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þÿ V A L U E C H A I N P E R F O R M A N C E IMPROVEMENT FOR ECONOMICALLY SUSTAINABLE TOMATO INDUSTRY DEVELOPMENT þÿ I N M E C H A W O R E D A

EDEN, ARAGAW ADDISU

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"VALUE CHAIN PERFORMANCE IMPROVEMENT FOR ECONOMICALLY SUSTAINABLE TOMATO INDUSTRY DEVELOPMENT IN MECHA WOREDA"

EDEN ARAGAW ADDISU

BAHIR DAR, ETHIOPIA

March 16, 2021

VALUE CHAIN PERFORMANCE IMPROVEMENT FOR ECONOMICALLY SUSTAINABLE TOMATO INDUSTRY DEVELOPMENT IN MECHA WOREDA

EDEN ARAGAW ADDISU

A thesis submitted to the school of Research and Graduate Studies of Bahir Dar Institute of Technology, BDU in partial fulfillment of the requirements for the degree of

Master in the production engineering and management in the faculty of mechanical and industrial engineering.

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Bahir Dar, Ethiopia

March 16, 2021

DECLARATION

This is to certify that the thesis entitled "Value chain performance improvement for economically sustainable tomato industry development in Mecha woreda" submitted in partial fullfillment of the requirements for the degree of master of science in Production engineering and management under mechanical and industial engineering faculty, Bahir Dar Institute of Technology, is a record of original work carried out by me and has never been submitted to this or any other institution to get any other degree or certificates. The assistance and help I received during the course of this investigation have been duly acknowledged.

Eden Aragaw	________	26/05/2013
Name of candidate	Signature	Date

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Approval of thesis for defense result

I hereby confirm that the changes required by the examiners have been carried out and incorporated in the final thesis.

Name of student Eden Aragaw Signature ______ Date 26/05/2013

As members of the board of examiners, we examined this thesis entitled "Value chain performance improvement for economically sustainable tomato industry development in mecha woreda" by Eden Aragaw. We hereby certify that the thesis is accepted for fulfilling the requirements for the award of the degree of Masters of science in "Production engineering and management".

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Bahir Dar University Faculty of Mechanical And Industrial Engineering

To all my family

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ABSTRACT

Sustainable development is the management and conservation of the basic natural resources through which organizational and technological changes are led to meet the present and future needs of humans. In developing and analyzing the solutions based on sustainable development principles a holistic approach needs to be adopted system dynamics has a vital tool for systemic analysis, and also it is an appropriate approach for perceiving problems and offering solutions. The aim of this study is to present a system dynamics model to analyze the existent dynamics in the value chain of the tomato industry. To achieve the mathematical equations and values of the model's variables, a simulation is carried out using the data gathered from the Mecha district, Amhara region, Ethiopia. The parameters of the model are selected and calculated considering the specifications of this case study. After modeling the system, Vensim simulation software has been employed, to measure the performance and to identify the leverage points of the model to improve the system; then, a set of scenarios have been proposed and tested through simulation to achieve an improved understanding of the system's dynamic behavior. Based on the scenario simulation result the model highlight the importance of direct tomato sell and the establishment of a fresh tomato market center to improve tomato producers' access to the market, increasing producers' profits and reducing post-harvest loss.

Keywords Sustainable development, System dynamics, Value chain performance, Tomato industry

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LIST OF ABBREVATIONS

CLD	Causal loop diagram
ETB.	Ethiopian birr
F&V	Fruit and vegetables
SFDs	Stock flow diagrams
SD	Sustainable development
SDM	System dynamics methodology
VC	Value chain(s)
VCA	Value chain analysis
VCP	Value chain performance
PHLs	Post-harvest losses

LIST OF SYMBOLS

Symbol	Description	Unit
N	Population size	People
E	Marginal error	%
N	Sample size	person

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CHAPTER 1

INTRODUCTION

1.1 Background

Agriculture is the backbone of every country's economic sector since it plays a major role in providing food for the population, employment opportunities, export earnings and high contribution to the nation's Gross Domestic Product(Neha & Praveen, 2014). In the world, agriculture employs about 40% of the active population globally and it persists to be a strategic sector in the development of most developing countries where more than 60% of the population in sub-Saharan Africa, Asia and the Pacific is highly dependent on it (Sinamics, 2014).

Ethiopia's agricultural sector plays an important role in the socio-economic development of the country. As in many developing countries in Africa and elsewhere, agriculture plays a major role in Ethiopia's economy and the livelihood of its people; it contributes almost half of the GDP, about 85% employment of the labor force, accounts for about 90% of export values (Fanos, 2015). The main sub-sectors of agriculture are food crops, horticultural crops pulses, livestock and poultry.

1.1.1 Tomato Industry in Ethiopia

Tomato (Solanum lycopersicum L.), is the most widely grown vegetable in the world being recognized as a reach source of vitamins and minerals. It is also among the most important vegetable crops in Ethiopia.

In Ethiopia there is no definite time recorded regarding the introduction of cultivated tomato. Today farmers are interested in tomato production more than any other vegetables for its multiple harvests, which result in high profit per unit area. It is an important cash-generating crop to small-scale farmers and provides employment in the production and industries. Tomato production gives an opportunity for production of high value-added products and increase small holed farmers' participation in the market. In the areas where irrigation was available farmers have access to the market. Tomato production is a major source of cash income for the households. Tomato products were supplied to the local markets. Tomato production and marketing were the major sources of livelihood for a large number of farmers, transporters, middlemen and traders in the area (Yemane, 1967)

1.1.2 Industry Development Challenges

The total production of this crop in the country has shown a marked increase (District & Kahsay, 2016), because it became the most profitable crop providing a higher income to small scale farmers compared to other vegetable crops. However, tomato production is highly constrained by several factors especially in developing nations like Ethiopia. The national average of tomato fruit yield in Ethiopia is often low (125 q/ha) compared even to the neighboring African countries like Kenya (164 q/ha) (FAO Production Year Book, 2004). Current productivity under farmers’ condition is 90 q/ha.

Major tomato production constraints include pests, drought, shortage of fertilizer, and the price of fuel for pumping irrigation water. Survey respondents cited opportunities for boosting horticulture production that include increased market integration, the need for intensive production in response to increasing population pressure, farmers' awareness of the benefits, the current outreach program in relation to supportive government policy, and limited water harvesting. Major constraints relating to marketing of tomato crop include lack of markets to absorb the production, low prices, a large number of middlemen, a lack of marketing institutions safeguarding farmers' interest, lack of coordination among producers to increase their bargaining power, imperfect pricing system, and a lack of transparency in market information system mainly in the export market.

1.1.3 The Value Chain Approach to Sustainable Industry Development

Agri-food industries are characterized by chains of business through which products flow to consumers. These chains result from a complex series of interrelated and interdependent activities involving businesses ranging from primary producers to final consumers According to Mitchell et al. (2009), sustainable development should be a core element of the value chain approach because such an approach can lead to consumer satisfaction, economic viability, contributions to society and environmental preservation.

1.2 Statement of the Problem

The production of fresh tomato constitutes an important production activity for producers in mecha woreda. However, the producers' market access is weak and inconsistent and producers earn lower profit margins as compared to other chain actors (local collectors, wholesaler, and retailers)., this situation affects negatively the prices paid by the customers. Yet, there is a lack of cooperation and integration in the market as well as the value-added chain. This is mainly because of lack of cooperation horizontally and vertically. In the face of these problems, it is important to study alternatives for improving value chain of tomato so as to bring sustainable economic development for the production sector. Therefore, this study adopts system dynamics approach to analyze and improve the tomato value chain for evaluating sustainable development options for tomato industry.

1.3 Objective of the Study

1.3.1 General Objective

- ❖ The main objective of the study is to analyzed and improve the performance of tomato value chain for sustainable development using system dynamics approach.

1.3.2 Specific Objectives

- ❖ To investigate the existing structure and performance of tomato value chain
- ❖ To identify the dynamic process in tomato value chain
- ❖ To use system dynamics, approach to evaluate tomato value chain improvement interventions for economic sustainable development.

1.4 Scope of the Study

Firstly, this study mainly deals with the tomato industry of Mecha woreda, which has its own dynamics due to its location and the institutional structure within which it operates. Hence, generalizations made based on the findings of the present study may have limited application in the other settings. secondly, the study is confined to only one dimension of sustainable development that is the economic dimension. Lastly, lack of previous studies relating to value chains and sustainable development, particularly in the case of tomato is limiting factors for comparative analysis and discussions of the result.

1.5 Significance of the Study

First, to the best of the researcher, studies made so far in Ethiopia with the objective of improving value chain performance for sustainable development of tomato industry are almost negligible. As a result, this study makes a number of contributions towards extended research in the area of value chain approach for sustainable industry development in Ethiopia. Second, it helps other researchers as a source of reference and as a stepping stone for those who want to make further study on the area afterwards.

Finally, it gives all stakeholders in the area the opportunity to gain deep knowledge about the causal relationship of value chain performance and industry sustainable development. The results of the system dynamics approach can be used to help managers and decision makers in order to find policies and decisions that are profitable and can be applied well within a certain period of time.

1.6 Thesis Organization

Figure 1.1 summarizes how the thesis has been organized into five Chapters, and how these Chapters are linked each other. Chapter One presents the background of the research in terms of an overview of tomato industry and constraints upon its development. It shows the importance of developing sustainable agri-food industries and the effectiveness of using a value chain approach and system dynamics modeling for industry development. The problem statement, the objectives this study seeks to achieve, significance or justification for the study and limitation of the study are also presented in this Chapter (that is chapter one). In Chapter Two, relevant literature on sustainable development, the value chain approach and systems thinking and system dynamics modeling are outlined.

Chapter Three elaborates the study's research methodology and identifying an appropriate methodology to fixing its objectives. Chapter Three also describes various research methods employed for data collection and analysis and procedures employed to ensure the study's model validation. Chapter Four presents the results and discussion part of the thesis. The final Chapter that is chapter five, contains conclusions from the study findings.

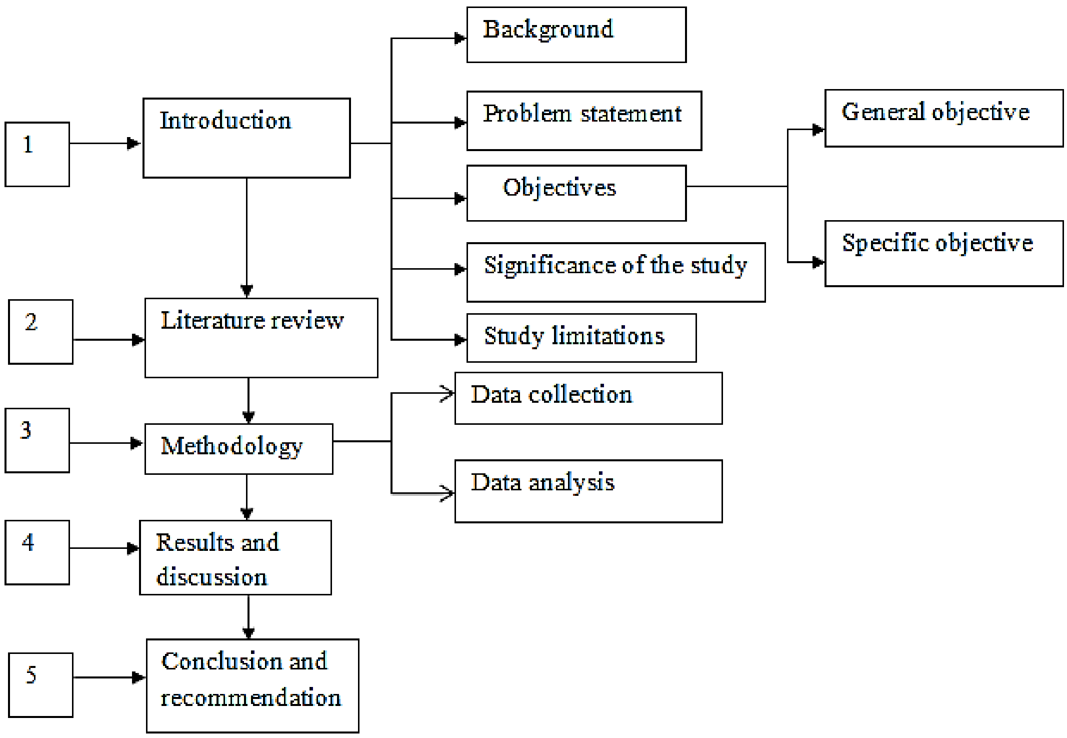

Figure 1.1 Thesis organization

CHAPTER 2

LITERATURE REVIEW

2.1 Sustainable Development

Sustainable development is commonly defined as meeting the needs of the present without compromising the ability of future generations to meet their own needs (Alam, Fatima, & Butt, 2007). According to the Brundtland Commission, sustainable development is about meeting the needs of the present without compromising the ability of future generations to meet their needs.

Sustainable development is defined as a concept of development that meets the needs of the present without compromising the ability of future generations to meet their own need. Sustainable development in the agrifood settings is more complex and challenging (FAO).

Sustainable development is the main concept of development and agriculture has enormous economic, environmental and social impact in the modern world therefore the development of this sector is linked with all three mentioned dimensions of sustainability. As global economy, social and technological development processes are still expanding, the analysis of new and specific forms, present in business is necessary in agriculture as well in order to achieve sustainable development of agriculture sector.

Sustainable development has been an interesting issue lately. Perhaps in light of the fact that there is a lot of uncertainty on the best way to accomplish it. There are studies done on sustainable economic development in system dynamics approach.

Sustainable development is a concept that integrates environmental, economic and social interests in a way that allows today's needs to be met without compromising the ability of future generations to meet their own needs.in agriculture and agri-food sector, sustainable development calls for ways of producing and processing food that protect or enhance the natural resources, which support agricultural production, are compatible with surrounding natural systems and processes, contribute to the economic and social well-being of all citizens, ensure a safe and high-quality supply of agricultural products and safeguard the livelihood and well-being of agricultural and agri-food businesses, workers and their families.

Sustainable development is commonly defined as meeting the needs of the present without compromising the ability of future generations to meet their own needs (Alam et al., 2007). All industries, including the Agrifood industry should contribute to the mission.

2.1.1 Dimensions of Sustainable Development

In the literature, sustainable development is often defined in terms of its three dimensions such as economic, social and environmental dimensions. In 1994, Elkington coined the term 'Triple Bottom Line' (TBL), and later, in 1995, he came up with the '3Ps' (people, planet and profit) to denote these three dimensions (Mark-herbert, Rotter, & Pakseresht, 2010)These three dimensions of sustainable development are briefly discussed in the following sections.

A. Environmental Dimension

The good health of the natural environment is vital for the current and future economic and social development of mankind. The commonly held view is that economic and social sustainability rely on environmental preservation (Diesendorf, 2017).Nevertheless, in pursuit of rapid economic growth, humanity has grossly miscalculated the nature and importance of this natural capital (both renewable and non-renewable) for present and future generations (Strategy, Dyllick, & Hockerts, 2002). Consequently, the world is now confronted with threatening environmental issues such as climate change, resource degradation and depletion, emission of pollutants and loss of biodiversity.

The environmental dimension of sustainable development calls for comprehensive management and redesigning of organizational processes and practices in a way that minimizes the environmental impacts of human report that initially businesses adopted environment sustainability practices simply to meet compliance requirements. However, more recently they have recognized the importance of compliance with environmental measures in order to meet their own organizational objectives.

B. Social Dimension

A Commonly accepted definition for the social dimension is not available, largely because there is no consensus on what is to be understood by the social', in the first place. Indeed, what defines the 'social' is determined by the underlying theoretical framework. Sustainable development is a normative concept which involves trade-offs among social, ecological and economic objectives, and is required to sustain the integrity of the overall system. This is usefully formalized in terms of a social welfare function which is based on an aggregate of individual preferences and, as a prerequisite of intergenerational equity and overall system integrity, on a set of sustainability constraints. While the concept of sustainable development (SD) generally refers to achieving a balance among the environmental, economic, and social pillars of sustainability, the meaning and associated objectives of the social pillar remain vague (Ciegis, Ramanauskiene, & Martinkus, 2009).

C. Economical dimension

Economic gain is the primary objective of all stakeholders involved in business activities. Korten (2011) suggests that this desire for productive investment is a natural condition. The economic dimension of sustainable development mainly involves profits, relationships and financial incentives, and the economic viability of individuals and businesses. It is argued that this dimension operates around efficient management of financial, tangible and intangible capital in order to achieve an organization's financial growth (Themes, Sustainable, & Chains, 2014)

Recently, the economic dimension of sustainable development is increasingly being implicated in the growing importance of value adding activities in business organizations. Adding value to production involves efficient management of all resources for the benefit of business stakeholders (Jamali 2006; Closs et al. 2011). It is argued that businesses should endeavor to improve their economic gains through value creation; by managing costs in their supply chain and making adjustments to their strategies (Diesendorf, 2017)

2.2 Value Chains

Different concepts and definitions of the value chain have been used in the literature, however the most common and popular definition is the one given by (Kaplinsky & Morris, 2000b) 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 value chain consists of actors who actively participate in the different nodes of the chain and who maintain dynamic relationships. It also involves the enabling environment, including policy-makers, service providers, and civil society, all of which impact on the value chain in different ways(Thinking, 2017).

2.2.1 Sustainable Industry Development through Value Chain Approach

Agri-food industries are characterized by chains of business through which products flow to consumers. These chains result from a complex series of interrelated and interdependent activities involving businesses ranging from primary producers to final consumers (Collins 2009; Gagnon 2012; Flynn & Bailey 2014).

Past development operations in agrifood have mainly focused on increasing agricultural production, whilst often ignoring the market and livelihood drivers involved. However, production activities are part of a wider network of interdependent businesses and it is therefore essential to examine them within the Value Chain as a whole. Value Chains are considered here as a sequence of production and income generation processes from the initial primary production to its end use and as a system of actors orientated towards the market. They are a major channel for agricultural development due to their capacity to create economic value and employment (Dabat & Orlandoni, 2018).

In literature, it has been suggested that sustainable development objectives in agri-food industries can be achieved by systematically integrating economic, social and environmental dimensions into all value chain activities and processes (Fritz & Schiefer 2008; Baldwin & Wilberforce 2009; Wognum et al. 2011). There are also evidence that environmental and social initiatives, such as improvements in packaging, better warehouse work conditions and more fuel-efficient transportation, can help to attain sustainable development objectives in value chains operating in any industry (Yakovleva 2007; Carter & Rogers 2008). For example (Mitchell, Keane, & Coles, n.d.) argues that value chain approach can lead to consumer satisfaction, economic viability, contributions to society and environmental preservation therefore sustainable development should be the main component of the value chain approach.

2.2.2 Value Chains in Agri-Food Industries

The industries in the agri-food sector are characterized by chains of businesses that operate to fulfill the food requirements of consumers (Collins 2009; Gagnon 2012). These chains encompass interrelated activities ranging from input supplies to farmers through to the consumption of food products (Pimbert et al. 2001; Silva & Filho 2007). In these chains, each stage involves functions and activities that contribute to the overall goal of making agri-food products available to consumers. The major objective of participants in these chains is to satisfy consumer needs in order to generate profits (Bertazzoli et al. 2011; Gómez et al. 2011). Figure 2.2 illustrates the typical structure of an agri-food industry value chain.

2.2.3 Improving Value Chain Performance

The literature suggests that the development of sustainable agri-food industries does not require new set of practices. Improvements to existing value chain practices, in line with sustainable development requirements, can adequately solve all of the problems mentioned above (Hamprecht et al. 2005; Verbeke 2005; Faisal 2010; Godfray et al. 2010; Wognum et al. 2011).

Value chain performance can be used to understand the nature of links between local industries and global markets, and to analyze links in global trade and production. Wheeler and McKague (2002) stated that it provides insights into the way producers - firms, regions or countries are connected with global markets, which influences their ability to gain from participating in the global economy. Furthermore, it also helps to explain the distribution of benefits, particularly income, to actors that are participating in the global economy. This allows identification of policies, which can be implemented to enable producers to increase their share of the gains that globalization can result in (Kaplinsky and Morris, 2000).

Gibbon et al (2008) indicated that one of the main advantages of value chain performance is that it provides insight into the mode of insertion of producers in global value chains. Another advantage of value chain performance is that it addresses the nature and determinants of competitiveness, and shows that the determinants of income distribution are dynamic. This implies that competitiveness at a single point in time may not provide for sustained economic growth.

Effectively measuring and managing of value chain performance is a complex and difficult task. If performance measurement is to lead to long-term and continuous performance improvement, then different stages of the performance measurement and management process such as design of measurement system, their implementation, and identification of appropriate measures to be used are to be successfully implemented.

In the view of Chan *et al.* (2003), VCP can be measured using both qualitative and quantitative indicators. In the view of Lotfi *et al.* (2013a), measurement indicators like added values, efficiency, and customers' satisfaction can be used to measure VCP. The study by Simatupangb and Sridharan (2001) suggests the use of process efficiency, customer satisfaction and financial indicators. In their study on the relationship between VCP and members' linkages, Won Lee *et al.* (2007) measured performance using efficiency and effectiveness as indicators. Though various performance measurement indicators were proposed, they are all highly interrelated (Vickery *et al.*, 2003).

Some authors argue that improving the performance of agri-food value chains should involve the integration of sustainable development considerations into all activities of the chain (Geibler et al. 2010; Neven 2014). However, others make the point that achieving such a level of integration is complicated by the dynamic and complex nature of issues involved in value chain performance (Banson et al. 2014; Neven 2014). Hence, addressing these challenges requires knowledge about the existing performance of the whole chain as a system and an in-depth understanding of the underlying issues (Pullman et al. 2009; Geibler et al. 2010).

2.2.4 Value Chain Analysis

The value chain analysis (VCA) provides a rational and systematical framework to describe and evaluate the role and relationship of people and organizations. This includes understanding the material flow and added value activities between different stages of the value chain. The value chain analysis is also made up of people as the main focus that allows an understanding of their role, motivation and behavior in the context of the social, economic and environmental drivers (Mango et al., 2015).

2.2.5 Strengths and Weaknesses of Value Chain Analysis

VCA is a systematic analytical framework that goes beyond firm-specific and activity specific analyses. It is a broad and flexible methodology which provides a context that helps to understand the complexities around flow of products, services and information, the business environment, relations, and decision-making in the value chain. This understanding supports design and implementation of value chain interventions that can support smallholder participation (Rich et al. 2011). VCA enables analysts to take the point of view of any of the actors in the chain, such as (M4P 2008).

VCA is an interdisciplinary approach with economic, social, natural, and sometimes environmental aspects. The interdisciplinary approach strengthens the likelihood for achieving commercial viability, while at the same time resulting in social benefits. The analysis is based on fieldwork and primary data collection with key stakeholders. A multi-method approach is often used by combining primary surveys, focus group discussions, semi structured interviews, and secondary data sourcing. On the other hand, VCA is time-, place-, and commodity-specific, and may leave out important dynamic effects and system-related aspects. It provides a picture of the value chain but does not effectively capture the changes that happen over time, whether it is within a season or over an extended period of years. This is problematic when considering the long-term effects of interventions. Economies and systems may change rapidly; a snapshot of today may be irrelevant after some years from now.

A value chain intervention can also may have a positive or negative effect that are often not recognized or analyzed. An intervention in a specific node of the value chain can have effects on production, governance, economic, and marketing-related aspects, which will affect various actors differently. When aiming for sustainable value chain development, these are critical aspects to assess.

VCA is mostly based on qualitative analyses, apart from calculating profitability, the value added, and distribution of value. The analysis often identifies several opportunities for upgrading in different places in the value chain, but it does not offer a way of empirically measuring the performance of different intervention options along a host of criteria (economic, social, environmental, inclusiveness). This requires a more detailed microanalysis of the economic, production, and marketing systems and how they are linked and affected by decisions made at nodal level (Rich et al. 2011).

2.3 Systems Thinking and Modeling

2.3.1 Systems Thinking and System Dynamics

System thinking is a methodology that evaluates and recognizes the linkages and interdependence between elements that compose an entire system. A system as “any group of interacting, interrelated, or interdependent parts that form a complex and unified whole that has a specific purpose”. according to his point of view, a human body, schools, businesses, social institutions, communities and national economies, forests, and agricultural value chains are typical instance of a system (Kim, 1999) . A central tenant of systems thinking is that system structure drives system behavior; it is an endogenous perspective on behavior (Richardson, 2011). An important advantage of applying systems thinking is to identify high leverage intervention points in the system for sustained improvement and to avoid adverse reaction (Gemechdndbsisis, Struik, & Emana, 2012). Typical undesirable reactions include policy resistance, unintended consequences, and counter-intuitive behaviors (Forrester 1971a). Systems thinking can be seen as a language to understand model complex systems (Richmond, 1994).

2.3.2 System Dynamics

System dynamics (SD) is systems thinking model and a simulation methodology. It was invented by Jay Forrester and his colleagues at the Massachusetts institute of technology (MIT) in 1960s. System dynamics can analyze the relationship between different factors, obtain information on the feedback structure, function and behavior of the system and simulate quantitative data. Hence, SD is usually used when studying the relationships in the behavior of a system over time and its underlying structure and decision rules so as to provide an easier way to understand the overall system and work out various relevant policy scenarios to manage the system's dynamic evolution.

System dynamics was initially developed and applied to engineering and industrial systems to understand, visualize and analyze complex dynamic feedback systems (Forrester, Lane, Lane, & Sterman, 2011). This approach then further developed and later applied to understanding the dynamics of urban systems (Forrester 1970) and world systems (Forrester 1971b). The approach is now used in a wide range of disciplines such as economics, public policy, environmental studies, and management.

2.3.3 Systems Thinking and Modeling Tools

Systems' thinking is applied using a different method, from informal maps to formal models with computer simulations, often referred to as System Dynamics modeling. The most common ones are causal loop diagrams (CLDs), stock and flow diagrams (SFDs) and feedback loops. SD models and tools are used to visually portray, the relations and feedback structures of a system, and if quantified can be used to conduct computer simulations that examine the impact of alternative scenarios over time(Ullah, Hossain, Dayarathna, & Nagahi, 2020).

A Causa loop diagram is a qualitative map of a system that visualizes how different variables in a system are interrelated. CLDs are a good way to make mental models of the system explicit. The CLD consists of multiple feedback loops that change the state of the system when decisions are made. Feedback structures can consist of physical relations such as the flow of products, or social relations such as attitudes or the ways decisions are made. Feedback relations can be positive and self-reinforcing, or negative and self-correcting. Reinforcing loops (R) strengthen the direction of the change resulting in continuous growth or decline. Negative feedback loops, often called "balancing feedback" loops (B), counteract change and result in stabilizing the process of growth or decay to some equilibrium (Sterman 2000). For instance, a population of people increases by number of births, which is a reinforcing feedback loop since the number of births increases the population, and when the population grows, the number of births grow as well. This positive cycle of growth is counteracted by number of deaths, a balancing feedback loop. On the other hand, growing population increases the number of deaths, which reduces the size of the population. This example is illustrated using a CLD in figure below.

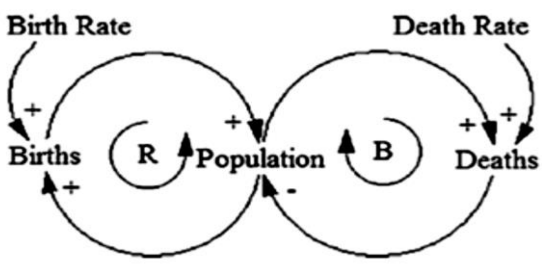

Figure: 2.1 Causal loop diagrams for population model with a reinforcing and balancing (Barlas, 2004)

Stock flow diagrams (SFDs) present an operational specification of the system by using stocks, flows, and converters to capture the different feedbacks present in a system. Stocks denote the state of the system, as well as anything that accumulates over time. These could be physical such as a population or money, or intangible such as knowledge. Flows are decision variables in the system and represent material or information that enters or leaves the stock over a period of time. Inflows enter into the stock and outflows leave to the stock (Meadows & Wright 2008; Sterman 2000), for instance, the number of births and deaths, or money that is earned and spent. A converter, also called a variable, influences one or several flows. It can be many different things, but always represents a relationship between something and the stock or the flow.

A simple SD model is illustrated in Figure 2.1, which is the stock and flow representation of the CLD of Figure 2.2. The total population, of people is a stock. The population increases by the inflow births. The number of births happening every year is determined by fertility, in Figure 2.2 named as “birth rate”. The population is reduced by the outflow, deaths, which are influenced by mortality, here called “death rate”. This makes up a balancing feedback loop, which counteracts with the reinforcing feedback loop of births. The dynamic interaction of these loops results in different forms of observed behavior over time. If the birth rate and the death rate are the same, there will be no changes to the total population. If fertility is higher than mortality, the population will increase, and vice versa. Delays are present in any system, and mean that the output, or outflow, lags behind the input. This could also be physical processes, such as the time it takes from a calf being conceived until birth, or the delay between planting and harvesting vegetables. An information delay arises if there is a delay between sending and receiving information (Sterman, 2000).

Figure 2.2 Stock and flow structure of a population

Systems thinking and modeling tools can be qualitative or quantitative. CLDs, including systems archetypes, are inherently qualitative. SFDs can be either qualitative or quantitative. The purpose of the analysis determines the type of model that is required (Vennix 1996). Qualitative SD models and associated tools highlight the structure of the system and the feedback relations, which provide insight into dynamic behaviors in the system. Qualitative SD models might be more accessible for various stakeholders without systems thinking experience, and can be useful when working with abstract concepts, such as power relations. CLDs can also be used as a way of summarizing and communicating SFDs. Quantitative SD models require more knowledge about modeling as well as data, which is not always available and can make the models speculative (Wolstenholme 1999). On the other hand, quantitative SD models enable simulation and testing of different scenarios over time. As a consequence of the different strengths and weaknesses of qualitative and quantitative SD models, it can be beneficial to use a mixed-methods approach, developing both a qualitative and quantitative model in a single project since they can easily and constructively build on each other (Wolstenholme 1999).

2.3.4 Application of Systems Thinking and System Dynamics Modeling to Value Chain Analysis

An advantage of SD modeling is that it can be extended to include almost any process or system. Value chains are complex systems composed of different nodes focusing not only the physical flow of products, but also involving economic, social, natural, environmental, and institutional aspects, which are highly interrelated. Both the VCA framework and the systems thinking and modeling framework are interdisciplinary. In SD modeling, the interdisciplinary aspects of VC systems can be represented through different subsystems. Micro-analysis of these systems can be combined through a meso-analysis that focuses on the feedback relations between the different subsystems of the value chain. Systems thinkers see both the generic system and the specifics of the system (Richmond 1993; Richmond 1994). These captures both upstream and downstream feedback in the value chain. It is, however, important to have a clear boundary in System Dynamics models. the boundary of system in company is usually well known as a result of each of the workers having roles within specific departments. However, in agricultural value chains, setting the boundary can be more challenging owing to long and complicated value chains (Voinov & Bousquet 2010).

Value chains are dynamic and change constantly due to complex feedback relations, which are poorly captured in traditional VCAs. VCA maps and describes the chain and what influences it. It usually concludes with suggesting different types of upgrading strategies and interventions, but cannot evaluate the costs and benefits associated with the suggested strategies. SD models address this by incorporating intended and unintended, as well as positive and negative effects of interventions. The conditions of participation in value chains can also be assessed using SD models. This is important information for policy-makers when considering different value chain interventions. This enables the conventional value chain approach to better address inclusion of smallholders and the effects on smallholders. Additionally, governance greatly affects value chain performance and is a central point in VCA. Different decision-making parameters such as power asymmetries, trust, and shared and individual goals can be included in an SD model as variables that drive change. SD models can be used for all four steps in VCA, focusing respectively on mapping, governance, upgrading, and benefits.

SD models can play an important role in developing quantitative models of value chains that provide greater guidance on the potential impacts of policies in value chains as compared to conventional qualitative value chain analysis (Kaplinsky & Morris, 2000) and (Rich, Perry, & Kaitibie, 2009).While conventional value chain analysis methods provide insights on the structure of the value chain and provide an important diagnostic tool, they are limited in their ability to prioritize or quantify the impact of possible policy interventions. As value chains are complex and dynamic, SD models provide an ideal laboratory to quantitatively model the processes and relationships inherent within the value chain that are informed by qualitative value chain analysis(Rich et al., 2009).

(Dizyee, 2017) developed a system dynamics model of the potato value chain as a means of assessing the dynamic impacts of different policy scenario options.

(Lie, Rich, & Burkart, 2017) developed Participatory system dynamics modeling for dairy value chain development in Nicaragua.

(Dizyee, Baker, & Rich, 2017) constructed an integrated system dynamics (SD) model that captures the feedbacks between the biological dynamics of cattle production, the economics of animal and meat marketing and trade, and the impacts that environmental pressures such as rainfall and animal disease have on the system.

(Dizyee, Baker, & Omore, 2020) This paper examines ex-ante impacts of two policy interventions that improve productivity of local-breed cows through artificial insemination (AI) and producers' access to distant markets through a dairy market hub.

(Bastan, Khorshid-doust, Sisi, & Ahmadvand, 2017),the aim of this study was to present an integrated and systemic model to analyze the existent dynamics in sustainable development of Iran's farming industry.

(Hidayatno & Rahman, 2012) this research developed a Jakarta Sustainable Urban Development Model using system dynamics to obtain interaction between economic, social, and environmental aspects of the capital city.

(Pande & Adil, 2019) in this paper, the framework suggested by them has been suitably modified to capture and organize sustainable practices relevant to manufacturing firms.

(Gautam, n.d.), this paper delivers a cohesive system dynamic model for the assessment of sustainable development indicators, which will assist to explore the alternative scenarios of access to market, human well-being, environmental degradation, pattern of energy consumption, environmental balance, sustainability, and quality of life.

A study conducted by Helene Lieand Karl M. Rich (2016) develops a SD model that represents the dairy value chain in Matiguás, Nicaragua. In this research a system dynamics approach was used to identify the dynamic process in the dairy value chain so as to assess intervention options and their potential effects on milk quantity and farm income. The conceptual system dynamics model was also presented in detail in this study, including the dynamic processes between herd dynamics, milk processing and sales, costs and revenues, and feed dynamics. However, the research did not highlight the impact of different scenarios that focus on, increasing the number of dairy cows, increasing the use of concentrates in the summer months, and increasing land used for improved pasture. But these aspects are critical to support decision-making among the various stakeholders in any value chain to add value and raise income.

2.5 The Tomato Industry in Ethiopia

Tomato (Lycopersicon esculent Mill.) is one of the most important edible and nutritious vegetable in the world. It ranks next to potato and sweet potato with respect to world vegetable production. It is widely cultivated in tropical, subtropical and temperate climates and thus ranks third in terms of world vegetable production (Gebisa Benti et al., 2017).

The introduction of tomato cultivation in Ethiopia dates back to 1935-1940 (Samuel et al., 2009), and currently it has significant economic importance for the country. It is grown in the lands that are 700-2000 m above mean sea level, with about 700-1400 mm average rainfall in different areas and seasons, in different soil characteristics under different weather conditions but with different levels of technology. The average yield of tomato in Ethiopia is low, ranging from 6.5-24.0 Mg ha-1 compared with average yields of 51, 41, 36 and 34 Mg ha-1 in America, Europe, Asia and the entire world, respectively (Faostat, 2010). Moreover, growers have been challenged by inconsistent production and low yields.

In Ethiopia, tomato is produced in the state and private horticultural enterprises, commercial farms and small farmers scattered in different parts of Ethiopia. It is produced mainly as a source of food and income both under rain-fed as well as irrigated conditions. Tomato is among the most important vegetable in Ethiopia (Jiregna et al., 2012).

According to Lemma et al. (2003) the total production of tomato in Ethiopia has shown a marked increase recently, indicating that it became the most profitable vegetable providing a higher income to small scale farmers compared to other vegetables. Currently the bulk of fresh marketable tomato is being produced by small-scale farmers. Farmers are interested in tomato production more than any other vegetables for its multiple harvests, which result in high profit per unit area.

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2.5.2 Tomato Industry Development Challenges

Though, the area planted to tomato and the production and export of the vegetable have increased significantly over time in Ethiopia, the tomato industry's performance is believed to be below its potential yet (Akhtar et al. 2013). While the industry has the potential to contribute significantly to sustainable development in Ethiopia, it is constrained by production, marketing and export related challenges that decrease the value of tomato to consumers and reduce the profitability of participants in tomato industry chains. In turn, these challenges impact on the industry's overall performance (Anwar et al. 2008; Kazmi et al. 2008).

Challenges facing tomato value chain include: production, processing and storage, marketing, funding, Research and Development (R&D).

The production constraints identified include: use of poor agricultural practices; lack of good quality seeds and over application of fertilizer and other insecticides by farmers. Other constraints include: high cost of critical production inputs such as irrigation equipment, machinery, fertilizer and pesticide, lack of experienced technical manpower in tomato production and management infrastructure. The lack of good quality seeds and non-adoption Agricultural Practice (GAP) result in poor yields and low productivity.

The perishable nature of tomatoes requires good transportation network and storage and adequate processing facilities. The limited access to these facilities has led to the loss of about 30-40% of the tomatoes produced in the country. The use of baskets instead of crates for storage and transportation causes heavy spoilage, low fluctuating prices and low tomato quality. High cost of storage materials has been a major problem leading to high wastage. The poor dissemination of research information on tomato storage and also the issues of pest and disease management and low productivity due to the use of unimproved varieties also affect tomato losses.

The market showed that price fluctuation resulted from the raw product availability changes during the season. The instability of prices implies that actors face difficulties in forecasting their revenue, leading to poor planning. Furthermore, the lack of knowledge or different ways of marketing, affects the marketing decision and production of the produce. The lack of a good marketing structure and marketing information is a major challenge that affects producer.

2.5.3 Overview of the Tomato Value Chain in Mecha Woreda

The presence of water resources for irrigation in Koga River, catchment area and availability of sufficient land could increase competitiveness of tomato producing farmers in North Mecha from the resource availability point of view. However, due to improper management practice, the farmers are not competitive in the central market, for example, to other producers in the Rift-valley.

Value chains for tomatoes are relatively unorganized, although there is some coordination in transactions based on the services that buyers provide to farmers. No links exist between farmers and formal tomato processors as in other Ethiopian regional states for the production of value-added products (e.g., the presence tomato paste processor in states such as Oromia. Following the typology of governance forms of Gereffi et al. (2005), most transactions of tomatoes follow a captive form of governance in which transactions between buyers and sellers are mediated by the provision of services (whether credit and/or storage) from the buyer to the seller, but where coordination of transactions does not depend on product attributes.

The study analyses the tomato value chains of Mecha district (Woreda) based on typical production, harvest and marketing parameters. Masaka district has the highest pig population density in Uganda with more than 50 heads of pigs per km2 (Uganda Bureau of Statistics, 2009). Most of the pork consumption occurs in per-urban Masaka. Demand for pork is reported to be highest during Christmas and Easter holidays. Pig trading in per-urban Masaka is significant, with smallholder farmers selling pigs for slaughter to a variety of intermediaries (live pig traders, collectors, and butchers) through uncoordinated spot-market transactions, based on oral agreements. Pig trading involves collection of pigs from individual pig farmers and bulking for sale or slaughter.

Table 2-1 Summary of literature review

Title, author(s), Year of Publication	Research Objective	Methodology	Limitation
Benchmarking Agri-Food Value Chain Performance Factors, (Samir Mili, 2017)	evaluating and comparing target VCs performance factors	Benchmarking	
Creating Sustainable Businesses by Reducing Food Waste: A Value Chain Framework for Eliminating Inefficiencies, (Gerry Kouwenhoven et al., 2012)	To propose value chain framework	Value chain approach	Quantification of the results that can be obtained using the suggested value chain framework was not done.

An evaluation of environmental sustainability in the food industry, (A. Del Borghi et al., 2014)	The present paper aims to present and discuss the results of a Life Cycle Assessment (LCA)	Life cycle assessment	
Modeling sustainable development, I. Moffatt, N. Hanley,		systems dynamic and input–output approaches	
Sustainable development of Agriculture, (Reza Ramazani Khorshid-Doust, Saeid Delshad Sisi and Alimohammad Ahmadvand, 2017)	to present an integrated and Systemic model to analyze the existent dynamics in sustainable development of Iran's farming industry.	System dynamics simulation	Lack of economic information about quantitative impacts of model parameters
Application of system dynamics for assessment of sustainable performance, (Shen L.Y. , Wu Y.Z. , Chan E.H.W., Hao J.L , 2003)	To develop simulation model to assess the sustainable performance of projects	System dynamics	

Research Gap: The previous studies use system dynamics approach qualitatively. But this study to quantify value chain analysis.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter provides a description of the methodology used in this study. specifically, the system under study is described to clarify the purpose of the study, and the approach used to conduct the study. first introduction and description of the system is modelled and simulated was given. Then, the modelling and simulation approach adopted for the study are discussed. The use of the collected data from the case study area is also discussed. A description of the steps involved in SD simulation modelling used in this study is also provided.

3.2 Description of The Study Area

This study is conducted in Mecha district which is located in West gojam Zone, Amhara National Regional State, Ethiopia. It is one of thirteen woredas found in West Gojam zone. It is located 30kms south of Bahir Dar town, the capital of Amhara region and its borders north Achefer in the North, South Achefer in the South and West and Yilmana Densa in the East. As in other parts of West Gojam, Mecha woreda has flat topography, which accounts for about 75% of the total are of the woreda.13% of the area is characterized as undulating topography, and the remaining 8% and 4% of the area are covered mountainous and valleys respectively. The altitude of the woreda ranges from 1,800 to 2,700 meter above sea level (Ayalew, 2018).

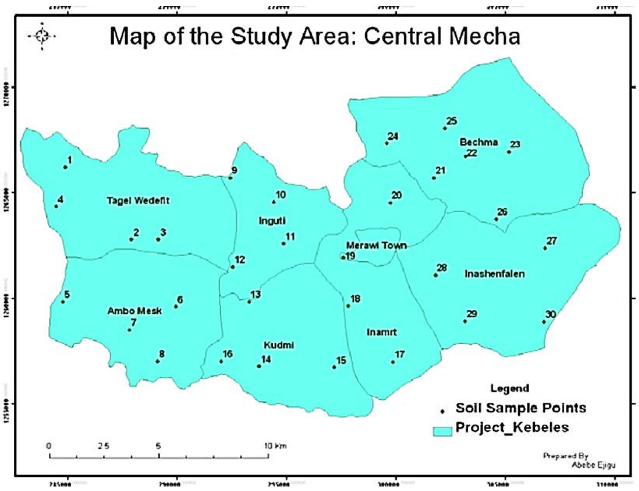

Figure 3.1 Map of the study area

3.2.1 Sampling and Sample Design

Prior to data collection, a preliminary survey was carried out to gain an overview of the study area. Officials from koga irrigation are consulted regarding the major tomato growing blocks. The population for this study constituted all farmers who produced tomatoes and traders who trade tomatoes for the 2019/2020 cropping season. A multistage sampling technique is used to sample farmers, local collector wholesalers, and retailers. At first, households within koga irrigation project are selected. Then from the selected households, a total of 99 representative respondents are selected based on the quota or proportionate system. In addition to producers, respondents are also purposively selected from collector, wholesalers, retailers and consumers from Merawi town.

3.2.2 Sample Size Determination

To determine the sample size for producer representatives, this study uses a simplified formula developed by Yamane (1967) at 95% confidence level and 10% non-response rate as provided below:

$$n = \frac{N}{1 + N(e)^2}$$

In mecha district there are 10498 tomato producers or farmers in 2011/12 production season. Hence the population size (N) is 10498 farmers. Confidence level (95%) and 10% marginal error are used to determine the sample size of the study. Therefore, the study’s sample size of farmers/ producers is: (Yemane, 1967)

$$n = \frac{10498}{1 + 10498(0.1)^2}$$

$$n = 99$$

Therefore, the sample size of farmers/ producer is 99 and 6 for local collector, 4 for wholesalers and 4 for retailers are randomly selected from Merawi market. Hence the total sample size of the study is 113.

3.3 Research Approach

In terms of the modelling and simulation method, this study uses system dynamics (Forrester et al., 2011), a methodology used for studying and managing complex feedback systems, particularly business and social systems. SD was developed initially as a means to provide quantitative and mathematically grounded insights to problems arising in industrial systems (Dizyee, 2016).

The selection of an SD approach for this study was based on its capability to overcome the limitation of Value chain analysis.

VCA is mostly qualitative and descriptive and it is therefore difficult to test or understand *ex-ante* the plausible impacts or outcomes that different interventions might have on these complex systems. An intervention will have both upstream and downstream effects, meaning that it can affect both the production and marketing features of the chain. These effects can be intended and unintended, and positive as well as negative, which can reduce the effectiveness of a specific intervention over time. Therefore, it is important to identify and use analytical frameworks that can provide a richer understanding of the impacts that different interventions and policies could have on the value chain and its participants.

System dynamics (SD) methods are means to address these limitations in traditional VCA. Systems thinking and modeling is a methodology for understanding the relationship between the structure of a complex system, such as a value chain, and its dynamic behavior over time (Sterman 2000). An SD model maps the material and information flows, processes, decision rules, relationships, and feedback effects that exist between actors operating within a complex system, such as a value chain. The methodology is interdisciplinary and can be used as a tool to test and analyze interventions and policies, as well as areas of potential policy resistance (Sterman 2000). Recent research on value chains has revealed the utility of this approach in agricultural and livestock systems in *ex-ante* testing of the potential dynamic impacts of feedbacks from different policy and technical interventions within the chain.

For example (Dizyee et al., 2017), developed an integrated system dynamics (SD) model that captures the feedbacks between the biological dynamics of cattle production, the economics of animal and meat. The model was used to run a series of scenarios associated with market liberalization and animal health shocks to quantify their impacts throughout the value chain. Three years later, these authors also develop a system dynamics model that examined ex-ante impacts of two policy interventions that improve productivity of local-breed cows through artificial insemination (AI) and producers' access to distant markets through a dairy market hub (Dizyee et al., 2020)

3.3.1 Data Collection

Mecha district (woreda) was used as a case study in this thesis to gain support for the study findings as well as to further validate the developed models for tomato value chain system. Moreover, some of the information and data collected from the study are useful in selecting the variables and the relationships among them to be used in the model development. data and information were collected through interviews with value chain actors.

A semi-structured interview was designed and used to collect primary data from tomato producers. Information's about issues such as tomato production, production costs price, and postharvest losses and its management and factors causing postharvest losses with respective economic description of respondents were covered. Interviews were done in local language (Amharic) in order not to create any language barrier. Key informant interview (KIIs) with regional research center experts (1), agriculture office managers (2), and development agents (DAs) at kebele level (6) was conducted to gather technical information in order to authenticate accuracy of information supplied by sample producers.

Secondary data were obtained from district council offices and electronic sources. Primary data were collected during field survey carried out between January and March 2020 using structured questionnaire, key informants' interview, direct observation and focused group discussion. The questionnaire was used to interview respondents to capture important information. data were also collected using field observation. In the field observation, estimation of losses was conducted by taking known quantity of samples across value chain in the study area. Some relevant data were gathered through examining secondary sources such as documents, reports and records maintained at the woreda office of agriculture.

3.4 System Dynamics Modelling Steps

The methodology of this study is based on the below general steps of system dynamics approach. This was first innovated by J. W. Forrester at Massachusetts Institute of Technology (MIT) in 1950.)

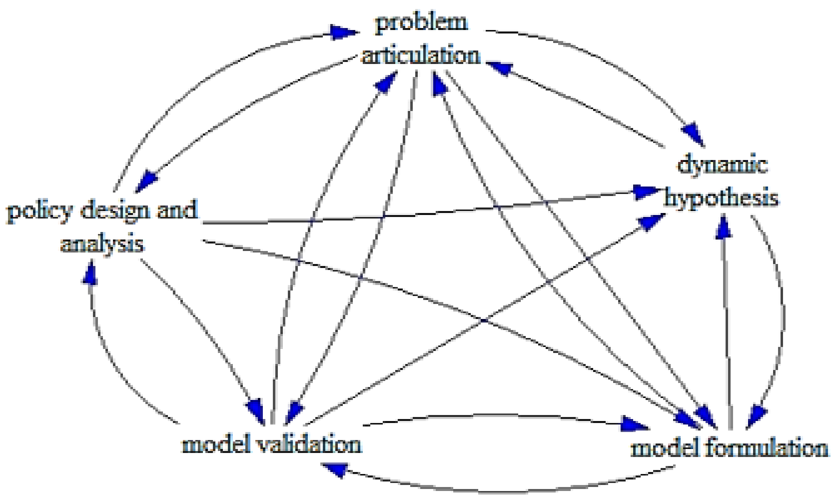

Figure 3.2 System dynamics modeling process; source; (Bala, Arshad, & Noh, n.d.)

3.4.1 Causal Loop Diagram (Qualitative Modelling)

The first step in the modelling process is represented by a description of the system structure through a Causal Loop Diagram (CLD).

3.4.2 Quantitative Modelling (Stock and Flow Diagrams)

After the CLD is developed, the next step is the quantitative analysis of the model. In order to study the quantitative aspects of the model, the variables used to develop the CLD are now defined and classified as: (1) level or stock variables; (2) rate or flow variables; and (3) auxiliary variables (Series & Sterman, 2003). The stock (level) variables determine the state of the system by accumulating the difference between the inflow and the outflow (Sterman, 2014) ,while the flow variables determine the physical flows in the system and generate change in the stocks, which is then used to make decisions. The auxiliary variables can be helpful to clarify the structure and process of the model. They usually represent constants or inputs into the model as well as converters or intermediate variables for the mathematical equations of the model.

A diagram called Stock and Flow (SFD) is used to represent the process of quantitative analysis of the model. With this diagram the dynamic relationships among stock, flow and auxiliary variables are Examined. Then, these relationships are used to establish mathematical equations in turn to run simulations of the model.

3.4.3 Model Validation

To validate the developed dynamic model, the model is tested with structure and behavior tests (Barlas, n.d.). The structure test assures that model structure agrees with relationships existing in the real-world. This validity test consists of the structure confirmation, parameter confirmation, and dimensional consistency tests (Barlas, n.d.)

Before conducting simulation of the model, validation and verification processes are performed. The validity for an SD model defines its capacity to reflect the structure and behavior of a real process model. In terms of the models testing for the validity process, this study followed the accurate study and analysis of model validity and validation in SD proposed by (Yassin, Researcher, & Azar, 2013). According to the authors, the structural and behavioral validity of a model should be established through tests, which are grouped as 'direct structure tests', 'structure-oriented behavior tests' and 'behavior pattern prediction test'. Direct structure tests, for which simulation is not required, compare each mathematical equation of the model with the available knowledge from a real system. These tests utilize several comparisons and include the form of the equations; the conceptual or numerical value of model parameters; the value of the output variable applying extreme conditions values to the input variables of the equations; and dimensional consistency for both sides of each equation.

The behavior validation of the model can also involve behavior pattern prediction tests. According to the authors, these tests determine whether the behavior patterns generated by the model reflect the major patterns exhibited by the real system. Specifically, they involve comparison between the model generated behavior and an observed behavior (Yassin et al., 2013).

3.4.4 Simulation of Scenarios and Evaluation

Modeling simulation begins with illustrating the relationship between variables in a causal loop diagram. The causal relation among the variables is entered according to the observation and literature review. The next step is to build simulation model in a stock and flow diagram based on the causal loop diagram. The stock and flow diagram are including mathematical equations for each variable according to the statistical data. Furthermore, verification and validation are conducted to compare the model structure and behavior with the actual system. The modeling is done using Vensim simulation software. After the model is declared valid the model is used to simulate the scenarios. The purpose of scenario simulation in this study is to improve the performance of the value chain.

CHAPTER 4

RESULTS AND SIMULATION ANALYSIS

4.1 Model Development

The modelling process in SD is characterized by a sequence of iterative activities and steps that involve continuous revisions and changes. the modelling process can be defined as a continual process of iteration among the problem articulation, the generation of hypotheses, data collection, model formulation, testing and analysis (Series & Sterman, 2003).

The development of a dynamic model requires several different, but connected, steps to map out the overall structure of the model. Vensim software is used to develop the SD model and to conduct the simulation.

4.1.1 Model Structure

The model consists of two main modules: tomato production and tomato marketing. Each section will be explained before presenting the dynamic interactions between the different modules. The model was constructed using the modeling software called Vensim PLE version 7.3.5. Each section was explained before presenting the dynamic interactions between the different sub modules as follows.

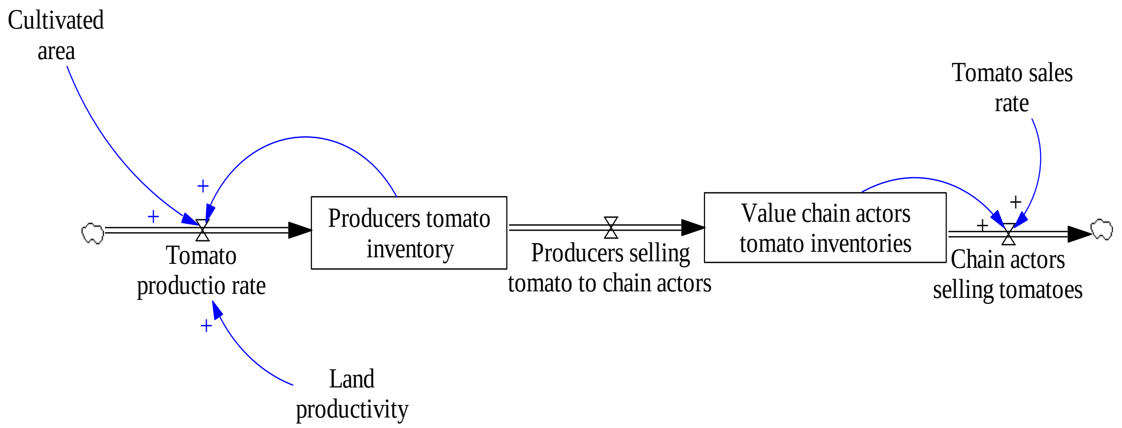

Figure:4.1 portrayal of tomato value chain model structure in Mecha district

The model includes two main sub-modules: production and marketing. The System Dynamics model is illustrated in Fig. 4.1. The main feedback loops and stocks in the system are highlighted. The central concepts of SD are stocks, flows and feedback loops. Stocks are accumulation of goods, services, or information (e.g. cultivated tomatoes in a field). Flows change over time (e.g. amount/volume of tomato harvested or sold over time). Feedback loops are circular connections that govern flows (Sterman 2000). Vensim PLE software is used to construct the qualitative value chain model (CLD) and the quantitative model (stock and flow diagram) in Fig. 1.

Each rectangular shape boxes (stock or levels) represents value chain actors' inventories of tomato. The thick arrows that link one stock to another are flows. Flows facilitate movement of tomatoes from producers to value chain actors (and among chain actors) to consumers over time. Flow of producers selling tomato to value chain actors represents volume of tomatoes producers sell to different chain actors over time; flow of tomato production rate represents quantity of new harvested tomatoes over time; flow of selling tomatoes represents amount/volume of tomatoes value chain actors selling represent volume of tomato sold to consumers over time. The thin arrows that link different model elements together are connectors. These connectors facilitate information flow among model components. Connectors are used to construct feedback loops and causal relationships among model components.

Feedback loops, regulate flows through causal relations among model elements. The label R and B denote a self-reinforcing (or positive) and a self-balancing (or negative) feedback loop, respectively. In a reinforcing feedback loop, the higher cultivation leads to more harvests which in turn results in higher.

4.1.1 Tomato Production Sub Module

In the tomato production module, total tomato production is the factor land productivity and area allocated to tomato (allocated area for tomato). Again, land productivity affected by various input variables as shown in the figure below.

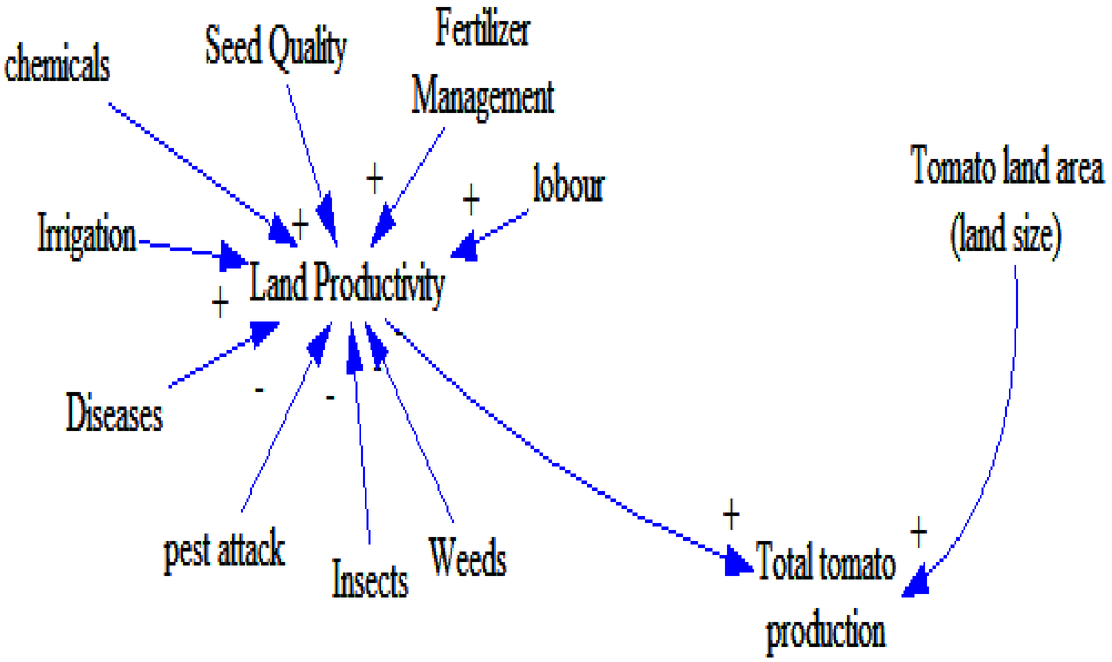

Figure 4.2. Tomato production sub module; source: developed by the researcher.

4.1.2 Tomato marketing sub module

The tomato flow module, shown in figure, illustrates the downstream activities in the tomato value chain in Mecha district.

The marketing channels among identified chain actors were mapped and quantified. Fig. 4.2 shows tomato value chain actors and marketing channels. Chain actors, at local market level, such as local collectors, wholesalers, and retailers trade fresh tomato. That is, they sell a percent of their tomato inventory as fresh tomato to consumers.

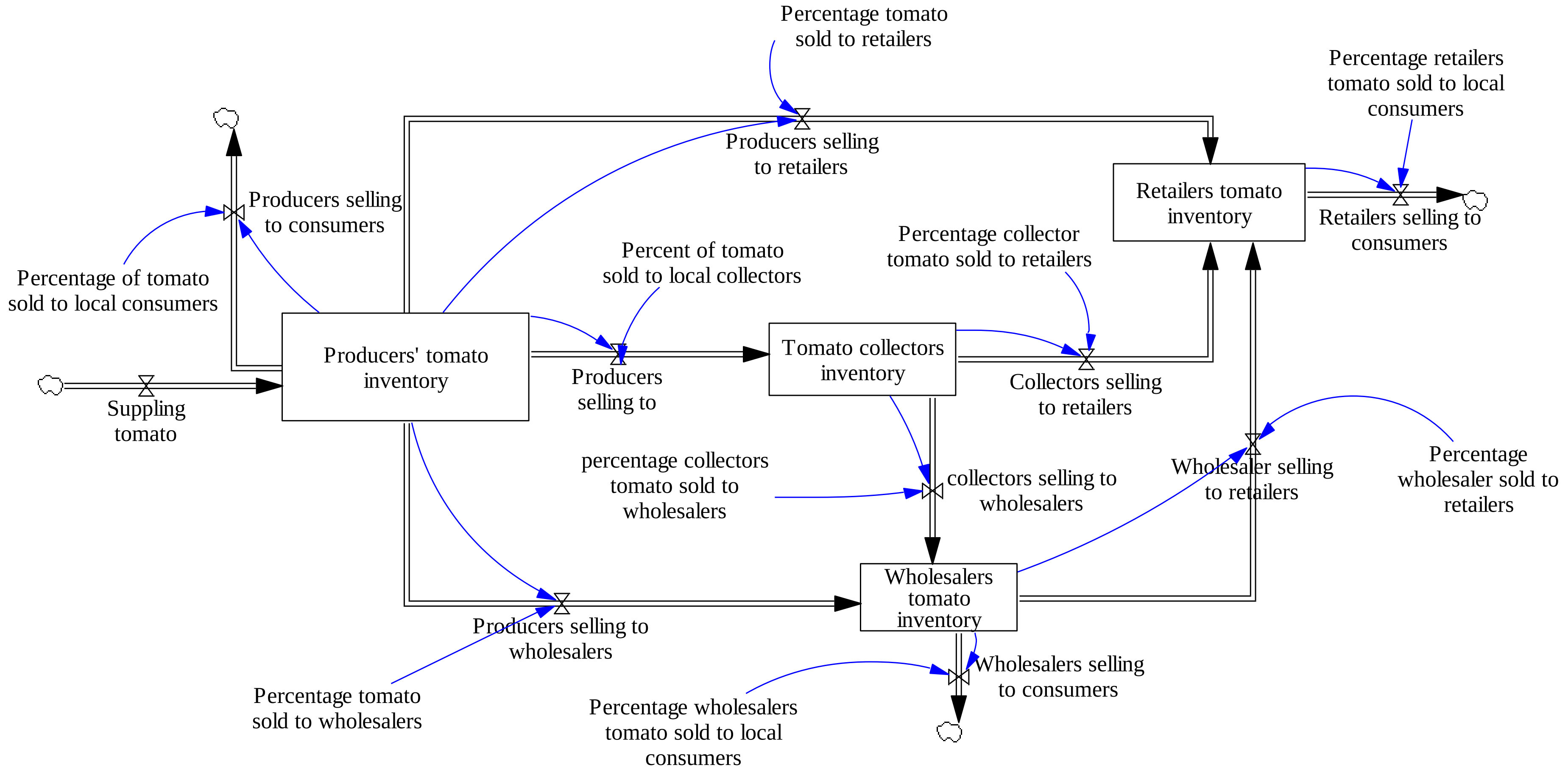

Figure 4-3 Fresh tomato value chain

In figure, above the stocks represent stock of tomato for producer and other value chain actors. Stocks change through inflows and outflows, which are governed by variables that regulate such flows. Connectors (arrows) between actors represent information feedback loops. Generally, tomatoes flow from producers to end markets by way of value chain actors, while money flows from end markets to producers along the value chain. Information flows occur in both directions.

4.1.3 Cost and Revenue Module

The costs and revenues module consists of variables. The main variable is tomato producers' profit, local collectors' profit, wholesalers' profit and retailers' profit, that results from revenues from fresh tomato sales and production costs and (producers) operational costs for the remaining actors. Revenues from tomato sales for producers include the total amount of tomato supplied to supplied to local collectors, wholesalers, retailers and consumers multiplied by the average tomato price. In this study. only one average tomato price is considered, but in reality, the tomato price varies between the actors. Total production costs depend on the average production cost per hectare and the total cultivated land. average production costs per hectare include costs for seed, fertilizers, chemicals, labor cost irrigation, water and maintenance. In the case of the study of this thesis tomato producers currently pay costs for irrigation, water and maintenance. Therefore, the cost for these inputs.

Variable tomato price represents producer's tomato price which is the same as collectors' tomato purchase price (and other chain actors who buy directly a portion of their tomato supply from producers). In a similar way, wholesalers tomato purchase price (e.g., the portion of wholesaler tomato supply sourced from collectors) is equal to collector's tomato purchase price (i.e. producers tomato price) plus collectors' operational cost per quintal. The same approach is applied for tomato purchase and sales price for other chain actors.

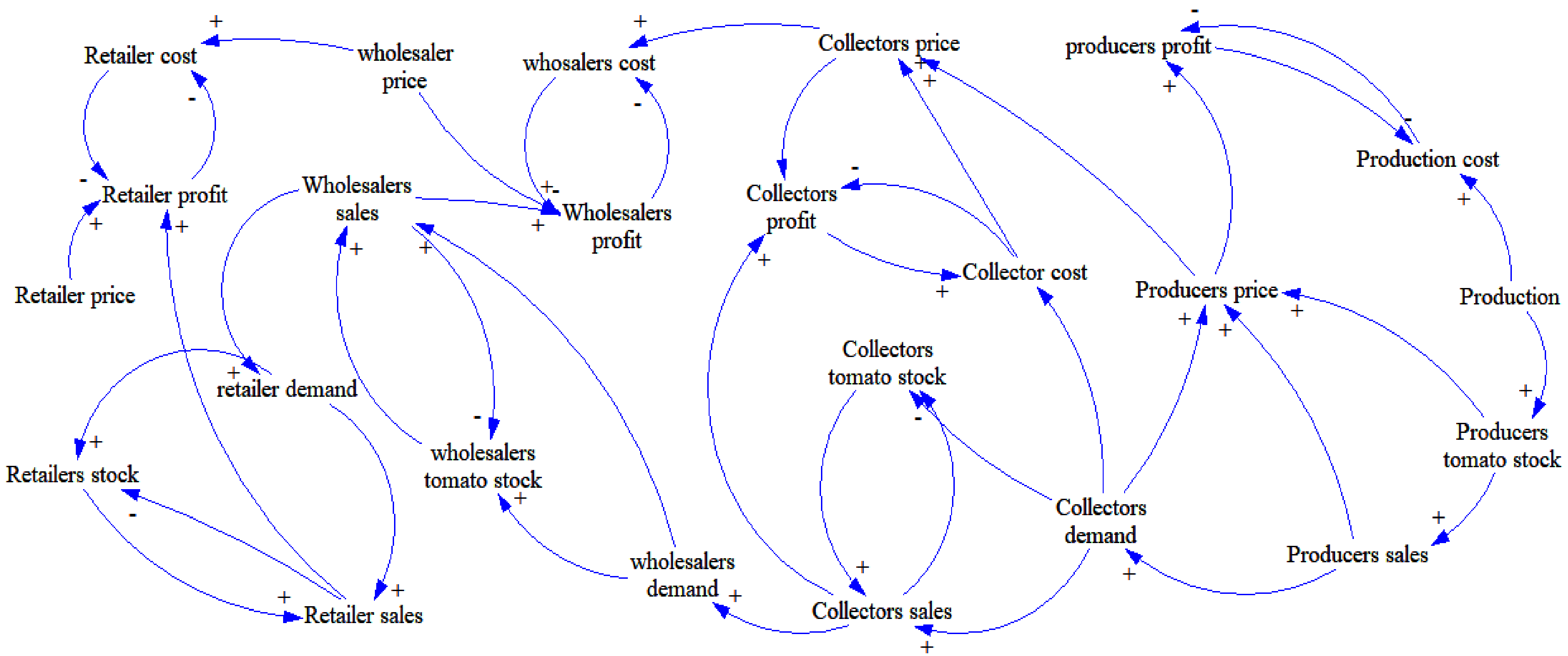

Figure 4-4 CLD for Value chain actor’s profit

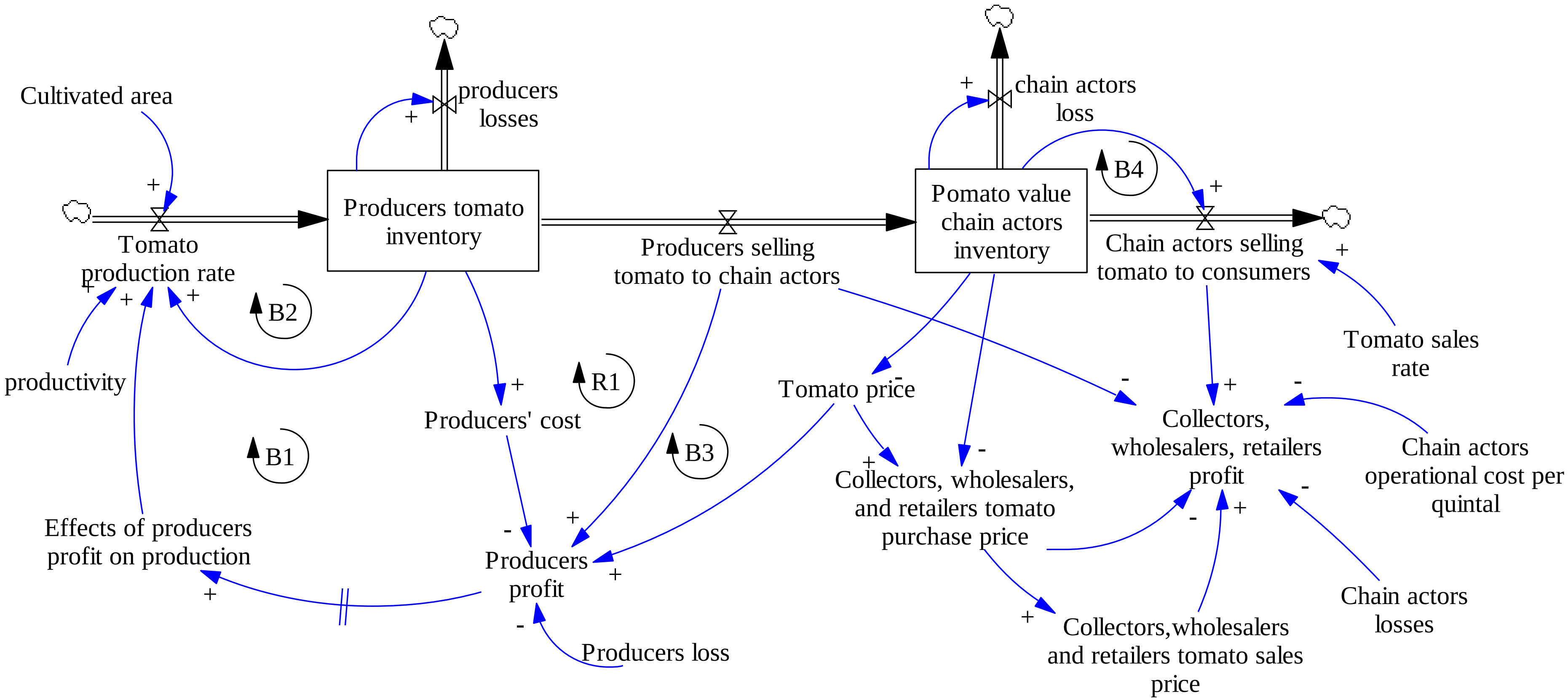

Figure 4-5 Producers and chain actors profit module (own construction)

4.1.4 The overall system dynamics model

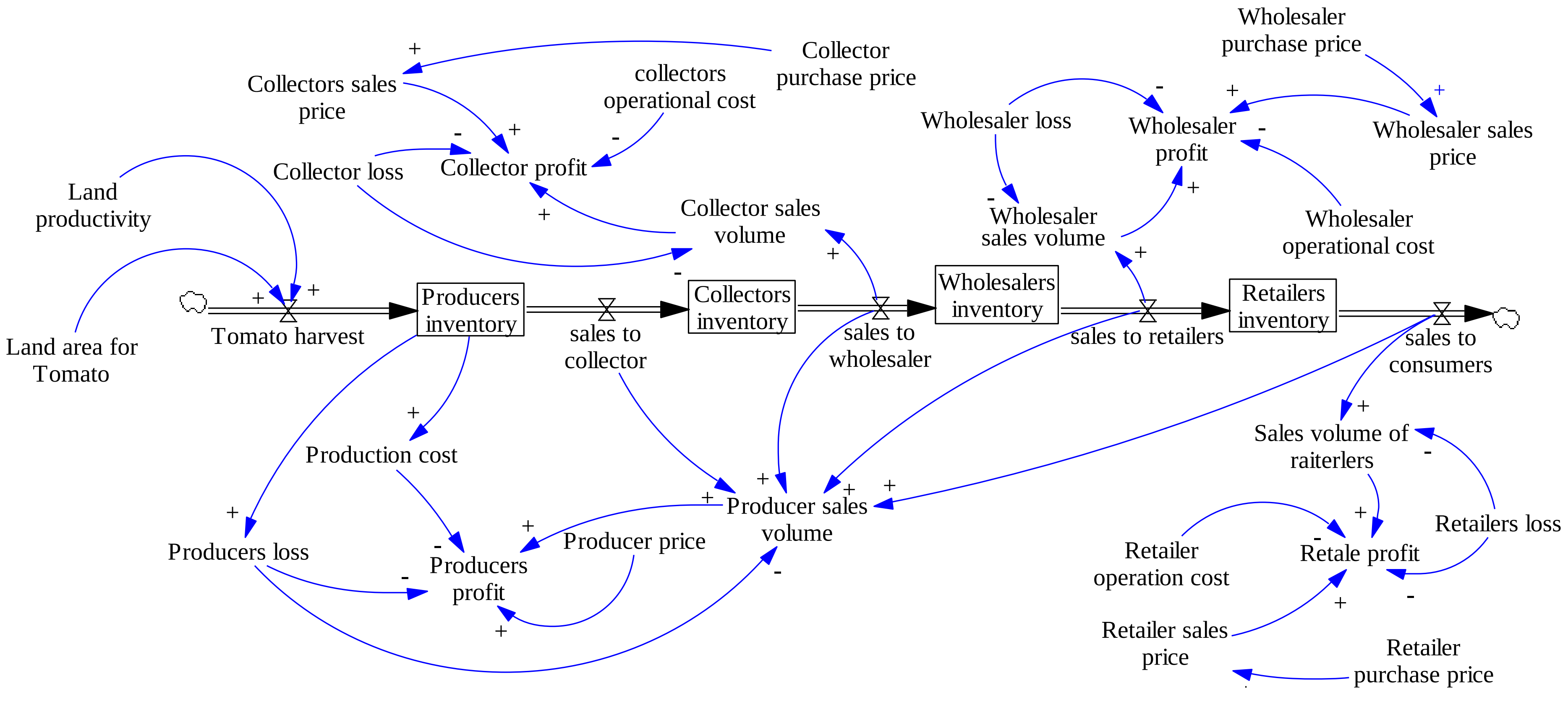

Figure 4-6 The combined system dynamics model

4.2 Model validation

Model validation, the accuracy of the model behavior reproduction of the structure of the model, is a significant step in system dynamic modelling hierarchy (Yassin et al., 2013). In this section, two types of modelling techniques from model validation perspective, namely: model structure tests and model behavior tests are evaluated. In series of model structure tests, the unit consistency test and extreme condition test are examined. Unit consistency test emphasizes on compatibility and consistency of units in model with Vensim software confirmed. For evaluating the model structure, in addition to unit consistency test, extreme condition test is also used. The extreme condition test, consider the feedback loops in model structure and question 'how real system operate in some aspects. Based on those techniques the model constructed are correct.

4.3 Simulation of Different Scenarios

The development of the model, and its validation, led to the final step in the process of SD simulation modelling, which involved simulation of scenarios focusing on the main parameters in order to reach conclusions, particularly to identify and evaluate the best policy and strategy to adopt and what happens in the system if factors change or events intervene. Here, the aim of the simulation is not predictions or forecasts of a future event, but rather to evaluate scenarios or alternative. Before the different scenarios can be designed and simulated, first the measure of performance and the base scenario used for the simulation analysis should be identified and presented. Then, the various scenarios employed in the analysis are discussed and the results of the simulations from which an evaluation can be undertaken of the best strategies to adopt to improve the performance of the system is presented. The proposed scenarios are:

1. Scenario 1 (baseline): the model is ran based on baseline data to provide a benchmark to compare performance of intervention scenarios.
2. Scenario 2: Assume that producers sell their produced tomato directly to consumers.
3. Scenario 3: This scenario assumes producers establish fresh tomato market center to collect surplus tomato through cooperatives and transport tomatoes to processors. Assume that producers sell 80% of their produce to fresh tomato

market center and sell the remaining 20% to other chain actors; such as local collectors, wholesalers, and retailers.

4.4.1 Performance Measure

The measure of performance for this simulation analysis represents the indicator whose changes in value under different scenarios and given certain values of the parameters enhance understanding of the conditions that might arise in the system. These conditions that represent the simulation results lead to an evaluation of strategies, which in turn provide guidelines as how to improve the performance of the system.

In literature review, it was found that in most agrifood value chain systems for sustainable development the primarily objective is to minimize (reduce) the post-harvest losses and to ensure profitability of chain participants. Therefore, in this study these two are considered as a measure of performance for the simulation analysis. However, the analysis is not aimed at determining the optimal profit or post-harvest level.

4.4.2 Scenarios Simulation Results

4.4.2.1 Base Model and Other Scenario Simulation Result

Base model scenario simulation result in the year 2011/2012 E.C are shown table below.

Table 4-1 Total tomato PHL in quintal and percent of in mecha woreda in 2011/ production season.

Actor	PHL in quintal	PHL in %
Producer	54.03	20.62
Collector	3.11	4
Wholesaler	4.36	7.98
Retailer	4.64	7.12
Consumer	_	_
Total value chain loss	66.14	39.72

Profitability

A. Producers profit

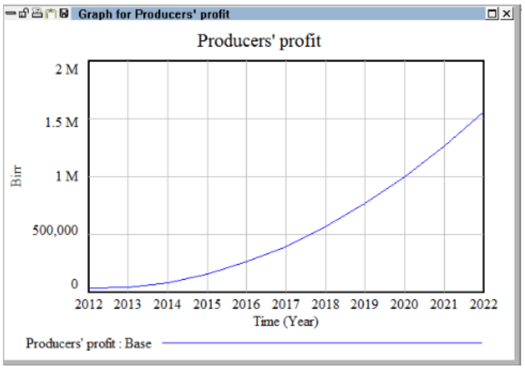

Figure 4-7 baseline producers profit simulation result

B. Collectors profit

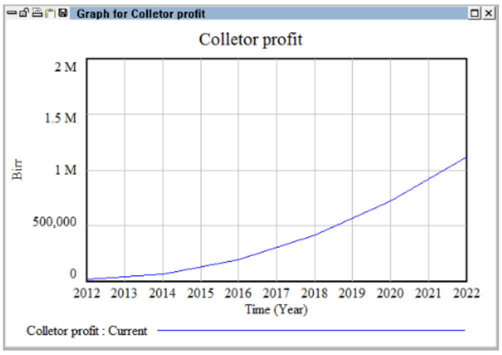

Figure 4-8 Collectors profit base line simulation result

C. Wholesaler profit

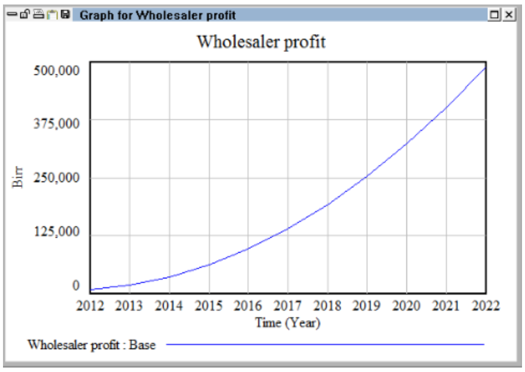

Figure 4-9 Wholesaler profit baseline simulation result

D. Retailer profit

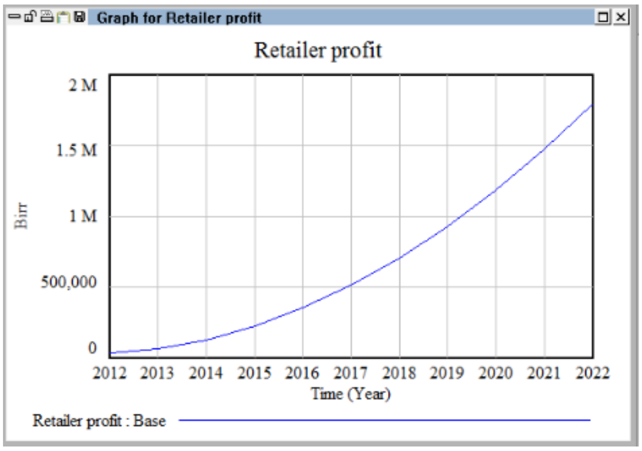

Figure 4-10 Retailers profit baseline simulation result

From the above baseline simulation results of each actors profit the total value chain profit, which is the sum of each chain actors' profit is calculated. The total profit of chain is shown below table.

Table 4-2 Total value chain profit based on baseline scenario

Actor	Profit in (Birr)
Producer	48,437.8
Collector	21,919.5
Wholesaler	8,744.0
Retailer	32104.0
Total profit	111,205.3

The same tendency was observed for remaining scenarios. The generalized scenarios simulation result showed in below table.

Table 4-3: scenarios simulation result

Scenario condition		**Profit (Birr)**	**Profit change %**	**PHL (%)**	**PHL difference %**
Scenario 1		111205.3		39.72	
Scenario 2	Price+10%	70,776	-36.6	20.6	-19.12
	Price-10%	58,200	-47.7	20.6	-19.12
Scenario 3	Price+10%	87111	-21.6	19.1	-20.62
	Price-10%	68418	-38.5	19.1	-20.62

4.4.3 Scenarios Simulation Result Analysis

The baseline scenario presents the status quo of tomato value chains in Mecha district. In the baseline scenario, the model is parameterized based on data from the tomato value chain assessment survey. The results of the baseline scenario are used as a benchmark to compare alternative scenarios. In this section it will present the results of the profit of producers, collectors, wholesalers, and retailers' base model. In this study using a time span starting from 2012-2022 E.C (Year).

Chain-wide analysis of data indicated that overall, the 39.7 per cent of tomato was lost before it reached consumers because of poor technical and management practices, such as poor harvesting method, traditional harvesting equipment, poor storage facility, lack of ready market are some of the causes of post-harvest loss as indicated by value chain actors. Tomato producers. From this percent of loss, tomato producers share the highest percent, followed by wholesalers, retailers and local collectors respectively.

Table 4-4: Scenario simulation analysis result

Scenario condition		**Profit to PHL ratio (Birr/%)**
Scenario 1		2799.73
Scenario 2	Price+10%	3435.73
	Price-10%	2825.24
Scenario 3	Price+10%	4560.78
	Price-10%	3582.09

Based on the scenario simulation results profit to PHL ratio the highest value showed that scenario 3 (establishment of fresh tomato market center) improve the value chain performance.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

This study presented a dynamic model of the tomato value chain in Mecha district of Amhara region, Ethiopia. The developed model was used to evaluate three scenarios including the baseline. The model results highlight the importance of direct tomato sell and establishment of fresh tomato market center to improve tomato producers' access to the market, in increasing producers' profits and in reducing post-harvest loss. Both direct market and the fresh tomato market center improve producers' profits significantly.

In measuring the performance of the tomato value chain using system dynamics, there were four sub models used, including the producers, collectors, wholesaler, and retailers' sub-models. The developed model was adjusted to the real conditions by conducting verification and validation. Validated and verified models will then arranged into several policy scenarios to find out the variables affecting the improvement of the tomato value chain performance in mecha with the profit and post-harvest loss approaches.

5.2 Recommendations

The developed dynamic value chain model used to evaluate different scenarios that improve the system perform in term of improving profitability of the value chain by reducing the post-harvest loss. In this study only two performance measures are used, but better result and conclusion to important two consider other additional performance indicators.

Based on the scenario simulation results, scenario 3 (establishment of fresh tomato market center) is recommended to improve the value chain performance. However, there is need to promote and facilitate this shift in traditional tomato value chains by encouraging value chain actors to develop relationships with each other.

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APPENDIX

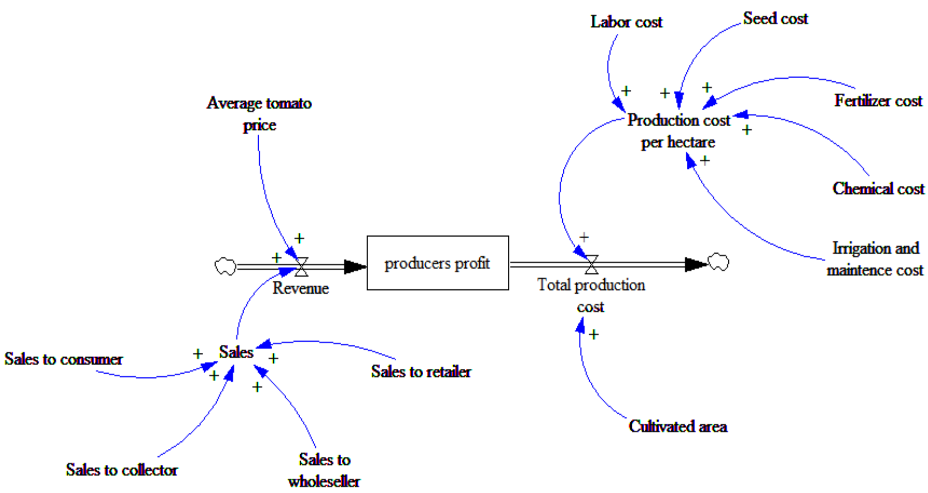

Figure 1 Stock and flow diagram of producers' profit sub model

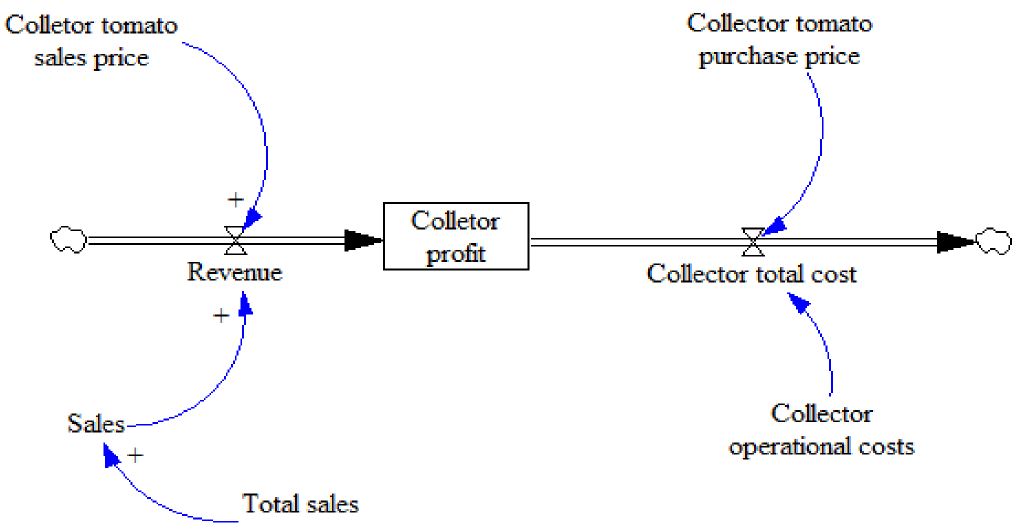

Figure 2: Stock and flow diagram of Local collectors' profit sub model.

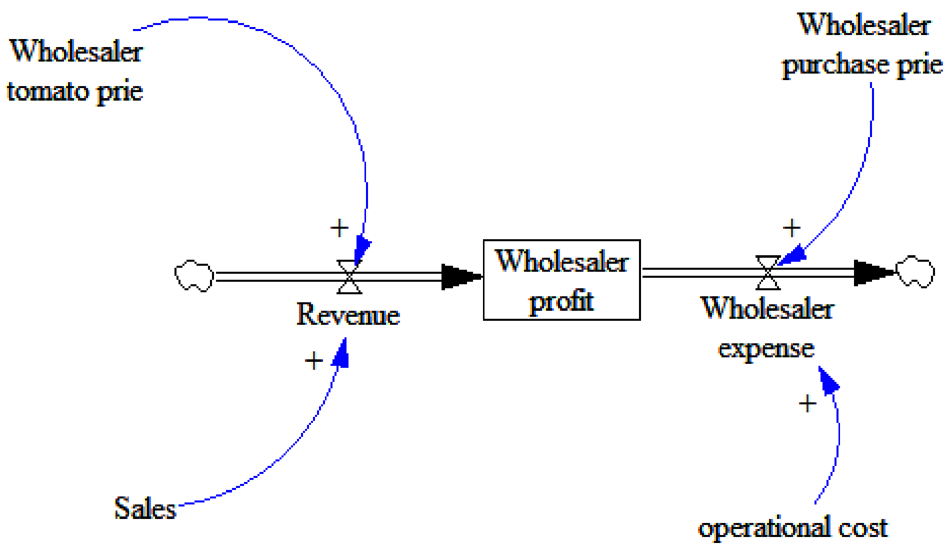

Figure 3: Stock and flow diagram of wholesalers' profit sub model

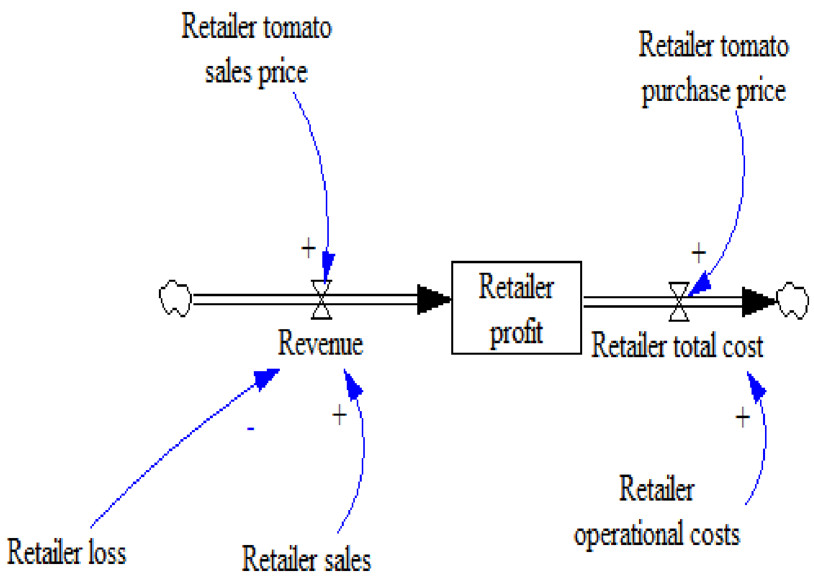

Figure 4: Stock and flow diagram of Local retailer' profit sub model.

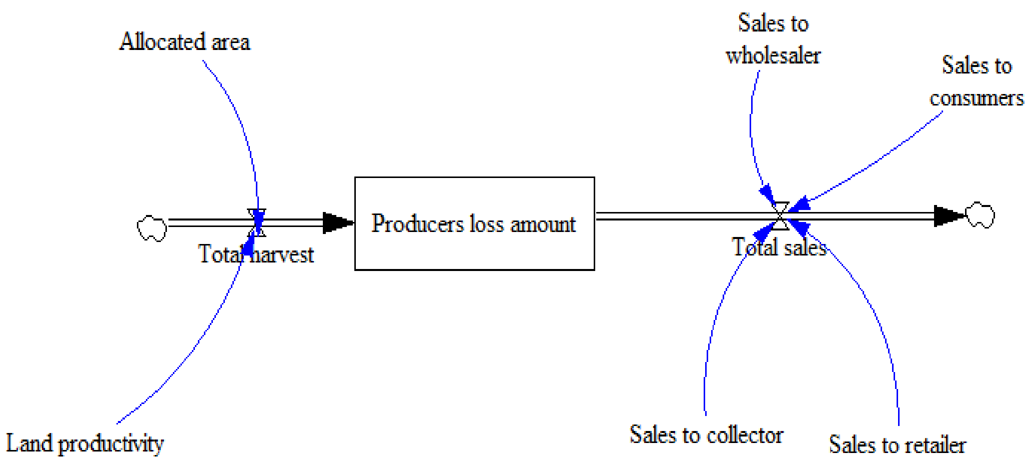

Figure 5: Stock and flow diagram of producers' post-harvest loss sub model.

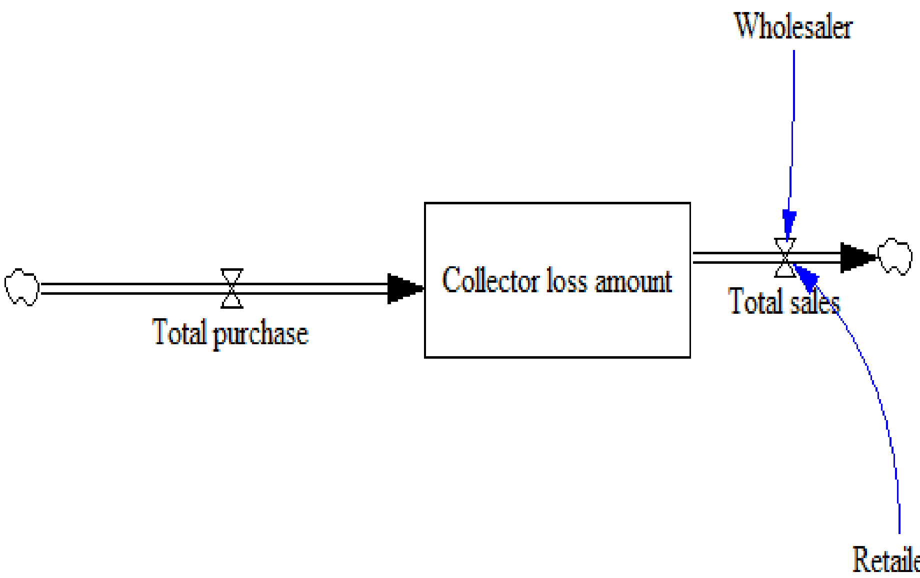

Figure 6: Stock and flow diagram of collector' post-harvest loss sub model.

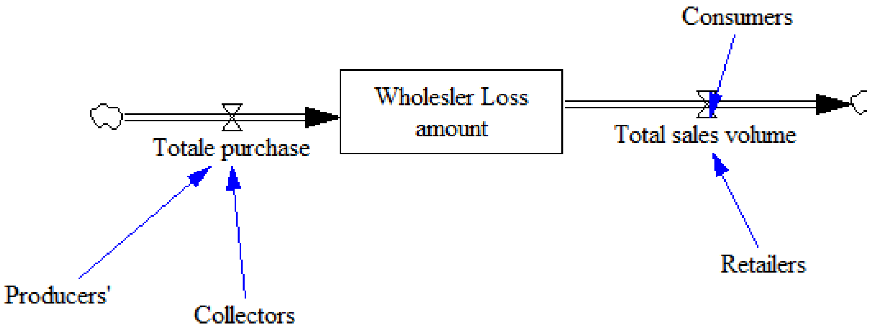

Figure 7: Stock and flow diagram of wholesaler' post-harvest loss sub mode

Data source: The key data and sources used in the model are summarizing in table below. The model initialized on the 2011/2012 production year as this was the most recent year for most sources of parameters for the model. Production and price data come from the department of agriculture.

Table 1A : Producers and other actors selling amount for different actors

Actor	Producer	Collector	Wholesaler	Retailer	Consumer
Producer	_	77.73	54.62	65.12	10.5
Collector	_	_	63.43	11.19	_
Wholesaler	_	_	_	42.72	7.54
Retailer	_	_	_	_	60.48
Consumer	_	_	_	_	_

Table 2A : local market price of tomato during the study period

Buyer	Farmers' tomato selling price (Birr/quintal)
Collector	150
Wholesaler	300
Retailer	250
Consumer	500
Average price	300

Table 3A: Tomato selling price of each value chain actor

seller	Tomato selling price Birr/quintal
Collector	450
Wholesaler	500
Retailer	800
Consumer	-
Average price	583.33

Table 4A: producers' tomato production cost

Expense for	Production cost Birr/ha
Seed	720
Fertilizer	7360
Chemical	1520
Labor	3840
Irrigation and maintence cost	0
Total production cost	13440

<u>Equations used for simulations</u>

- Sales = Production-Farmers level loss
- Profit = Revenue-Total production cost
- Production = Cultivated area*productivity
- Revenue = Average tomato price*Sales
- Production cost per hectare = Chemical cost +Fertilizer cost +Irrigation and maintenance cost +Labor cost +Seed cost
- Total production cost = Cultivated area*Production cost per hectare

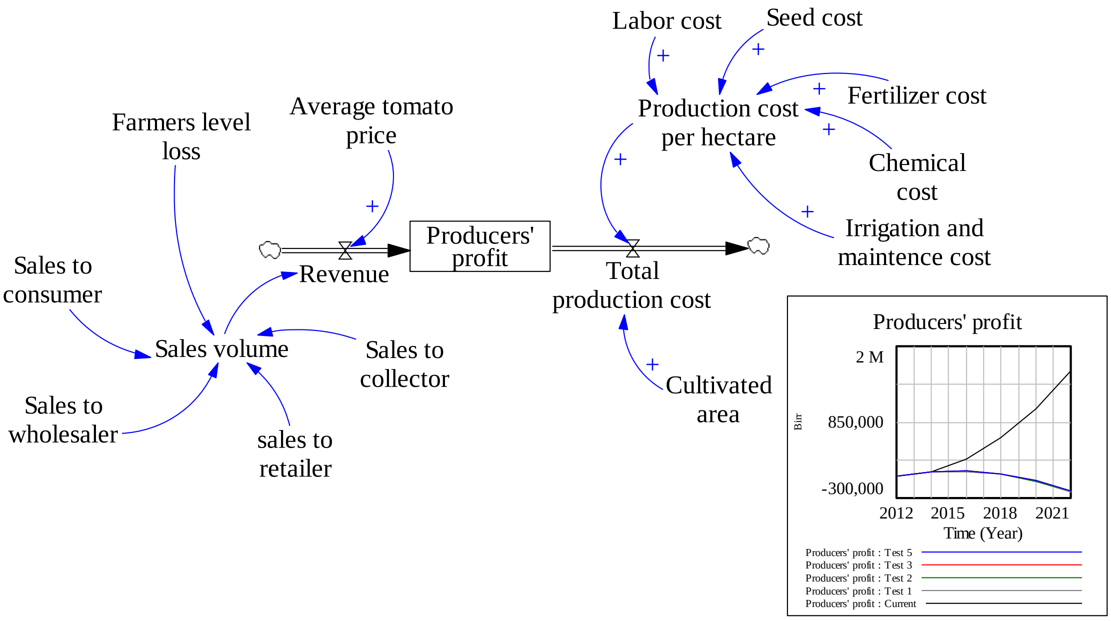

Fig. 8: Producers profit over time (simulation results)

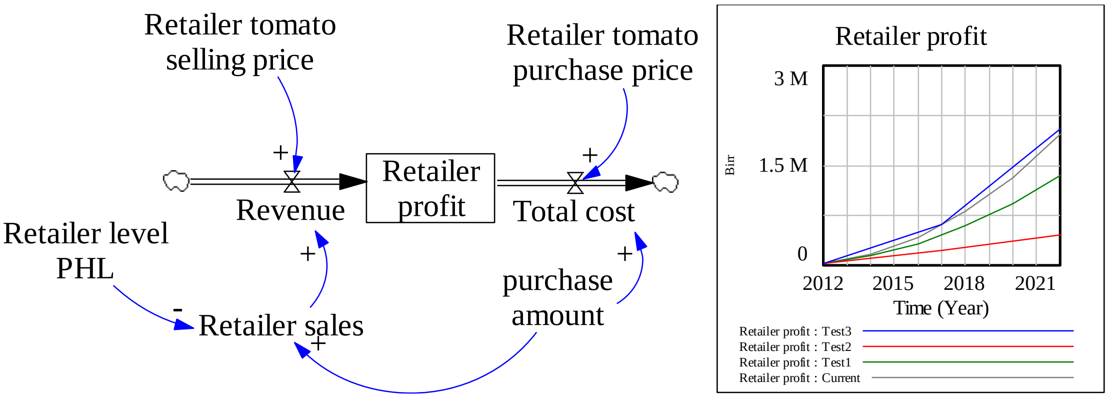

Fig. 9: Retailers profit over time (simulation results).

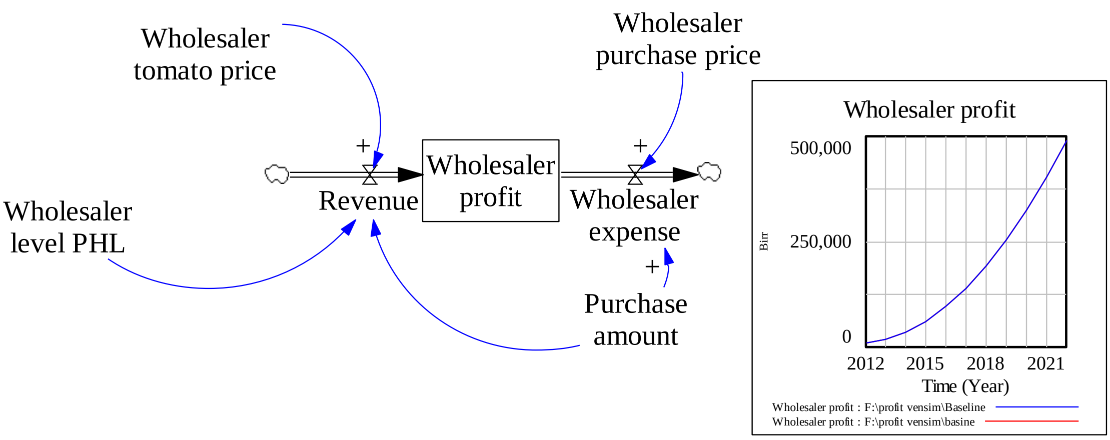

Fig. 10: Wholesalers' profit over time (simulation results).

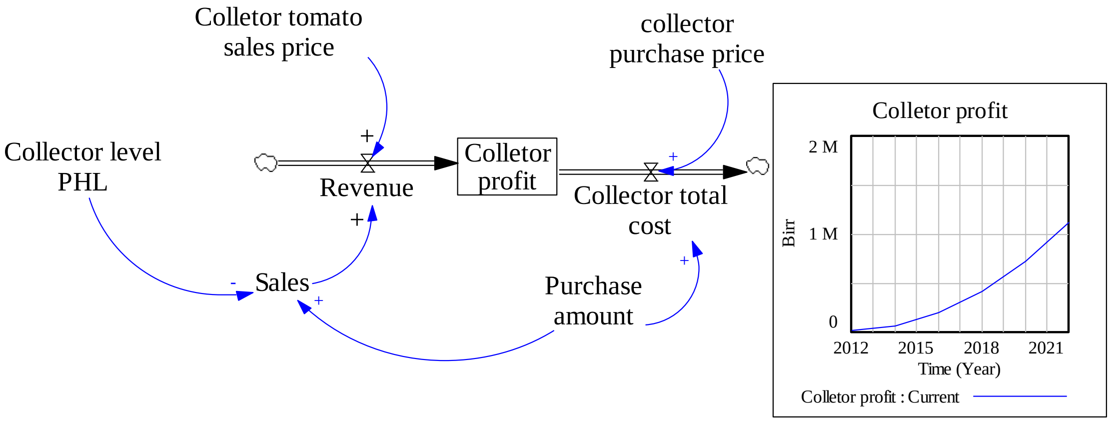

Fig. 11: local collectors' profit over time (simulation results)

Table 5A: Volume of tomato that producers soled to different value chain actors

Sales to	Soled tomato in quintals
collector	77.73
wholesaler	54.62
retailer	65.12
consumer	10.5
Total soled	207.97

Table 6A: Tomato local market price

Buyer	Farmers' tomato selling price Birr/quintal
Collector	150
Wholesaler	300
Retailer	250
Consumer	500
Average price	300

Table 7A: Tomato selling price

seller	Tomato selling price Birr/quintal
Collector	450
Wholesaler	500
Retailer	800
Consumer	-
Average price	583.33

From the above data we can calculate the post-harvest losses at each node of the value chain in quintal.

1.05 ha area were cultivated by tomato in the year 2012 E.C and the productivity of the tomato cultivated area is 250 quintal/ha. The expected production is calculated as:

$$\text{Production} = \text{Productivity} * \text{Cultivated area}$$

Based on the above equation the expected production is 262 quintals. And in order to know farmer level loss, we must identify farmer selling amount in quintals. Above table show that producers selling amount for different actors. The producers' total selling amount for different actor is 207.97 quintals. Therefore, the farmer level loss is:

- Farmer level PHL = Production – Total selling amount = 54.03 quintals.

For other actors PHL is:

- Collector level PHL = 77.73 – 63.43+11.19 = 3.11 quintals
- Wholesaler level PHL = 54.62 – 42.72 + 7.54 = 4.36 quintals
- Retailer level PHL = 65.12 – 60.48 = 4.64 quintals