (1996) stated the risk of opportunism may rise under certain situations in supply chains where the bargaining power of chain actors is not equally distributed. For instance, when there are only few buyers of a product from many suppliers as in most agricultural produces in rural areas in

developing countries, the producers bargaining power may be limited, hence, there is high risk that the buyers may act opportunistically.

Information asymmetry is related to the bounded rationality and opportunism described above. There are two major opportunism behaviors that appear commonly in literature resulting from information asymmetry, namely: the *adverse selection* and *moral hazard*. Hobbs (1996) calls these as *ex ante* opportunism and *ex post* opportunism, respectively. Adverse selection *or ex ante* opportunism refers to the hidden information prior to transactions with intention of getting advantage by one party to the transaction that intentionally hides the information for later use to its advantage. Moral hazard or *ex post* opportunism arises because of the hidden behaviors and actions of individuals after transactions; one party to the transaction may act opportunistically to increase own advantage because their actions are not directly observable by the other party to the transaction.

Transaction specific investments (TSIs)

Transaction specific investments also known as asset specificity are also another important concept that could affect supply chain governance structure and relationships management. Transaction specific investments refer to situation where specific investment is made for the sake of specific transaction with the other partner in the relationships.

Zhang and Aramyan (2009), noted TSI as the acquisition of assets which will be used only with one transaction partner or where it is costly to shift it and use for other purpose. According to Hobbs (1996, p. 17), asset specificity occurs "*when one partner to an exchange has invested resources specific to that exchange which have little or no value in alternative use.*" In agro-value chains most investments are transaction specific and this has potential implications for food supply chain governance choice, meanwhile the choice could also motivate transaction specific investments.

Trust

Another important concept in supply chain governance and relationship management is trust. Anderson and Narus (1990, p. 45) defined trust as "*the firm's belief that another company will perform actions that will result in positive outcomes for the firm, as well as not take unexpected actions that would result in negative outcomes for the firm."* According to the authors, the firm's belief strength on its working partner relations lead it to making trusting response and commits itself to possible loss depending on the actions of the relation partner. The authors distinguished between honesty and benevolence levels of trust. The former refers to reliability and consistency in fulfilling

promised role obligations in the relationships while the latter refers to motivation in joint gains and genuine care for others' interest and welfare in the relationship. Trust is central issue in food supply chain management. In an ideal food supply chains, the chain actors need to have trust on each other and trust on overall chain value maximizations.

1.2.6 Performances in food supply chains

The idea of overall chain value maximization is replacing the '*resource based competitiveness*' view, which argues business success depends on access to important resources. The overall chain value maximization depends on '*relational view of competitiveness*', which argues "*firm's critical resources may span firm's boundaries and may be embedded in interfirm resources and routines*" (Dyer and Singh, 1998, p. 660).

The central point of supply chain management as well as relational view of business competitiveness is that business organizations that form smart partnerships, strategic alliances, and efficiently coordinate the value chains generate better overall supply chain performance than those striving separately (Junqueira, 2010). In this regards, supply chain performance is important issue to be scrutinized in food supply chain management process.

Supply chain performance refers to the overall chain performance which is dependent on performances registered at each stages of the supply chain (Aramyan, 2007). However, supply chain performance is not the arithmetic sum of profits or other quantifiable measures along the chain or it is not the success registered in specific stage along the chain. Instead, it is measured by standard indicators which measure overall synergy of the chain. In order to identify the overall supply chain performance, performance measurement became integral part of supply chain management.

Farahani *et al*., (2009) stated "*If you can't measure it, you can't control it; if you can't control it, you can't manage it; if you can't manage it, you can't improve it.*" Thus, the purpose of performance measurement in food supply chain is to control and mange performances so as to achieve performance improvement across the whole chain. In this regards, different authors (Van Der Vorst, 2006*;* Amaratunga *et al.,* 2010*;* Aramyan *et al.,* 2007) tried to develop a framework for food supply chain performance measurements by adapting from performance measurements designed for supply chain performances in general. Supply-Chain-Operations-Reference model (SCOR) is another general and comprehensive supply chain performance measurement framework developed and endorsed by the Supply-Chain Council (Council, 2003). SCOR is a process reference model that has been developed so as to

serve as the cross-industry standard diagnostic tool for supply chain management.

In this thesis the supply chain performance indicators from the framework recommended by Aramyan *et al.*, (2007) were adapted and analyzed against the chain actors' supply chain governance choice (Paper VI). Brief explanations of these performance indicators are presented in the following paragraphs.

Efficiency

Supply chain efficiency measures how well the resources in the supply chain are utilized (Pettersson, 2008). Efficiency signifies a level of performance that describes a process that uses the lowest amount of inputs to create the greatest amount of outputs. Achieving efficiency of supply chain would rather be a difficult task as much as it is important. This is because the other objectives in the supply chain such as responsiveness are contradicting with efficiency objectives.

For instance, Randall *et a*l., (2003) distinguished responsive and efficient supply chains. According to the authors, a responsive supply chain is characterized by quick response to customers demand and has short lead-time, small batch sizes, and often higher unit costs. However, an efficient supply chain is differentiated by low cost per unit but may be at an expense of responsiveness and characterized by longer lead-times, high set-up costs, and large batch sizes.

The efficiency-responsiveness comparison also extends to the lean-agile supply chain paradigms. The agile paradigm emphasizes on the quick responses to the fast changing customer needs or responsiveness while the lean supply chain focuses on reducing costs and waste across the supply chain, hence, more concerned with efficiency.

Mason-Jones *et al*., (2000), argued against the general idea that agile manufacturing is adopted where demand is volatile and lean manufacturing adopted with functional products used for our basic needs such as food, which have stable demand. The authors argued that pursuing such arguments in isolation may result in loss of the power of each paradigm and proposed a total supply chain strategy they termed as *"Leagile*" made from the combination of the terms lean and agile emphasizing that supply chain strategy should balance both paradigms.

The details of supply chain efficiency, responsiveness, and lean or agile are beyond the scope of this study. However, the importance of efficiency of the supply chain is a forefront issue in food supply chains. If supply chains are

inefficient, that would be a threat to all other objectives by frustrating the chain actors with losses and wastes.

In this study, efficiency as one of the supply chain performance indicator was assessed against the chain actors' supply chain governance choice using the cost and return relationships as indicated under the supply chain performance indicators framework developed by (Aramyan *et al*., 2006; Aramyan, 2007). It should be noted that, efficiency in context of this study refers to input-output relationships to achieve the objectives by the food supply chain actors for ease of measuring it. However, efficiency could be used in broader sense which may embed other performance indicators including responsiveness.

Flexibility

Flexibility may be thought as the ability to change or react to environmental uncertainties within less time, effort, cost, and without compromising overall performances. Calantone and Dröge (1999) stated that supply chain flexibility encompasses those flexibilities that directly impact a firm's customers and are the shared responsibility of two or more functions along the supply chain. The author noted that supply chain flexibility has several dimensions and discussed five major supply chain flexibility dimensions, namely:

Product flexibility which is dealing with the value-adding attribute to the product that is immediately visible by customers. The features may include options of sizes and colors or other specifications.

Volume flexibility is the other type of flexibility that is concerned with the ability to respond to changes in volume in response to customer demands. Volume flexibility is important in managing stock-out problems in high demand situations.

Launch flexibility is a type of flexibility that deals with the ability to rapidly introduce new products and product varieties, which requires a strategically important flexibility of the integration of numerous value activities across the entire supply chain.

Distribution or access flexibility is the ability for providing widespread distribution coverage.

Flexibility in terms of responsiveness to target markets could be thought as the sum effect of other flexibilities and is the ability to meet or exceed customer requirements in many dimensions.

Similarly, Duclos *et al.*, (2003) discussed these five types of flexibilities and showed six important flexibility competencies the supply chains needs to have to achieve these flexibilities. These are operations system flexibility,

market flexibility, logistics flexibility, supply flexibility, organizational flexibility, and information systems flexibility.

Stevenson and Spring (2007), after intensive review of literature related to supply chain flexibility also identified these generic principles: flexibility is multi-dimensional, different elements of flexibility are more important in certain environments than in others, and flexibility is a capability that does not have to be demonstrated.

For detail of flexibility as a measure of supply chain performances one may refer to (Steven-son and Spring, 2007; Duclos *et al*., 2003; Calantone and Dröge, 1999) and other ample literature on the topic. However, it is important to note that flexibility is another important performance issue in food supply chains. This is because the seasonality of demand and supply of food commodities and short-shelf lives for the food commodities requires supply chains flexibility competences in terms of volume, price, and associated performances. In this study, flexibility is considered from the marketing point view and assessed on the bases of volume flexibility, delivery place flexibly, delivery time flexibly, and delivery price flexibly.

Quality and safety

It is general consensus that food products now days are consumed thousands of miles away from where they are produced. These modern food supply chains are responsible to deliver food products as quickly as possible and to ensure certain levels of safety and quality, which can satisfy the growing needs of consumers. It is obvious that food quality and safety is important as much as its physical accessibility is.

As much as the food supply chain is expanding, the food quality, safety, and related standard scandals are also growing. In response to these scandals and the needs of consumers for safe and quality foods an effective and credible food safety regulatory system became critically important role for public policy and that of the supply chain actors (Hobbs *et al.*, 2002). According to the author, designing a system that ensures the safety and quality of food in supply chain remains a challenge.

Related to food safety and quality are the concepts of short-supply chain and traceability. Aung and Chang, (2014) argued that the current food labelling system can’t guarantee food safety and quality. The authors believed good traceability systems helps to minimize the production and distribution of unsafe or poor quality products, thereby minimizing the potential for bad publicity and liability.

In this study, quality and safety was analyzed from regulatory efforts perspectives. The chain actors were asked regarding the existence of product

standards and related rejections, production process inspections, and product quality and safety inspections along the supply chain.

Level of integrations

Integration is an important aspect of successful supply chains. "*An integrated supply chain can be defined as an association of customers and suppliers who are using management techniques, work together to optimize their collective performance in the creation, distribution, and support of an end product*"(Council, 2000, p. 3). Supply chain integration is related to the very sense of supply chain management and to the relational view of business competitiveness. Due to this fact, some authors defined supply chain management as the process of integration of the activities in the supply chain.

For instance, Handfield and Nichols (2002) defined supply chain management as the integration of the activities across the supply chain through improved supply chain relationships to achieve sustainable competitive advantage.

From food supply chain perspectives, these activities to be integrated in the supply chain may include all activities associated with the flow and transformation of food products from the raw materials stage, through the end user, as well as the associated information and finance flows. Supply chain integration affects operational performance, costs, and efficiency along the supply chain (Bagchi *et a*l., 2005).

In this study, how the chain actors' governance structure choice influences the level integration is evaluated. The level of integration is analyzed from the relationship among the chain actors point of view. The relationship of the focal firm with its suppliers and customers in terms of frequency of transactions, size of transactions (money and volume of transactions), betraying of transaction contracts, overall long time cooperation, and dependability on the relationships were evaluated through questionnaire against chain actors' governance structure choice.

1.2.7 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 and nine types of economic live animals.

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, 2015), indicate that national crop production is dominated by cereals, in terms of both cultivated land acreage and volume of production (*see* Appendix B). The report showed that cereals contribute about 81% of land under cultivation and about 87% of total grain crop production.

Looking further to the cereals section in Appendix B, *teff*, maize, sorghum and wheat dominate land coverage, occupying about 24%, 16%, 14% and 13% 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 about 27%, 18%, 16%, and 16%, 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 52 million), sheep (about 24 million), and goats (about 22 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 still dependent on imported food commodities. Ethiopia's agricultural products imports value and volume have grown from $1 billion to about $1.8 billion and from 1.9 million metric tons to 3 million metric tons, respectively between 2010 and 2015 (Francom, 2017). Thus, the food insecurity problem remains intact 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 commodities. 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.

The main constraints in the food and agriculture sector in Ethiopia are:

- 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;
- Inadequate 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 transport

In particular, losses of major foods such as cereals (Hodges *et al*., 2011), dairy products (Steen and 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. The thesis, particularly dealt with supply chains and post-harvest loss issues for four major food commodities, milk, *teff* wheat, and *warqe*. These commodities were selected based on national data that indicate their importance in national food security and observed problems during the pilot study. Furthermore, with regards to the selected food commodities, there has not been sufficient previous research 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.

Specifics of the selected food commodities examined in this thesis are further discussed in the following paragraphs.

***Milk*:** With about 52 million head of cattle (CSA, 2011/12), 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 *Finfinnee/* Addis Ababa, 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 (Ethiopian currency) 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, similarly 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 24% of all land under cultivation (first among all cultivated crops in terms of acreage) and contributes about 18% to grain production, second next to maize in terms contribution to total grain production (CSA, 2015). Some reports indicated that *teff* is gaining an acceptance in the international market 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-seed 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 2 shows a *teff* crop growing on an Ethiopian farm and a close-up view of a *teff* plant.

Figure 2. *Teff* crop growing on a farm (left) and close-up view of a *teff* plant (right)

Wheat*:* Wheat is one of the most important cereals cultivated in Ethiopia. Wheat products contributed to 14% of the total caloric intake in Ethiopia, which made wheat the second most important food, behind maize (19%) FAO (2014) as cited in (Kasa *et al*., 2015). It ranks fourth after t*eff*, maize and sorghum in area coverage and third in total production (CSA, 2015). According

to the same source, wheat contributes to about 15% of total annual grain productions in Ethiopia.

Some studies indicated that the magnitude of wheat post-harvest loss in Ethiopia was significant ranging from 10% to 20% (Hodges *et al*., 2011). This figure is quite large especially for Ethiopia where a great majority of people are food insecure (WFP, 2014). In Ethiopia, wheat is produced by smallholders, state farms, and commercial farms. The production is dominated by smallholders and almost all wheat producers in the country produce under rain-fed conditions. According to (FAO, 2014), the largest volume of wheat production in Ethiopia originates from Oromia regional state (57.5 %), where almost all zones of Oromia region grow wheat. However, Arsi, Bale, West Shewa, East Shewa and South West Shewa are the major wheat producing zones in order of production volume rank in the region. With annual production of about 1.5 million tons, these zones contributes to more than 80% of the wheat production of the region (FAO, 2014). The *Arsi* and *Bale* areas are usually called as Ethiopia's *wheat belt.*

***Warqe*:** *Warqe* aka enset is a perennial plants (*see* Figure 3) 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 that could be consumed after boiling it.

Figure 3. Warqe crop growing on a farmyard (left) and close-up view of the warqe plant (right)

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, 2010). 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). *Warqe* is also grown on small plots in the densely populated Ethiopian highlands, where the land is not quite suitable for other farming. The responses of value chain actors and observations made during the 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.

From a review of the literature, the consultative workshop, and field observation made during the pilot study before the start of this thesis work, it was recognized that post-harvest food losses in the four food value chains were major problems. Moreover, it was found that there are very limited scientific studies addressing these problems. Therefore, in a first step to combat the problem of food losses, investigations on the value chains of these four commodities were deemed to be of paramount importance, in order to identify loss hotspot points and overall deficiencies in the value chains, which can serve as a base for necessary and high priority interventions by stakeholders.

1.2.8 Research questions

Particularly in developing countries, 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 systems that could improve the food supply chains' performance in terms of increasing profitability, flexibility, 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:

- How are the value-chains of the selected food chains (milk, *teff*, wheat, and *warqe*) constituted?
- What are the levels 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 chains?
- What are the factors affecting farmers' value addition decisions?
- What are the interfaces between supply chain governance structure choice and supply chain performances?
- Is there any potential for improvement of the selected food chains through improvement in food supply chain management?

1.3 Objectives

The main objective of this thesis was to analyse selected food commodities 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.

The specific objectives for the selected food commodities (milk, *teff*, wheat, and *warqe*) were to:

1) map and analyse the supply chains (Papers I-III,V)
2) assess and identify the levels post-harvest food losses, loss-hotspot points, and factors causing these losses, (Papers I-IV)
3) identify factors affecting farmers' decisions on value addition, (Paper II)
4) examine the interface between supply chain governance structure choice and supply chain performance (Paper VI), and
5) evaluate the potential of supply chain management for improving food supply chain performance, including reduction of post-harvest food losses (Paper I-VI).

1.4 Scope and limitation of the study

The scope of this study spans over characterisation in terms of production, marketing, value share among chain actors, food losses, relationships, and logistics practices in the supply chains of milk, *teff*, wheat, and *warqe*. The assessment of governance structure choice and its interface with supply chain performances was limited to dairy chain. The 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 for comparative analysis and discussions of the results. Moreover, postharvest loss assessments were based on subjective estimates made by the chain actors of the respective selected food commodities supply chains.

1.5 Structure of the thesis

The thesis structure was depicted in Figure 4. Acquiring sufficient knowledge on the selected food supply chain including identifying the estimated level of post-harvest food losses, loss hotspot points, factors causing these food losses and overall characterizations of the food value chains were addressed in Papers I-IV. Assessment of logistics practices were performed in Papers I, II, III, and

V. Assessment of the interface between supply chain governance structure choice and supply chain performance was conducted in Paper VI. Based on the findings of the study, expected outcomes include 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 reduce losses' of food commodities in the value chains and improve the supply chains' overall performances in terms of efficiency, flexibility, integration, and quality. The ultimate goal is better food security.

Research focus	Selected food value chains				Main methodologies
	Dairy	***Teff***	**Wheat**	***Warqe***	
PHL identification along the supply chains	X X	X	X	X	○ Survey ○ Consultative workshop ○ Value Chain Analysis ○ Descriptive statistics ○ Probit ○ Tobit ○ SEM
Characterization of the nature of value chains of selected food produces	X	X	X	X X	
Assessment of logistics practices along the chains	X	X		X	
The interfaces between supply chain governance choice and supply chain performances	X				
	I VI	**II**	**III**	**IV V**	
	Papers				

Figure 4. Structure of the thesis work

2 Materials and methods

In this study, value chain analysis, questionnaire-based post-harvest loss estimations, Likert scale-based loss factor evaluations, SEM for assessment of the interface between governance structure choice and supply chain performances, and multiple case study methods have been applied.

2.1 Selection of study sites

The case studies were carried out in the central and south eastern part of Ethiopia. The value chains for the selected commodities starting at producers in North, East and West Shewa (dairy), West Shewa (*teff*, and *warqe*), and Arsi (wheat) zones and come through various market tiers to the capital city, Finfinnee/Addis Ababa. The starts of the food value chains for each commodity were selected purposively from among high-producing areas for the commodities and areas with potential for value chain development.

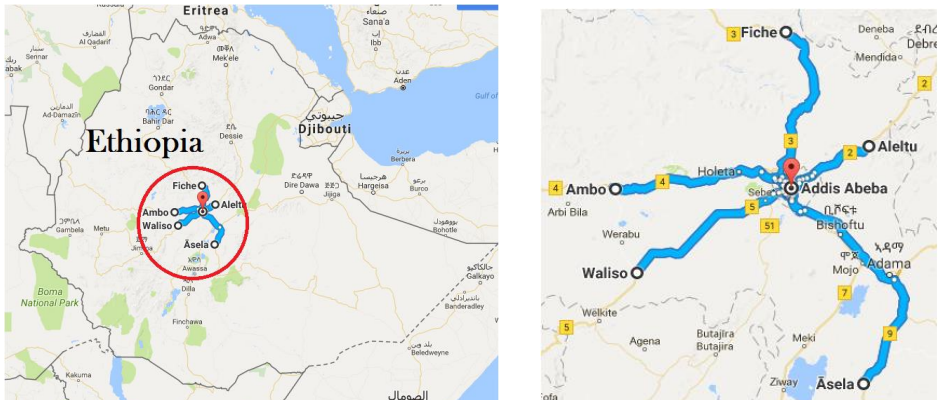

Figure 5. Location of study sites

2.2 Case study method

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

Gillham (2010, p. 1), 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 four food commodities (milk, *teff*, wheat, *warqe*) at the selected study sites.

Yin (2003) noted that the case study is one of the several ways of doing research, *i.e*. experiment, survey, archival analysis, and history. The author noted that case study 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 the author's earlier work (Yin, 1981), case study was noted as 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. Different literatures (Yin, 1981/2003; Voss *et al*., 2002; Flyvbjerg, 2006) showed that a well-planned case study method is as useable as any other research method.

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 could be confusing, with the 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, logistics practice, losses, and governance structure and

supply chain performances 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 and methods this thesis followed, such as the value chain analysis methodology, the food supply chain management approach, and structural equation modelling, 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.

2.3 Food loss assessment methodologies

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 the load-track method, which 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 as it depends on subjective estimates, it is difficult to get the precise facts of food commodity losses. The second method was employed in this study.

2.4 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.

Furthermore, in Paper VI, the Likert scale of rating from 1 to 5 was employed to evaluate the factors in the business scenario which affect chain actors' supply chain governance choices such as level of transaction costs, transaction specific investments, uncertainty, advantages of collaborations, and willingness to collaborate.

2.5 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 P values were estimated based on the level of consistency observed during the pilot study for each case. 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 summary, 382 dairy farmers (262 Paper I; 120 Paper VI), 196 *teff* farmers, 150 wheat farmers, and 209 *warqe* farmers, in total, 937 farmers were responded in the studies. The determined sample size was distributed to *Kebeles* in each district based on stratification using the actual number of households. Then, the farmer samples from each *Kebele* were taken using lottery method. The samples for other chain actors and for Paper VI were selected purposefully based on their willingness to cooperate and other particular factors associated with each chain's actors.

2.6 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 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.

2.6.1 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 four food chain actors (milk, *teff*, wheat, 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.

2.6.2 The survey questionnaire

Gray, (2004, p. 187), defined questionnaires as "*Questionnaire is 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 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).

In the development of the questionnaire pervious literature in similar contexts were also used. For example, in Paper VI the data collection protocol was adapted from (Ji *et al.*, 2012) for supply chain governance part and

developed based on the framework given by (Aramyan *et al*., 2006) and Supply Chain Operations Reference (SCOR) model (Council, 2003) for measuring supply chain performance part. The semi-structured survey questionnaire was translated into the local language before being used in the studies. The general survey questionnaire adapted to each food commodity (for Papers I-V) was appended to the softcopy version of this thesis (Appendix D) and could be found at the link to the thesis (http://pub.epsilon.slu.se/). The survey questionnaire used in Paper VI was published as appendix to the paper.

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.

2.6.3 Interview of the 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. Moreover, all the data obtained in this process was used as supplementary to the questionnaire data (triangulation) and used in the discussion.

2.7 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, structural equation modelling, Probit, and Tobit models. The analyses were mainly quantitative, but narrative-qualitative descriptions were also made regarding socio-economic characteristics, value addition decisions and the extent of post-harvest losses, logistics practices, and supply chain governance structure, and supply chain performance issues in the selected food commodity supply chains. The major analysis methods applied are briefly discussed in the following section.

2.7.1 Value chain analysis

The 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 6). 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 in line with the framework developed by Taylor (2005) is presented below.

Figure 6. Summary of value chain analysis methodology (Taylor, 2005, p. 747)

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 of 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,* wheat, and *warqe* were the selected value streams for which attempts were made to show the crude supply chain structures in the study areas.

Stage 3*:* 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, i.e., 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, 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 the SCM system.

Stage 6: Develop whole chain future state map and recommendation
This is an important phase in which the to-be state map of the selected value chain is recommended. In this thesis work based on the problems identified by findings of all the Papers (I-VI) different recommendations were forwarded which could alleviate the problems. Particularly, in Paper VI, it was addressed how factors in the business environment influences chain actors' decision on their governance relationships and how the governance choice influences food supply chain performances.

2.7.2 The Tobit and Probit Models

The Tobit and Probit models were used to investigate factors affecting post-harvest losses and value addition decisions, respectively. These 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 and* wheat were analysed using the Probit and Tobit models, respectively, as these were considered latent variables, unobserved variables with respect to the measured multiple observed variables or factors. The observed variables or the factors were elements of the questionnaire.

2.7.3 Structural Equation Modelling

Structural Equation Modelling (SEM) is statistical modelling technique which is used for analysing multivariate data that has been long known in behavioural science particularly, appropriate for theory testing (Hox and Bechger, 2007; Savalei and Bentler, 2010).

Jais, (2007, p. 97) defined SEM as *"SEM is a class of methodology that seeks to represent hypothesis about the means, variances and covariance of observed data in terms of smaller number of structural parameters defined by hypothesized underlined model."* According to the author, SEM is a system that stems from econometrics but increasingly applied in various business

related disciplines and behavioural science such as psychology, sociology, political science, and education.

Many researchers (Ji *et al*., 2012; Wisner, 2003; Stank *et al*., 1999; Maloni and Benton, 2000; Lado *et al*., 2008; Stank *et al*., 2001; Cousins *et al*., 2006; Ryu *et al*., 2009) used SEM in areas of supply chain governance and performance researches. In this thesis, SEM was used in Paper VI to empirically verify the interface between factors, which determine the chain actors' governance structure choice and the supply chain performances.

SEM was used with its justifiable benefit such as comprehensiveness, testability, graphical representations, and solutions through use of purpose-based software, in this study, IBM AMOS version 24, and its relevance to test the hypothesizes stated in Paper VI.

The path analysis in structural equation modelling was employed to assess the interface between factors in business scenario, the chain actors' governance structure choice, and the supply chain performances.

The study hypotheses were structured and presented using Amos graphics version 24 (*see* Figure 7). The left to middle view of Figure 7 depicts the basic factors for governance structure choices which were selected in the study, i.e., Transaction Cost (TC), Uncertainty (U), Trust (T), Transaction Specific Investments (TSI), and additional two variables, Collaboration Advantages (CA) and Willingness to Collaborate (WC) which together with Uncertainty were expected to explain Trust.

Figure 7 also shows how these factors play role in chain actors' governance structure choice and how the factors are correlated to each other.

These basic factors are measured based on the questions on the questionnaire. For example, Transaction Cost is measured by ten elements of the questionnaire (*see* section B of Appendix 5 on Paper VI). The sum score for each respondent is used for analysis, i.e., for Transaction Cost as the highest score for an individual for each question is five (5), it means the highest score for the ten(10) questions will be 50.

Looking form middle to the right of Figure 7, we can see how the supply chain governance choice explains the supply chain performances. In the study, Efficiency (E), Flexibility (F), Quality and Safety (QS), Level of Integration (LI), and Level of dairy Losses (L) were selected as basic supply chain performance indicators for assessment. Efficiency and loss were measured on the absolute values of data obtained from the respondents. The total cost divided by total revenue for each respondent was used as measure of efficiency. Only operational costs of a single year were considered against the revenue of a year. For the other performance indicators, the sum score for each respondent is used for analysis. In case of Flexibility and Quality & Safety,

even though the data was collected using binary response questions, they were converted to Likert scale rating based on the four questions asked by each respondents in order to fit to the model for analysis. For the procedure how the questionnaire collected with a binary response question were converted to a 5 degree Likert scale ratings (*see* Appendix 4 on Paper VI).

The one side arrow shows the factor is measuring /causing the other factor to happen where the direction of the arrow shows the cause-effect (tail-head) relationship. On the other hand, double-headed arrows between the factors show that the factors are correlated without referring to the cause-effect relationship. In relations to the structural equation modelling, different model diagnosis were made and the results of the diagnosis were checked before running the model.

Internal reliability test is a prerequisite of all analysis where predictor variables are developed from sum score of elements of questionnaire (Santos, 1999). In this study, Cronbach's Alpha was used as it is the most commonly used statistics for reliability test (Peterson, 1994; Bland and Altman, 1997a&b). The test result showed the data has no internal reliability problem.

Model Goodness of fit tests commonly used in SEM (Bagozzi and Yi, 1988) were also applied to check how well the model developed fits the purpose before running the model to test the hypothesises. Accordingly, it was found that the model more-or-less fits the data; hence statistical testing of the hypotheses using the model was justified and used accordingly.

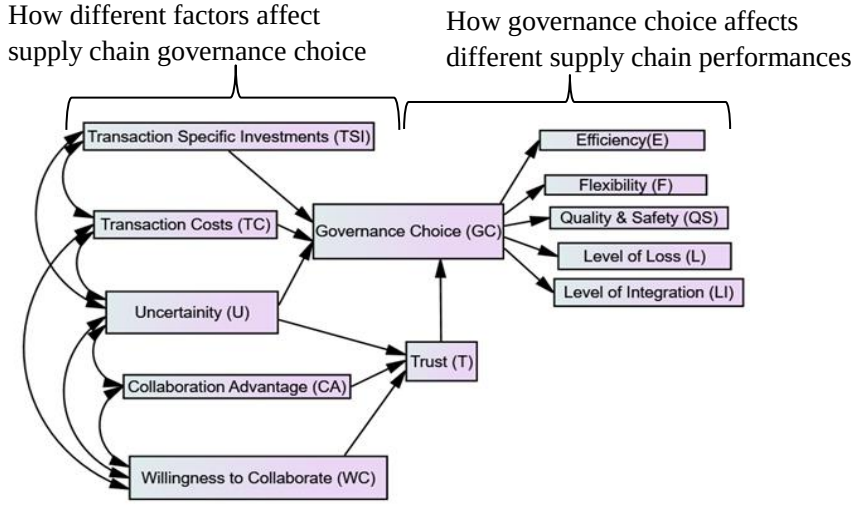

Figure 7: The SEM paths of analysis

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*), 10 (wheat), and 12 (*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* and wheat the supply chains were relatively more open, which made tracking to consumption level difficult, *i.e*. there were flows of *teff* and wheat 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%). 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 is bidirectional, where processors buy fresh milk from wholesalers and wholesalers buy processed milk from processors.

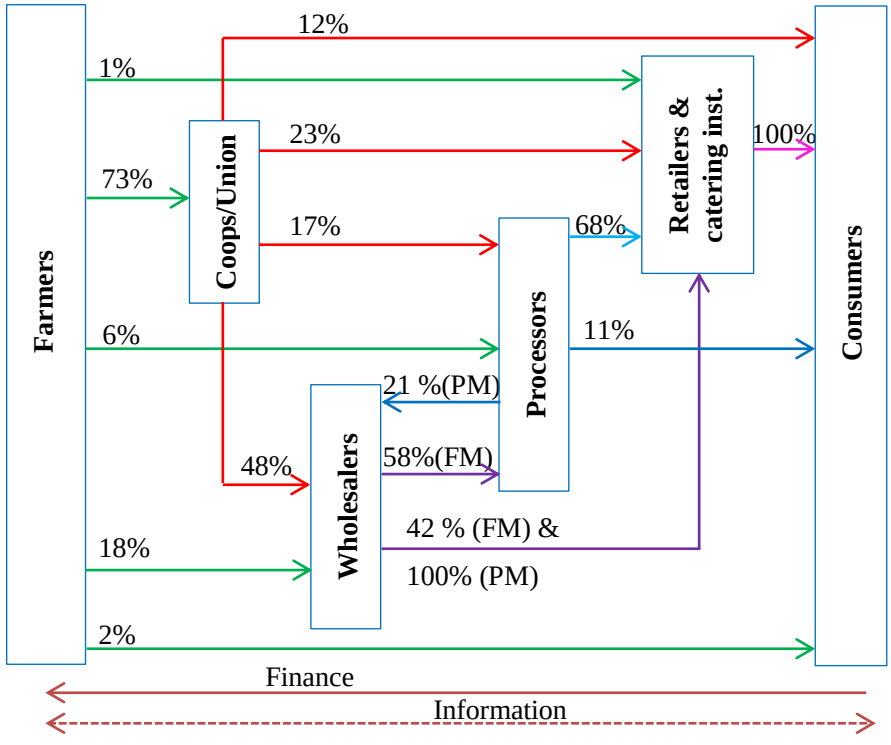

Figure 8. Simplified flow chart of dairy products in the supply chains, with sales distribution in the study area distinct coloured arrows (green-farmers, red-co-ops, purple-wholesalers, blue-processors, and pink-retailers); the percentages represent the sales distribution from each actor; FM and PM 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, *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 interest.

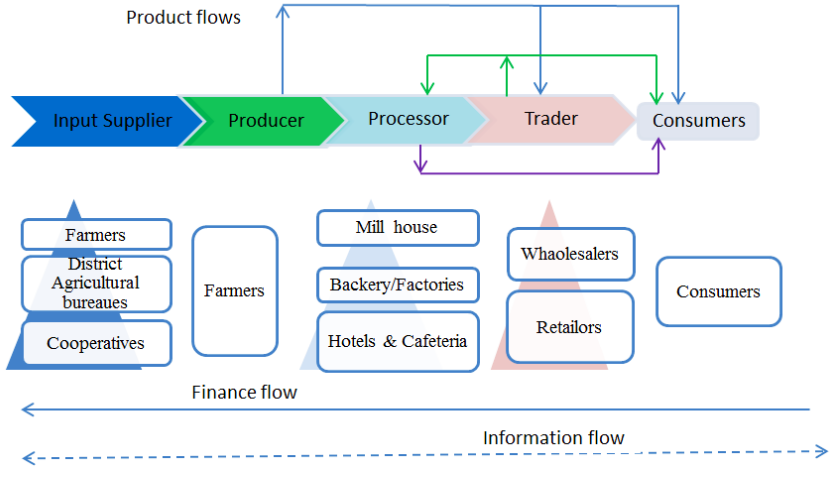

Figure 9. Simplified flow chart of *teff* in supply chains in the study area

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.

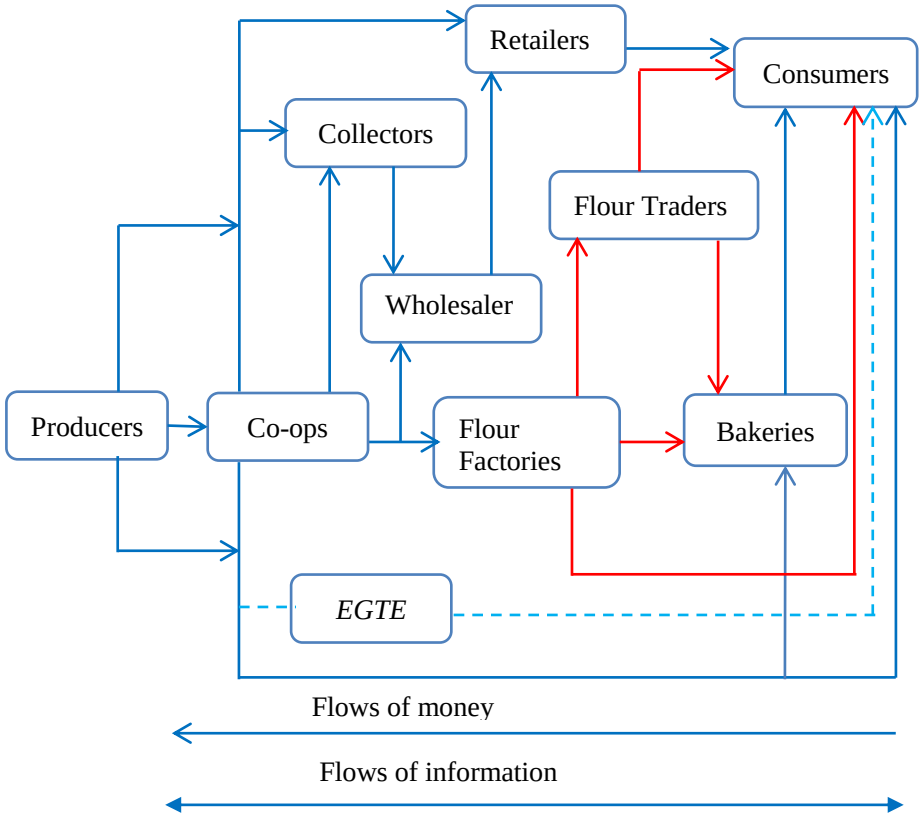

Figure 10. Simplified flowchart of wheat in the supply chains in the study area (blue, red, and dotted lines connecting boxes represent physical flow of wheat, wheat flour, and the occasional flow wheat through *EGTE*, respectively, *EGTE* refers to Ethiopian Grain Trade Enterprise)

The wheat chain assessed was almost similar with the *teff* chain described previously with minor exceptions in terms of the chain actors and interactions in the chain. Figure 10 presents simplified flow chart indicating the flows of products, information, and finance in the supply chain for wheat in the study area.

As in the *teff* chain, in the wheat chain the primary actors included producers, cooperatives, collectors, wholesalers, retailers and processors. Exceptional to wheat chain was the existence of Ethiopian Grain Trade

Enterprise (*EGTE*), which is a state-owned enterprise that is engaged in stabilizing grain market in Ethiopia as a market leader in grain export and import. The enterprise stated its aim as "*to stabilize agricultural product market and be a leader in export revenue earning*." The broken line in Figure 10, indicate the flow of wheat from producer and producers' cooperatives to *EGTE* and from *EGTE* to consumers in a non-regular basis.

Warqe is a perennial plant with multiple uses. As illustrated in Figure 11, three separate food commodities are extracted from the plant, namely *kocho*, *bulla*, and *amicho*.

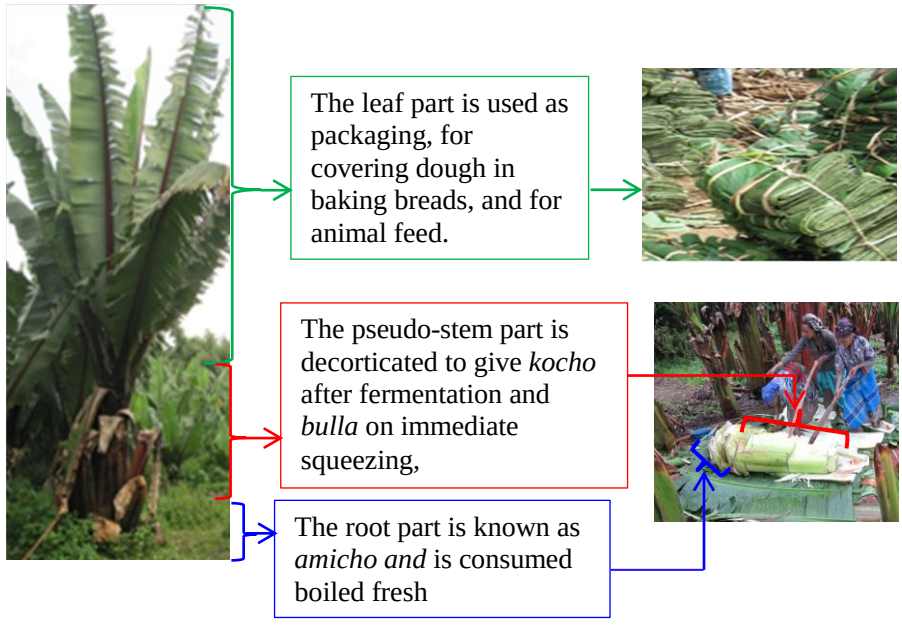

Figure 11. Major parts of the *warqe* plant and its main use

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 depicted in Figure 12.

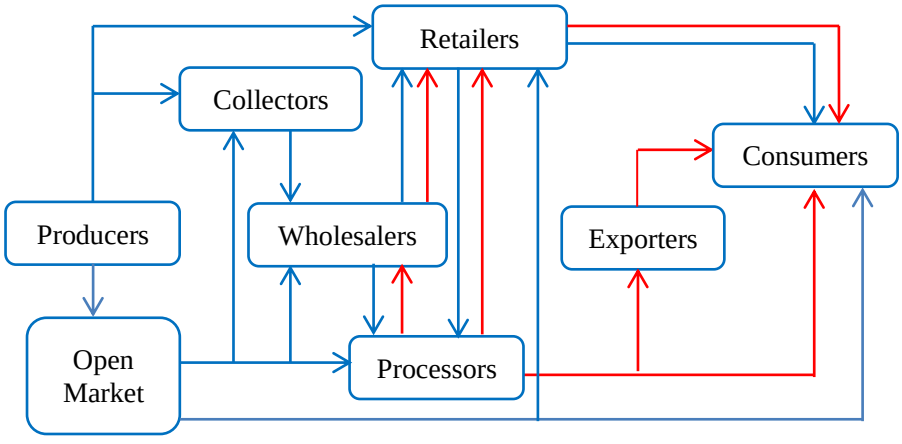

Figure 12. Simplified flow chart of *warqe* food products in supply chains in the study area (blue lines represent the flow of *kocho and* fresh *bulla* and red lines represent the flow of processed *bulla*)

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 was exported.

It was observed that the *warqe* supply chain to the central market in Finfinnee/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 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 Post-harvest losses and factors causing the losses

3.2.1 Estimated level of losses

Figure 13 presents the estimated percentage losses of the food commodities studied across the stages in the whole value chains. The sum of the reported estimated losses from the total marketed products along the whole chains were 14%, 16%, 39%, and 50% for dairy, *teff*, wheat, and *warqe* foods (both *kocho* and *bulla*), respectively.

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.

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 threshing, harvesting, and transportation from harvesting site to home. Threshing was the severest problem identified as regards losses.

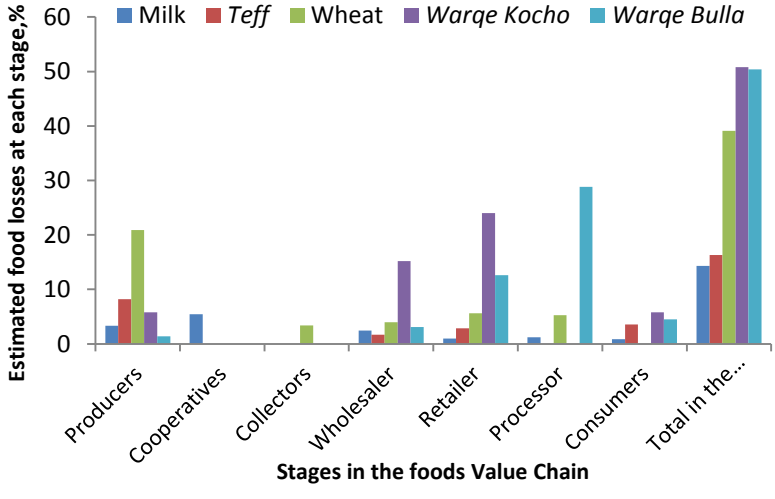

Figure 13. Percentages of estimated losses of the food commodities studied at different stages in the value chains

In wheat case, it was reported that 21% of wheat produced was lost at farm level. This was the highest loss point across the chain; hence farmer level was the loss hot-spot point for wheat similar to *teff*. Storage problems on the field and problems during the harvesting activities such as bad weather conditions

and poor harvesting mechanisms were reported as major causes of the farm level high losses of wheat.

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 old and traditional equipment.

3.2.2 Causes of losses

The chain actors believed that there were a number of factors causing food losses in these food value chains. Figure 14 and 15 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 14).

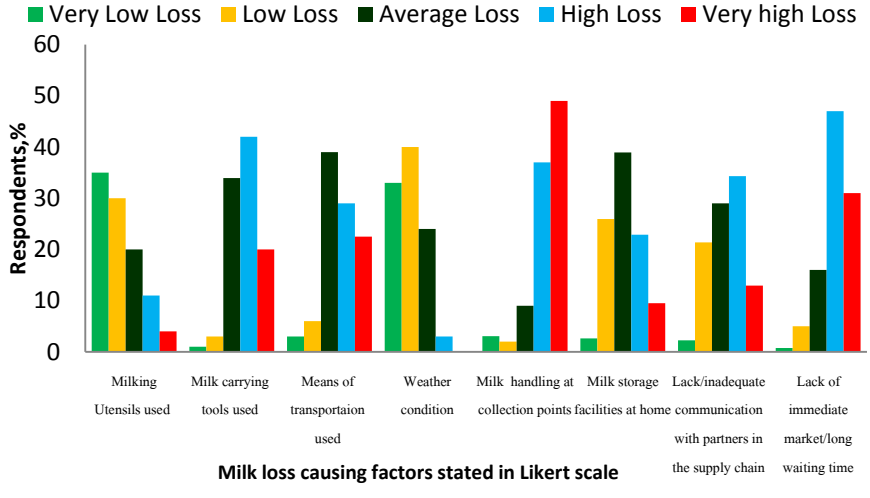

Figure 14. Factors perceived by chain actors as causing milk losses in the value chain of milk

Farmers' perceived causes of post-harvest losses of *teff* in the area were presented in Figure 15. According to the result threshing process was listed as the top problem causing the losses.

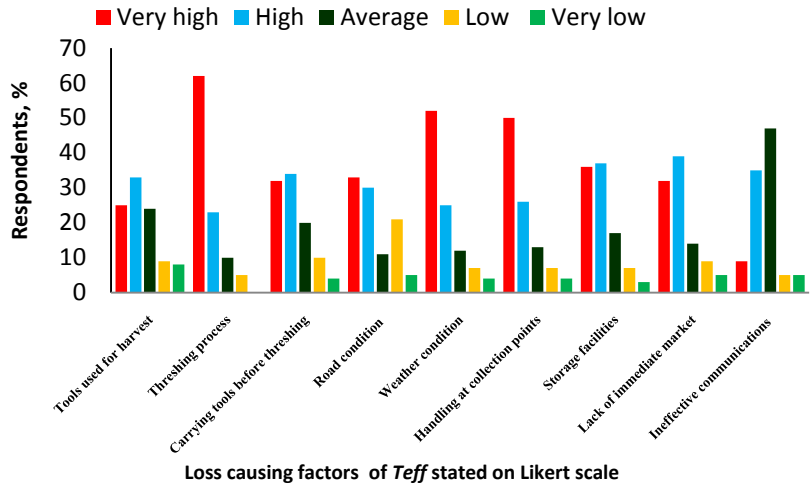

Figure 15. Factors perceived by farmers as causing post-harvest losses of *teff*

In Figure 15, very high and high losses are symbolized by red and light blue. According to the farmer respondents, the main factors that cause post-harvest losses of *teff* in order of severity are: the threshing process, weather conditions, handling at collection points, storage facilities, and lack of immediate market, carrying tools before threshing, road conditions, harvesting tools used, and ineffectiveness of communication in the chain.

Tobit model analysis was used to assess factors determining post-harvest losses of *teff* (Paper II) and wheat (Paper III) at farmer stage in the area and the results were presented in Table 1 and Table 2.

According to the results in Table1, 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 1, having a female household head resulted in an increase of *teff* post-harvest losses by about 9%. As household size increased by one active labour person, the amount of post-harvest losses decreased by about 4%. Note that, in the model the 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 by 100kgs increased the amount of post-harvest losses by about 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 by a kilometre increased *teff* post-

harvest losses by 11.3% and post-harvest loss of *teff* could 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 1. *Result of the Tobit model analysis of factors affecting teff post-harvest losses*

***PHL* causing factors**	**Coefficient**	**Standard error**
Sex of household head	-0.0894**	0.0413
Age of household head	0.0008	0.0010
Family size	-0.036*	0.0150
Distance to nearest market	-0.113***	0.0037
Education status of household head	-0.007	0.0365
Farm size	0.00241	0.0158
Output	0.044***	0.0012
Weather	0.015*	0.0138
Storage facility	0.069**	0.0147
Transportation	0.0339	0.0150

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

As in *teff* case, several variables (*see* Table 2) were imagined to influence the level of post-harvest loss of wheat by sampled producers. Among the variables included in the analysis three variables: volume of production, storage facility on filed and at home, and weather conditions significantly contributed to wheat losses in the area at 1% statistical significance. According to the result on Table 2, an increase in a 100 kg of wheat production resulted in an increase in post-harvest losses of 5.18 kg or 5.18% post-harvest losses. The existence of good storage facility could save 4.06 kg of wheat per quintal, and occurrence of bad weather conditions during harvesting time contributed to 1.36 kg of wheat losses per quintal. At 5% statistical significance, many of the variables appeared contributing to post-harvest losses of wheat in the area. These include sex of household head, active-age household family size, livestock holding, and distance to the nearest market place, conditions during threshing process, and transportations conditions (*see* Table 2).

Table 2. *Tobit model results of factor affecting post-harvest loss of wheat*

Variables	***Coefficients***	***Standard error***
Sex of household head	-0.12**	0.043
Age of household head	-0.001	0.001
Active-age family size	-0.013**	0.005
Education status of household head	0.031	0.035
Volume of production	5.18***	0.44
Livestock holding	-2.88**	2.68
Wheat Farming experiences	-4.31*	0.25
Distance to nearest market	1.255**	6.22
Access to credit	-4.68	6.22
Type of seed used	0.76	6.14
Weather conditions	-1.36***	0.0027
Conditions during Threshing process	-0.39**	0.022
Transportations' conditions	-0.035**	0.044
Storage facility on field and at home	- 4.06***	0.005

****, **, and * are statistically significant at 1%, 5% and 10% significance 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*.

3.3 Farmers' value addition decisions

In the *teff* chain (Paper II), 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). 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. 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%.

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

3.4 Value share

In wheat chain (Paper III), by taking into consideration the marketing costs and estimating the marketing and profit margins, the marketing performance of the markets and the value share among the chain actors were analysed. Table 4 indicated different types of marketing cost related to the transaction of wheat producers, collectors, wholesalers, retailers and processors, and the benefit share of each chain actors.

Each of the wheat value chain actors adds value to the product as the product passes from one actor to another. In a way, the actors add value to the wheat through improving the grade by sorting, cleaning or create space and time utility. Compared to producers, traders' (collectors, wholesalers, and

retailers) value addition share was not as significant. Producers involved in land preparation, planting, input application, weeding, harvesting, and transporting the produce to the market place, which could be imagined as more than 50% of the value added to the wheat.

However, their share both in marketing margin and profit margin were below 50%, i.e., 29% in market margin and 16% in profit margin (Table 4). The traders who involved only in a limited value addition practices were getting nearly the same share in profit margin with the producers. Collectors', wholesalers', and retailors' share in profit margin were 13%, 14%, and 6% respectively, which sums to about 33% of the profit margin. That means by simply buying from the producers and selling to next chain actors, with very few additional value addition tasks such as sorting, storage, and transporting, traders took 33% of the total profit margin. While producers, doing all the work of producing wheat and bearing the associated risks, took only 16% of the profit margin.

More importantly, the highest profit share goes to processors, where 51% of the profit margin accrues. This indicated that how much processing-based value addition is important in wheat chain studied. Though from the cost list the processors seemed inefficient, the high price of wheat flour resulted in high share of profit margin for the processors. As can be seen from Table 4, the flour price (selling price at the processor) was more than the wheat retail price by 35%. The majority of the processors in the area were engaged in converting the wheat to flour and selling the flour to bakeries and food companies. Few of them, have engaged not only in selling flour but also have bakeries as side business.

The disproportionate share of benefits is the reflection of power relationship among actors. The price change from producers' price to consumers' price is 33% at retail price and 80% at processor (flour) price. Looking at the last two rows in Table 4, one of the cost items that made producers profit margin at small amount is the level of high post-harvest loss at this stage, without considering post-harvest loss as a cost farmers' profit margin grows to 28%. This is still small share compared to the imagined proportion of value added by the producers. However, this is important information that shows how the producers were suffering from post-harvest losses. Note that the price and cost information in Table 4 were averages from all assessed markets for each category and are not constant throughout the year. Furthermore, whereas the costs for other chain actors were directly obtained from the actors on a per 100kgs bases, the production cost for producers were calculated by relating the average resources applied to a hector of land and average production per hector for the sampled producers.

Table 4. *Wheat cost structure and profit shares among the actors*

Items(birr/100kgs)	**Producer**	**Collector**	**Wholesalers**	**Retailers**	***Processors**	**Sum**
Purchase price	_	750	850	900	950	3440
Production cost	450	_	_	_	_	450
Production or purchase cost (a)	450	750	850	900	950	3890
Marketing costs:						
Labour	30	5	5	4	20	64
Transport	20	10	10.5	2	25	74.5
Overhead cost	4	3	2	1	10	20
Packaging materials	5	5	5	5	10	30
Tax	_	-	4	3	7.5	17.5
Total marketing cost (b)	59	23	26.5	15	72.5	206
****Post-harvest loss as a cost (c)**	157.50	24.45	36.6	56.7	67.5	342.75
Total cost/TotC/(a+b+c)	666.50	782.45	913.10	971.7	1090	4438.75
Selling price (SP)	750	850	985	1000	1350	4775
Market margin(SP-a)	300	100	135	100	400	1035
Share in market margin	0.29	0.10	0.13	0.10	0.39	1
Profit margin (SP-TotC)	83.50	67.55	71.90	28.30	260	511.25
Share in profit margin	0.16	0.13	0.14	0.06	0.51	1
Profit Margin without considering post-harvest loss as cost	241	92	108.5	85.5	327.5	854.5
Share in profit margin without considering post-harvest loss as cost	0.28	0.10	0.13	0.10	0.39	1

*For simplicity, 100kgs of wheat is assumed to be converted to 100kgs of wheat flour,

**Level of post-harvest loss was estimated at each stage of the value chain

3.5 Governance structure and supply chain performances

In Paper VI, an attempt has been made to empirically verify:

(a) the relationships between factors existing in the business scenario (transaction costs, transaction specific investments, uncertainty, and trust) and the chain actors' governance structure choice (spot-market, relational, and formal contractual), and

(b) how the chain actors' governance choice determines the supply chain performances (efficiency, flexibility, quality and safety, level of dairy losses, and level of integrations) of dairy chains in Ethiopia.

The factors potentially influencing supply chain governance structure choice were identified and assessed by reviewing literature in the area of transaction cost economics in relation to the supply chain management. The summary result of literature was used to develop testable hypotheses and tested using the structural equation modelling. The following few paragraphs discuss these results from Paper VI.

3.5.1 The governance-performance interface hypotheses

After review of literature in areas of transaction cost economics, relationships and supply chain management the following hypotheses were developed and tested.

HA: The scenarios in the supply chains affect chain actors' supply chain governance choice

HA1: Transaction costs explain chain actors' supply chain governance choice

HA2: Transaction specific investments explain chain actors' supply chain governance choice

HA3: Trust explains chain actors' supply chain governance choice

HA4: Uncertainty explains trust

HA5: Willingness to collaborate explains trust

HA6: Collaborations advantages explains trust

HA7: Uncertainty explains chain actors' supply chain governance choice

HB: Chain actors' governance choice predicts supply chain performances

HB1: Supply chain governance choice explains efficiency of the supply chain

HB2: Supply chain governance choice explains flexibility of the supply chain

HB3: Supply chain governance choice affects level of dairy losses in the supply chain

HB4: Supply Chain governance choice affects quality and safety in the supply chain

HB5: Supply chain governance choice affects the level of integrations in the supply chain

3.5.2 The supply chain governance- performances interfaces

Figure 16 presents the model result of the Amos path analysis. As can be read from the path analysis (Figure 16), the associated standardized regression weights (Table 5) most of the hypotheses, except two, were confirmed as formulated. Note that the significance threshold for that study was set at the p value of 0.05. In Tables 5 and 7, the p values given as three stars (***) refers to ($p < 0.001$).

As can be observed from Figure 16, transaction costs, uncertainty, and trust appear to influence chain actors' choice of the governance structure.

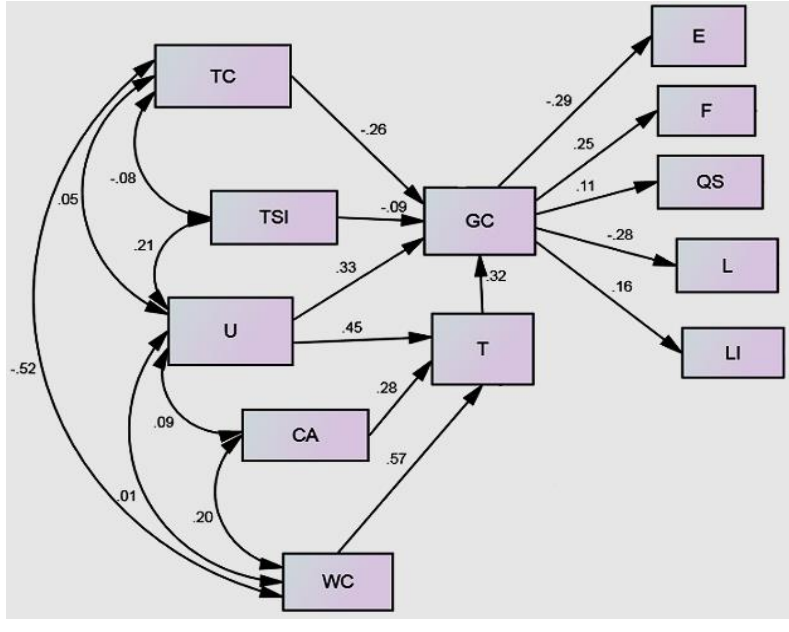

Figure 16. SEM path analysis standardized estimate results

From the result in Figure 16, trust, on the other hand, is predicted by collaboration advantages, uncertainty, and willingness to collaborate.

Chain actors' governance structure choice effect on supply chain performances also become evident based on the result in Figure 16. According to the result presented in Figure 16, chain actors' governance structure choice affects almost all the supply chain performance indicators selected in the study.

The results in Figure 16 show how the factors in business scenarios influences chain actors' governance structure choice and how the chain actors'

governance structure choice in-turn influences supply chain performances. However, in order to test the hypothesis using the SEM results, we need to view the standardized regression weight estimates of the study which are presented in Table 5. Based on the results in Table 5, the hypotheses tests result are presented in Table 6.

According to the result in Table 5, it is visible how factors are influencing the other factors with the level of significances. Accordingly, collaborative advantage (CA), willingness to collaborate (WC), and uncertainty (U), predict trust (T) significantly ($p < 0.001$). Similarly, trust, transaction costs (TC), and uncertainty predicted chain actors' governance choice (GC) significantly ($p < 0.001$).

On the other hand, efficiency (E), Flexibility (F), and level of losses (L) are significantly ($p < 0.001$) predicted by chain actors' supply chain governance choices. Governance choice also explained the level of integration at ($p < 0.05$). Contrary to the hypotheses, transaction specific investments (TSI) fails to predict the chain actors' governance choice. Similarly, chain actors' supply chain governance choice has no significant influence on the situation of dairy quality and safety (QS) issues in the chain as per the results in Table 5.

Table 5. *Supply chain governance structure and performance interfaces-Regression Weights*

	Related variables			**Estimate/ coefficient**	**P**
Factors determining Trust	T	<---	CA	.276	***
	T	<---	WC	.566	***
	T	<---	U	.446	***
Factors determining chain actors' supply chain governance choice	GC	<---	TSI	-.094	.086
	GC	<---	T	.316	***
	GC	<---	TC	-.262	***
	GC	<---	U	.328	***
The impact of supply chain governance choice on supply chain performances	E	<---	GC	-.286	***
	F	<---	GC	.254	***
	QS	<---	GC	.107	.116
	L	<---	GC	-.278	***
	LI	<---	GC	.159	.019

Table 6. *Tests of governance-performance interfaces hypotheses*

No	Hypotheses content	Decision-based on model result
HA1	Transaction costs explain chain actors' supply chain governance choice	Confirmed
HA2	Transaction specific investments explain chain actors' supply chain governance choice	Not confirmed
HA3	Trust explains chain actors' supply chain governance choice	Confirmed
HA4	Uncertainty explains trust	Confirmed
HA5	Willingness to collaborate explains trust	Confirmed
HA6	Collaborations advantages explain trust	Confirmed
HA7	Uncertainty explains chain actors' supply chain governance choice	Confirmed
HB1	Chain actors' supply chain governance choice explains efficiency of the supply chain	Confirmed
HB2	Chain actors' supply chain governance choice explains flexibility of the supply chain	Confirmed
HB3	Chain actors' supply chain governance choice affects level of dairy losses in the supply chain	Confirmed
HB4	Chain actors' supply chain governance choice affects quality and safety in the supply chain	Not confirmed
HB5	Chain actors' supply chain governance choice affects the level of integration in the supply chain	Confirmed

On the other hand, Table 7 shows the correlations among the factors explaining governance structure choice with the respective p values. According to the result in Table 7, it was found that the correlations between transaction costs (TC) and willingness to collaborate (WC) was negative and significant ($p < 0.001$). Similarly, the positive correlations between collaborative advantages (CA) and willingness to collaborate (WC) and between transaction specific investments (TSI) and uncertainty were found significant (U) ($p < 0.05$). The correlations among the other factors presented in Table 7 were not significant at p-value of 0.05 or less.

Table 7. *Correlations among governance determinant factors*

Related variables			Estimate/coefficient	P
TC	<-->	TSI	.082	.158
TC	<-->	U	.047	.484
TC	<-->	WC	-.522	***
CA	<-->	WC	.195	.001
U	<-->	WC	.012	.852
CA	<-->	U	.094	.160
TSI	<-->	U	.214	.002

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 on the four 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 geographical positions of Ethiopia and its potential for wheat production is an opportunity to be used to develop and integrate to global wheat value chain from Ethiopia
- The marketing role of cooperatives in the food 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
- Unproportioned share of benefits among the chain actors

- Weak market performances(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 described 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 could be 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*, wheat, 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' decisions on value addition

The Probit model was employed to assess farmer-level value addition decisions in the *teff* chain. Note that the value addition decisions for the 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, pesticides, 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 as 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 about 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 could all 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 The value share

The assessment of wheat value chain for value share among the chain actors found unproportioned distributions of benefits among the chain actors (Paper III). The producers who were in a position of adding the highest portion of value to the wheat received only 16% of the profit margin. The traders (collectors, wholesalers, and retailers) jointly shared 33% of the profit margin and the remaining 51% of the profit margin goes to processors.

In the new business arena, the concepts of integration and collaboration among the business partners of the food supply chains have got high importance. Business today are in the era of inter-network competition hence self-standing business competition does not give much sense (Lambert and Cooper, 2000).

The 'resource or market based competitiveness', which argues business success as a function of access to crucial resources or as a result of existing market power is now considered as a traditional view and was replaced by 'relational view'.

In the 'relational view', business organizations that form smart partnerships, strategic alliances, and efficiently coordinate the value chains will have competitive advantage (Junqueira, 2010).

Critical to the relations view is the quality of relationships among the business partners in the food chains. The partners need to develop trust on each other and a trust on the idea that overall profitability of the chain will lead to individual firms' profitability. Where majority of the benefit obtained in the

process is going only to few actors in the chains, as in this case study, it is rarely possible that trusting food value chain can be developed. Hence, it needs to design and implement a policy for fair benefit sharing among all chain actors in the assessed wheat value chain.

There should be a systematic support to the poor, particularly to the producers in order they get share of the benefit in proportion to the value they contributed. That will improve benefits not only to the producers but also to the whole chain actors by stimulating higher production and efficient and effective marketing along the food value chains.

4.4 The interface of governance choice and performances

4.4.1 Transaction costs versus supply chain governance choice

In this study, it was found that transaction cost explained chain actors' supply chain governance choice significantly ($p < 0.001$). This is in line with the theories dealing with transaction costs. Transaction costs explain governance choice due to the fact that businesses in the supply chain always intend to make rational choices; even though, the choices are limited by bounded rationality.

Williamson (1979) stated that governance structures are regarded as part of the optimization of rationalization problem as the shift from one structure to another may permit a reduction in transaction costs. The author discussed this matter in relations to possibilities of reducing the costs associated with writing complex contracts, costs of effecting the contracts, and reducing of ex-post opportunism.

In this study, governance structure choice varied among three alternatives: spot-market, relational, and formal contractual governances. As it was reported in Figure 16, most of the hypotheses that were stated as factors expected to predict chain actors' governance choice were confirmed (*see* Table 6). The meaning of this result could be understood from transaction costs analysis theories.

According to the result, the chain actors who shifted from spot-market to relational or formal contractual governance structures have managed to reduce transaction costs.

Note that in this case the supply chain governance structure choices were reduced only to three options based on the results that these were the only prominently existing choices in the dairy chain studied. However, different authors discussed different governance structure types. For instance, Gereffi *et al.*, (2005) identified five value chain governance types based on the complexity of transactions, ability to codify transactions, capabilities in the supply base, and degrees of explicit coordination and power asymmetry.

For more details of possible governance forms and associated issues one may refer to the works by (Gereffi *et al*., 2005, Gyau and Spiller, 2008, Hobbs, 1996, and Williamson, 1999b).

4.4.2 Transaction specific investments versus governance choice

Another important concept in the process of chain actors' governance structure choice is transaction specific investments or asset specificity. Even though transaction specific investments were not confirmed directly affecting the chain actors' governance choice in this study, different studies (e.g. Rokkan *et al*., 2013) discussed transaction specific investments as important components of firms' marketing strategies, hence, explain chain actors' governance choice.

On the other hand, most literature in transaction cost economics also considered transaction specific investments as strongly correlated to transaction costs (Ji *et al*., 2012; Loader, 1997; Hobbs, 1996). This could be the reason that the transaction specific investments hypothesis was not directly confirmed by this study since it is correlated to the other factors. Of course, from the general knowledge in multiple regression analysis, if two predicting variables are strongly correlated, none of them may give a significant unique variance in explaining the dependent variable. In this case, the correlation between transaction specific investment and uncertainty was found positive and statistically significant. The prediction of uncertainty on trust is also statistically significant implying that transaction specific investments and trust could be correlated. These could be the reasons that transaction specific investment's direct prediction on governance choice was not confirmed.

4.4.3 Trust versus chain actors' supply chain governance choice

In this study, it was found that trust significantly predicated chain actors' supply chain governance structure choice. Trust was also significantly predicted by uncertainty, willingness to collaborate, and collaboration advantages.

Many authors (Ghosh and Fedorowicz, 2008; Kwon and Suh, 2005; Delbufalo, 2012; Panayides and Lun, 2009; Fawcett *et al*., 2012; Sahay, 2003; Laeequddin *et al*., 2010) discussed trust as the vital issue influencing relationships in supply chains. In summary of the literature, trust determines many aspects including how chain actors choose the governance structure. On the other hand, trust develops over time and is dependent on scenarios in the business environments. It is also very important to note the bidirectional influence of factors in food value chains on each other. For instance, it is logical to think of trust also influences willingness to collaborate. Fawcett *et al.*, (2012) argued that trust is the foundation for building and sustaining

collaborative alliances in the supply chain. According to the authors, trust in the supply chain can grow if and only if partners wish to build it and are willing to invest in its signals that create mutual confidence.

The willingness to collaborate and the collaboration advantages discussed in this paper are concepts similar to partners' wish to increase trust and willing to invest to build it in Fawcett *et al*., (2012) work, and it is also in confirmation of it. Panayides and Lun, (2009) also argued trust is a significant predictor of relationships performances. On the other hand, Kwon (2005) used SEM and assessed factors explaining trust and how trust influences the degree of chain actors' relationships commitments. According to the author's work, trust significantly and positively influenced the degree of chain actor's relationships commitments. The present study is in confirmation of this work as trust was found significantly predicted by uncertainty and it predicted chain actors' supply chain governance choices significantly.

4.4.4 Uncertainty versus supply chain governance choice

In general, the lesser uncertainty, the better would be the trust on relationships among chain actors. On the other hand, high uncertainties may create poor relationships along the supply chains. Therefore, uncertainty has paramount implications in chain actors' supply chain governance choice.

In this study, it was found that uncertainty significantly predicted the level of trust among the chain actors. Moreover, uncertainty significantly explained chain actors' choice of governance structure. Note that the estimates of uncertainty to trust and governance choice were both positive due to the fact that higher score was given for lesser uncertainty (Paper VI). This means, as the uncertainty increase trust decrease. Higher uncertainty is associated with spot-market governance choice.

Uncertainty in supply chain governance choice is mainly related to the information asymmetry caused opportunism problem, which is associated with the supply chain relationships management as discussed by Hobbs (1996).

4.4.5 Supply chain governance choice versus performances

This study showed chain actors' supply chain governance choices significantly influencing the supply chain performances. Efficiency, flexibility, level of losses, and level of integrations were significantly explained by chain actors' governance choice. These were the expected results as per the formulated hypothesis and are more or less consistent with few researchers' work.

For instance, Gyau and Spiller (2008) stated that in spot-market governance, chain actors are likely to act opportunistically in order to maximize short-term benefits and may incur costs to safeguard themselves

against these opportunistic behaviours (increase transaction costs), hence the overall economic performance of the supply chain may be reduced. The authors showed that chain actors' governance structure choice significantly predicted efficiency (cost reduction) and overall financial success.

Wisner (2003) noted increasing the value of products and services to customers in the supply chain with the lower costs as the main aim of SCM.

Stevens (1989) discussed the importance of supply chain integrations in general as crucial issues for businesses competitiveness. According to the authors, businesses could obtain benefits resulting in increased market share with a lower assets base if they recognize and manage the inter-relationships between component parts of the supply chain and ensuring a good fit between its design and operation and with their competitive strategy.

Prajogo and Olhager (2012) noted that long-term relationship between supply chain partners has a vital role in enhancing the logistics integrations activities concerning the flows of physical materials and information and ultimately improves competitive performances.

The finding of the present study was found consistent with these studies. It could be argued that, through improving relationships in the food supply chains, it is possible to improve supply chain performances including reducing food losses along the supply chain continuum.

4.5 Potential of SCM to improve the food chains

In this thesis, the supply chains of four food commodities were analysed focusing on post-harvest losses and value chain performances. Effort was made to identify the possibilities of improvements in the food supply chains, particularly through the use of supply chain management approaches. In the following paragraphs, few empirical evidences from previous literature were discussed in relations to the present study.

Padmanabhan, (1978) discussed the white revolution in India where 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.

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 about 10% cost savings with the SCM approach

compared with the existing approaches without the SCM scenario. The study noted inefficiencies as a result of non-integrated logistics activities in the studied food chains could be alleviated and overall cost could be reduced thorough integrations of the supply chains.

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, particularly the information cost aspect
- Potential for improving customer satisfaction.

Francesconi *et al*., (2010) noted the potential emergence of supermarket-led dairy supply chain in Ethiopia, which may bring positive impacts to 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, if not well-managed.

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 dairy farmers in Ethiopia.

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 practices 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.

In confirmation to these notes in previous paragraphs, this thesis found situations, where poor handling practices at collection points (Paper I), distance to the nearest markets (Paper II and III), the nature of logistics (Papers, I-V), and the nature of governance and relationships in the supply chain (Paper VI) significantly contributed to high losses of foods along the food supply chains. Hence, establishing small markets near to the farmers' settlement could reduce these 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.

On the other hand, 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.

The inefficiencies as a result of non-integrated logistics activities in the studied food chains could be alleviated and overall cost could be reduced. Application of SCM could also alleviate the self-orientated logistics service uses, hence reduce costs, improve the flows of information among chain actors, reduce transaction costs, and 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 them to invest more (pooled resources) on establishing better logistics facilities that will serve the whole chain. This was also well-confirmed in Paper VI where the relatively established chain actors manage to improve efficiency, flexibility, and level of integrations while reducing food losses.

SCM could also serve to alleviate the opportunistic behaviour and unproportioned share of benefits in the food chains (Papers III, VI), which could compromise quality. For instance, 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 (Paper I). Through SCM, it is possible to establish quality standards that will be jointly monitored and controlled by the chain actors.

This thesis provides an indication of the importance of comprehensive food SCM that includes and benefits the whole 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 (e.g. producers who are imagined to contribute more than 50% of the value are only sharing 16% of the profit margin, Paper III).

This thesis also 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. The summary of major problems identified by this thesis work and the possibility for improvements through use of the SCM are presented in Table 8.

Table 8. *Summary of major problems in the studied food chains that could be solved using the SCM approach*

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. This can alleviate the problem of production technology.
Milk chain	Low milk production per cow per day Lack of access to improved cow breeds	
All chains	Small yield/productivity Lack of access to finance 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 altogether as a chain, Paper VI showed moving to relational or formal contractual relationships can improve efficiency, flexibility, level of integrations, and reduce food losses.
All chains	Relationships characterised by opportunistic behaviour Focus on own profit and lack of system thinking among the chain actors	
Wheat chain	Unfair share of benefits	
All chains	No strong trust-based relationships among the chain actors and no ultimate customer conceptualisation	
Milk chain	High transaction cost, low trust, and high losses associated with spot-market	

5 Conclusions and recommendations

5.1 Conclusions

In this thesis, supply chain management and postharvest losses of four major food commodities, milk, wheat, *teff* and *warqe*, in Ethiopia were analysed. The results showed that farmers, cooperatives/unions, processors, traders, catering institutions, and consumers were the major chain actors.

In the assessed food value chains, significant food losses were estimated along the supply chain continuum. The sum of the reported estimated losses from the total marketed products along the whole chains were 14%, 16%, 39%, and 50% for dairy, *teff*, wheat, and *warqe* foods (both *kocho* and *bulla*), respectively. Farmer stage for *teff* (8%) and wheat (21%), cooperatives for milk (5.5%), retailers for *warqe kocho* (24%), and processors for *warqe bulla* (29%) were identified as loss hotspots points across the chains. Poor handling practices at milk collection points, the threshing process in the *teff* chain, harvesting problems and bad weather conditions in the wheat chain, and poor packaging, display, and processing facilities in the *kocho* and *bulla* chains were the forefront factors causing the losses.

Using the Tobit model, distance to the nearest market and level of production were found to be the most important factors determining farmers' stage post-harvest losses in *teff* and wheat chains, respectively.

The Probit analysis identified attendance in formal education as most determining for value addition decisions in *teff* chain.

The assessments in wheat chain market performances identified unfair share of benefit among the chain actors. The producers who were in a position of adding the highest portion of value to the wheat received only 16% of the profit margin.

The assessment of the interfaces among the factors determining supply chain governance choice and supply chain performances identified the following important findings:

- Transaction costs, trust, and uncertainty significantly predicted chain actors' supply chain governance choice ($p<.001$),
- Uncertainty, willingness to collaborate, and collaborations advantages predicted trust significantly ($p<.001$),
- Chain actors' supply chain governance structure choice significantly explained efficiency, flexibility, and level of losses at ($p<.001$) and level of integrations at ($p<0.05$).

In all of the selected food commodities' supply chains, supply chain management approach was found relevant in alleviating many problems along the supply chains. Reducing food losses, improving the relationships among the chain actors, and enabling the use of coordinated logistics facilities were few of the potential of supply chain management approach identified in relations to the studied food supply chains.

5.2 Recommendations

In general, working towards supply chain management and relational view of business could be recommended based on the problems identified in the thesis work. The following points could be forwarded as recommendations for prioritized interventions:

- Establishing stakeholder platforms,
- Awareness creations to the chain actors on the intrinsic rewards from working in collaboration in the food chains,
- Use of food standard packaging and processing facilities,
- Coordinated logistics facility use (transportation and others),
- Technological solutions are highly required in production and postharvest activities of all the studied food commodities,
- Facilitating the enabling environment from GOs and NGOs,
- Strengthening/establishing farmers' cooperative associations, and
- Attention needs to be paid on how to improve trust among the chain actors, reduce transaction costs, and reduce uncertainty which in turn will have an improving effect on supply chain performances including reducing food losses in the food supply chains.

6 Future Research

Supply chain management has been discussed related to the idea of transforming agribusiness through networking and trustful partnership in food chains. However, SCM is a young science (for the first time used in literature in 1980s) that demands inquiries of its various perspectives. The discipline status of SCM has got different views. Ellram and Cooper, (2014) noted that some authors viewed SCM as a discipline, others as a discipline in its early evolution, others as a discipline with multidisciplinary nature, and some others even argued that SCM at the present status does not meet the criteria of discipline in a strict scientific sense. The authors made an intensive review of literature on conceptualizations of supply chain management and identified five perspectives regarding the way how SCM was viewed so far. These perspectives were the discipline view, the functional view, the process view, the philosophical view, and the governance structure view.
However, the authors noted the last three perspectives of SCM (i.e., SCM as: *a process*, *a philosophy*, and *a governance structure*) contributed to the theoretical and practical understanding and execution of supply chain management. According to the authors, issues related to supply chain efficiency which involves understanding and improving the activities in the supply chain management, inter-organizational linkages, sharing information, and sustainability issues are the *process perspectives* of SCM. On the other hand, SCM as *a philosophy* deals with the critical understanding and the value to the concept that SCM can add to competitive advantages. Supply chain orientation is the base for the SCM philosophical perspective. SCM as *governance structure* deals with the relationship issues and how that is managed including who controls various aspects of the supply chains.

For the SCM to grow and contribute to the organizations and the society, inquiries in the SCM perspectives for understanding and linking them is

essential (Ellram and Cooper, 2014). To this end, the role of research is critical. Particularly, the application of SCM to different industries serves this purpose.

The food supply chain is one sector where SCM could grow theoretically and serve practically. In this regards, researchers are expected to influence policy makers and food supply chain actors with empirical evidences.

This thesis attempted in producing some evidences in these perspectives of SCM by overall chain characterizations, relationships in the chain, and the interfaces among the variables in business scenario, the chain actors supply chain governance structure choice, and supply chain performances. Essentially, the process, philosophical, and governance structure perspectives of SCM were discussed with empirical evidence, particularly relating to food losses along the food chains.

In relations to this, the present study will have sensible contribution to the literature. Particularly, the comprehensive study on how the factors in the business environment influences supply chain governance choices, how the choices influence supply chain performances, the consideration of food losses as indicator of food supply chain performance, and the overall insight to SCM as an approach to reduce food losses could be considered as the original works of this study.

Related to this, sustainability, supply chain performances, social capital, information and other technologies, and logistical optimizations in relations to food supply chain management, within the supply chain management perspectives discussed above, are few of the topics that are considered as opportunities for further research.

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Appendix A. National and FAO Classification of food and economic commodities and live animals in Ethiopia (CSA, 2016)

Main category	National local codes	National nomenclature	FAO codes	FAO nomenclature
Crops	7	Teff	108	Teff
	3	Finger millet	79	Millet
	1	Barley white	44	Barley
	8	Wheat white	15	Wheat
	2	Maize	56	Maize
	6	Sorghum	83	Sorghum
	4	Aja	75	Oats
	5	Rice local	27	Rice
	13	Faba beans/Horse Bean	181	Broad beans dry
	15	Field peas	187	Field peas
	12	Haricot beans	176	Haricot beans
	11	Chick-peas	191	Chick-peas
	14	Lentils	201	Lentils
	16	Grass peas/Vetch	205	Grass peas
	18	Soya beans	236	Soya beans
	36	Fenugreek	723	Spices NES
	17	Gibto	210	Lupins
	25	Neug	339	Oil seed NES
	23	Linseed	333	Linseed
	24	Groundnuts	243	Groundnuts
	28	Safflower	280	Safflower
	27	Sesame	289	Sesame
	26	Rape seed	270	Rape seed
	57	Lettuce	372	Lettuce
	52	Head cabbage	358	Cabbage
	56	Eth. Cabbage	358	Cabbage
	63	Tomatoes	388	Tomatoes
	59	Chillie Peppers	401	Chillies Peppers
	69	Swiss chard	373	Spinach
	51	Beetroot	463	Vegetables NES
	53	Carrot	426	Carrot
	58	Onion	403	Onion
	60	Potatoes	116	Potatoes
	55	Garlic	406	Garlic
	64	Godere	136	Taro
	62	Sweet potatoes	122	Sweet potatoes

	84	Avocados	572	Avocados
	42	Bananas	486	Bananas
	65	Guavas	603	Fruit Tropical NES
	44	Lemons	497	Lemons
	46	Mangoes	571	Mangoes
	47	Oranges	490	Oranges
	48	Papayas	600	Papayas
	49	Pineapples	574	Pineapples
	71	Chat	674	Not Available
	72	Coffee	656	Coffee
	75	Hops	677	Hops
	74	Enset	149	Roots and Tubers NES
	37	Ginger	720	Ginger
	154	Sheep	976	Sheep
	156	Goats	1016	Goats
	166	Horses	1096	Horses
	168	Donkeys/ Asses	1107	Donkeys/ Asses
	167	Mules	1110	Mules
	158	Camels	1126	Camels
	161	Poultry /Chickens	1057	Poultry /Chickens
	164	Beehives	1181	Beehives
Product form Live animals				
Meat	159	Camel meat	1127	Camel meat
	152	Cattle meat	867	Cattle meat
	162	Chicken meat	1058	Chicken meat
	157	Goat meat	1017	Goat meat
	155	Sheep meat	977	Sheep meat
Milk	153	Cow milk, whole, fresh	882	Cow milk, whole, fresh
	160	Camel milk	1130	Camel milk
Eggs	163	Hen eggs, with shell	1062	Hen eggs, with shell
Honey	165	Honey	1182	Honey

Appendix B. Area, Production and Yield of Crops for Private Peasant Holdings 2014/15 (2007 E.C), Ethiopia, (CSA, 2015)

Crop	Number of holders	Area in Hectares	% Distribution	Production in Quintals	% Distribution	Yield (Qt/Hec)
Grain Crops	**14,159,734.00**	**12,566,239.98**	**100.00**	**270,396,048.03**	**100.00**	
Cereals	**13,346,462.00**	**10,152,015.05**	**80.76**	**236,076,624.38**	**87.30**	
Teff	6,536,605.00	3,016,062.55	24.03	47,506,572.79	17.58	15.75
Barley	4,095,273.00	993,938.74	7.92	19,533,847.83	7.23	19.65
Wheat	4,614,159.00	1,663,845.63	13.26	42,315,887.16	15.66	25.43
Maize	8,685,557.00	2,114,876.10	16.78	72,349,551.02	26.74	34.31
Sorghum	4,993,368.00	1,834,650.81	14.57	43,391,342.61	16.03	23.69
Finger millet	1,607,677.00	453,909.38	3.62	9,153,145.18	3.39	20.17
Oats/'Aja'	255,008.00	27,899.64	0.22	508,059.26	0.19	18.21
Rice	118,079.00	46,832.21	0.37	1,318,218.53	0.49	28.16
Pulses	**7,931,562.00**	**1,558,422.02**	**12.42**	**26,718,344.54**	**9.89**	
Faba beans	3,759,029.00	443,107.88	3.53	8,389,438.97	3.10	18.93
Field peas	1,663,488.00	230,667.20	1.84	3,426,367.80	1.27	14.85
White Haricot beans	970,630.00	126,195.69	1.01	2,021,192.52	0.75	16.02
Red Haricot beans	2,242,178.00	197,131.58	1.57	3,116,055.55	1.15	15.81
Chick-peas	1,081,755.00	239,755.25	1.91	4,586,822.55	1.70	19.13
Lentils	768,748.00	98,869.15	0.79	1,373,542.40	0.51	13.89
Grass peas	744,321.00	136,883.77	1.09	2,514,390.03	0.93	18.37
Soya beans	109,055.00	35,259.76	0.28	721,837.45	0.27	20.47
Fenugreek	523,227.00	20,524.42	0.16	251,286.63	0.09	12.24
Mung bean/"Masho"	62,377.00	14,562.00	0.12	140,676.54	0.05	9.66
Gibto	93,390.00	15,545.36	0.12	176,905.80	0.07	11.38
Oilseeds	**2,936,158.00**	**855,762.91**	6.82	**7,600,993.24**	2.81	
Neug	826,877.00	252,584.38	2.01	2,244,625.07	0.83	8.89
Linseed	810,657.00	82,325.78	0.66	831,305.05	0.31	10.10
Groundnuts	313,072.00	64,649.34	0.52	1,037,062.38	0.38	16.04
Sunflower	131,813.00	5,625.81	0.04	63,250.64	0.02	11.25
Sesame	867,347.00	420,494.87	3.35	2,887,700.79	1.07	6.87
Rapeseed	478,727.00	30,082.74	0.24	537,049.31	0.20	17.85

Vegetables	**5,762,200.00**	**139,717.15**	100.00	**5,954,004.03**	100.00	
Lettuce	32,279.00	114.14	0.08	*	*	*
Head Cabbage	364,315.00	4,541.48	3.26	289,189.96	4.86	63.71
Ethiopian Cabbage	3,421,976.00	31,385.65	22.45	3,267,608.99	54.89	104.28
Tomatoes	220,506.00	5,026.68	3.58	306,999.50	5.14	61.12
Green peppers	1,039,383.00	5,889.02	4.20	367,926.32	6.17	62.69
Red peppers	1,691,480.00	92,455.73	66.21	1,707,656.64	28.69	18.48
Swiss chard	99,917.00	304.47	0.22	*	*	*
Root Crops	**5,903,835.00**	**216,971.05**	100.00	**54,615,540.22**	100.00	
Beetroot	333,072.00	1,949.77	0.90	182,079.42	0.33	38.67
Carrot	159,136.00	3,697.27	1.71	142,970.14	0.26	101.35
Onion	705,877.00	22,771.88	10.52	2,307,451.89	4.23	136.85
Potatoes	1,288,146.00	67,361.87	31.13	9,218,320.70	16.90	*
Yam/'Boye'	314,237.00	3,717.39	1.71	*	*	*
Garlic	1,768,487.00	9,257.81	4.28	934,868.73	1.71	100.98
Taro/'Godere'	1,700,269.00	48,817.41	22.41	14,488,345.20	26.47	297.81
Sweet potatoes	1,729,229.00	59,397.64	27.33	27,015,989.97	49.47	456.56
Fruit Crops	**9,478,920.00**	**1,298,590.13**	**100.00**	**30,009,711.12**	**100.00**	
Avocados	1,382,199.00	13,798.04	1.05	536,977.64	1.79	39.61
Bananas	2,574,035.00	53,956.16	4.12	4,782,510.44	15.94	89.41
Guavas	331,529.00	2,830.24	0.22	39,322.77	0.13	13.92
Lemons	222,942.00	1,238.77	0.10	79,038.14	0.26	64.11
Mangoes	1,146,419.00	12,860.54	0.97	905,613.94	3.02	72.30
Oranges	454,707.00	3,298.97	0.25	314,276.98	1.05	96.50
Papayas	572,313.00	2,434.14	0.18	404,350.56	1.35	171.89
Pineapples	36,797.00	251.35	0.02	*	*	*
Chat	**3,066,655.00**	**249,358.02**	**19.16**	**2,758,345.28**	**9.19**	**11.10**
Coffee	**4,723,483.00**	**568,740.00**	**42.76**	**4,199,801.56**	**13.99**	**7.57**
Hops	**2,378,125.00**	**28,541.94**	**2.18**	**372,731.44**	**1.24**	**13.20**
Sugar-Cane	**1,270,627.00**	**30,296.16**	**2.32**	**15,612,347.12**	**52.02**	**519.41**

Enset/Warqe	**Number of Trees/plants/ Harvested**	**Production in Quintals**			**Yield (Qt/Tree)**		
		Amicho	**Kocho**	**Bulla**	**Amicho**	**Kocho**	**Bulla**
	98,002,435.00	**22,929,729.96**	**26,219,341.21**	**1,022,800.30**	**0.23**	**0.27**	**0.01**

"*" data not available

Appendix C. Total number of livestock and livestock products by type at the country level for the years 2009/10 and 2011/12 in Ethiopia (CSA, 2012)

Livestock And Product Type	2009/10 (2002 E.C)	2010/11 (2003 E.C)	2011/12 (2004 E.C)	Percentage change of 2010/11 over 2009/10	Percentage change of 2011/12 over 2010/11
Cattle	50,884,005	53,382,194	52,129,017	4.9	-2.35
Sheep	25,979,919	25,509,004	24,221,384	-1.8	-5.05
Goats	20,833,336	22,786,946	22,613,105	9.38	-0.76
Horses	1,995,306	2,028,233	1,961,949	1.65	-3.27
Donkeys	5,715,129	6,209,665	6,438,435	8.65	3.68
Mules	365,584	385,374	368,781	5.41	-4.31
Camels	807,581	1,102,119	987,006	36.47	
Poultry	42,053,263	49,286,932	44,893,009	17.2	
Beehives	4,598,226	5,130,322	4,993,815	11.57	-8.91
Honey (in kg)	41,524,967	53,675,361	39,891,459	29.26	-2.66
Cow Milk (in lit)	2,940,216,526	4,057,998,244	3,329,854,796	38.02	-25.68
Camel Milk	150,315,343	262,821,534	176,399,866	74.85	-17.94
Egg	78,065,930*	98,301,052	94,675,782		-32.88

"*" The amount of egg production for 2009/10 is only for represent indigenous poultry breed