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PERFORMANCE OF ETHIOPIAN NATIONAL QUALITY INFRASTRUCTURE IN PRODUCTION AND PRIMARY PROCESSING ACTIVITIES OF COFFEE VALUE CHAIN

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A Thesis Submitted to the School of Mechanical and Industrial Engineering in partial fulfillment of requirements for the Degree of Masters of Science in Mechanical and Industrial Engineering (Industrial Engineering stream)

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I hereby declare that the work which is being presented in this thesis entitled *"Performance of Ethiopian National Quality Infrastructure in Production and Primary Processing Activities of Coffee Value Chain"* is original work of my own, has not been presented for a degree of any other university and all the resources of materials used for the thesis have been duly acknowledged.

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ABSTRACT

Coffee is the number one source of export revenue generating crop about 25-30 percent of Ethiopia's total export earnings and plays a vital role in the country's economy with about 15 million people directly or indirectly deriving their livelihoods from it. Quality of coffee end product, raw (green) coffee, is determined on every step in the value chain activities starting from seedling preparation to retailing. To achieve this quality of coffee product, the performance of Ethiopian NQI elements (standard, metrology, conformity assessment and accreditation) in each main activity of coffee value chain has an important role. Therefore, this study was conducted with an objective of assessing the performance of Ethiopian NQI in production and primary processing activities of coffee value chain and followed by proposing a way to improve the performance. Secondary data from Ethiopian conformity assessment body (CLU) was collected, seven coffee quality experts, six NQI experts, two traders and three machine operators were interviewed and observations of warehouse, conformity assessment practices, laboratories etc. were made during the research and all used as an input of the analysis. During the data presentation, Excel 2013 was used as a main tool in developing charts based on the data collected. The results were revealed that ENQI elements are weak in performance in both production and primary processing activities of coffee value chain. Lack of standards in coffee cherries grading and weak in standards implementation in piling of coffee direct contacted with wall, piling on bare ground, store empty bags with coffee filled bags together etc. were investigated. Also, lack of testing of temperature and humidity during storage and transportation, lack of soil nutrition testing of coffee lands, weak in inspections performance of pests, diseases, ripeness, drying level, fermentation level, proper washing, proper separation of coffee beans from husks and hulls etc. were seen. Moreover, there is no any accreditation practices were performed through these two activities of coffee Value chain. In order to improve these problems within the performance of ENQI elements in production and primary processing activities of coffee value chain, a new working framework was proposed that can link the two sectors (NQI and coffee sector) to work cooperatively. Therefore, it is recommended that to use the newly proposed framework and the four NQI authoritative bodies have to go distances such as establishing their office in a place coffee production and primary processing takes place, show usage of their service in practice by performing it on selected model actors, like Metrology Institute, asking and moving to them to give services, etc. to reach and serve the coffee sector (actors in coffee production and primary processing activities) instead of waiting this sector to come a distance to them to get their services.

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ABBREVIATIONS

CLU - Cup Liquoring Units

CRF - Coffee Research Foundation

ECAE – Ethiopian Conformity Assessment Enterprise

ENAO – Ethiopian National Accreditation Office

ENMI – Ethiopian National Metrology Institute

ENQI – Ethiopian National Quality Infrastructure

ESA – Ethiopian Standard Agency

ISO – International Standards Organization

MoT – Ministry of Trade

NCE – Nairobi Coffee Exchange

NQI – National Quality Infrastructure

NSB – National Standard Body

QI – Quality Infrastructure

QSAE – Quality and Standards Authority of Ethiopia

SME – Small and Medium Enterprise

WTO – World Trade Organization

CHAPTER ONE

1 INTRODUCTION

1.1 Background of the study

The products and services have to be competitive in the target market with respect to quality, availability and price. In an increasingly globalized economy, the production for the export market is highly dependent on the adherence to and respect of prescribed quality parameters. The Ethiopian export market is characterized by an export of primary products, and market orientation to low cost and less stringent market requirements. The main factors that led to export of primary products and orientation to low cost and less stringent market requirements are mainly related to competitiveness issues, supply and technology capacity. The major factor affecting the export sector of Ethiopia is lack of compliance with the requirements of the international market [1]. One of the Ethiopian most export product allied with such condition is coffee.

Coffee is the single most important tropical commodity traded worldwide, accounting for nearly half of total exports of tropical products. Implies it is an important source of income for many developing countries in the tropical regions of Middle and South America, Africa and Asia [2]. World coffee production is about 8.75 million tons, which accounted for export worth an estimated 23.4 billion US dollar in 2013. World total coffee sector employment estimated at about 26 million people in 56 producing countries of four continents [3].

Coffee crops are represented by three botanical species such as Coffea Arabica, C. canephora, mostly represented by the variety Robusta, and C. liberica [4]. Ethiopia is the birthplace of Coffee Arabica and mostly produces this variety. It is cultivated in most parts of the tropics, accounting for 80 percent of the world coffee market, and about 70 percent of the production. It is also an important source of income and employment in developing countries producing coffee [2].

Ethiopia remains the largest producer of coffee in Africa and is the fifth largest coffee producer in the world next to Brazil, Vietnam, Colombia, and Indonesia, contributing about 4.2 percent of total world coffee production [5]. It has economic, environmental as well as social significance to the country. Coffee is the number one source of export revenue generating about 25-30 percent of the country's total export earnings. Also coffee production is vital to the Ethiopian economy with about 15 million people directly or indirectly deriving their livelihoods from it. Predominantly

around 95% of the total production of the county come from small holder farmers on average farms of less than 2 hectares and the rest 5% is from government or private investors [6].

Quality is an order wining criteria in today's global market. According to Birhanu *et al.* (2013), quality of the end products, raw of green coffee as well as a cup of coffee, are determined on every step in the value chain activities starting from seedling preparation, including planting, weeds and pests controlling, harvesting, primary and secondary processing, marketing, storing and transporting. They stated that the two stages of harvesting practices as general sources of quality problems. At the pre-harvesting stage, the collectors pick unripe and over ripped coffees together (strip piking method) as a result of misunderstandings of harvesting earlier will cash in early on the crops. On the other hand, at post-harvesting stage, use ground for coffee drying, beans discharged with the skins broken and lost, nipped and hulled of their parchment cover, inclusion of coffee seeds floated on the water surface, ground smell during drying, inclusion of impurities and the loss of moisture content, improper storage and transportation facilities are raised as a source of low quality.

Also, Anwar (2010) emphasizes the above quality problems of coffee products and raised another additional problems such as uncontrolled shade level, lack of stumping, pruning and weeding, collecting dropped fruits from the ground. In addition to this, natural impediment such as prolonged rainy weather, particularly during harvesting and drying season can also contribute to reduced coffee quality. Also Coffee Berry Disease is revealed as the most serious problem of coffee production commonly prevailing in many coffee growing regions of the country [7].

Even though poor management of pre and post-harvesting, uncontrolled shade level, lack of stumping, pruning and weeding, Coffee Berry Disease are studied as the source of coffee quality problems, there are no researches considering the lack of national quality infrastructure (NQI) or low performance of NQI is the source of quality problems of coffee products in any activities of coffee value chain. This is not missed at national level, but also at international level. Therefore, this research is aimed to focus and conduct on the performance of NQI in production and primary processing activities of coffee value chain in Ethiopia in order to achieve the qualified coffee products for the local and export markets aimed to satisfy customers, and enables to increase export quantity to gain more foreign currency.

Although National Quality Infrastructure is a newly emerged concept to come up with quality products, process and services, it is not finding valuable attention in any aspect of life as other quality management practices. Moreover, the availability and implementation of Quality Infrastructure services are becoming a pre-requisite for a country to have efficient and cost-effective production of quality products, processes and services and for attaining compliance with safety regulations and market requirements [1], [8].

As an introduction, the term National Quality Infrastructure denotes the totality of infrastructure (both public and private) required establishing and implementing all the fields standardization, metrology (scientific, industrial and legal), testing, inspection, certification (product, system and personnel) and accreditation services necessary to provide demonstrable and acceptable evidences that products and services should meet [1], [8], [9]. Standards are formal documentation containing the requirements that a product, process or service should comply with and essentially they are voluntary in nature. Metrology is a science of measurement. Metrology as scientific; it is the organization and development of the highest level of measurement standards, as legal; it is the accuracy of measurements where these have an influence on the transparency of economic transactions, health and safety and as industrial; it is the adequate functioning of measurement instruments used in industry, production and testing. The determination of product characteristics (total destructive, non-destructive and combination of the two) against the requirements of the standard is termed as testing. Inspection is the other element of NQI that uses to examine product design, product, service, process or plant, and determination of their conformity with specific requirements or, on the basis of professional judgment, general requirements. Certification is the formal substantiation that a product, service, organization or individual meets the requirements of a standard. Accreditation is an activity of providing independent attestation as to the competency of an individual or organization to provide specified services such as testing, certification, etc. [8], [9]. These elements are all interrelated and to some extent all required to provide the purchaser, consumer or authorities with the appropriate confidence that the product, process or service meets expectations.

There are responsible bodies in Ethiopia for preparation, implementation and improvement of these all NQI elements. The Ethiopian Council of Ministers approved regulations on February, 1st 2011 to split up the former Quality and Standards Authority of Ethiopia (QSAE) in which most of

the NQI implementing functions are embedded in and not in line with international best practice into four entities [1]. They are an Ethiopian Standard Agency (ESA), Ethiopian Conformity Assessment Enterprise (ECAE), Ethiopian National Metrology Institute (ENMI) and Ethiopian National Accreditation Office (ENAO). Then it puts them under the direction of the Ministry of Science and Technology. This is done for the sake of in line with international best practice and for better implementation of NQI through better practices of NQI elements in an efficient and effective way.

1.2 Statements of the problem

Even though coffee is the number one source of export revenue generating about 25-30 percent of the country's total export earnings and vital to the Ethiopian economy with about 15 million people directly or indirectly deriving their livelihoods from it [6], it has not find appropriate focus to its quality through all of its value chain activities as equal to its economic importance. This results different quality problems to the product. Due to these quality problems, a huge amount of coffee products failed to the exports' requirements and very low quality coffee that are rejected to export grades are supplied to the local market.

According to Sette (2012), these quality problems of coffee are raised from three main Ethiopian coffee quality challenges. The first is structural challenges such as lack of infrastructure, lack of competitiveness, poor access to markets, long supply chain, inadequate access to services, low value addition, inadequate technology transfer and research. The second is policy environment challenges listed as low levels of public investment in agriculture, disengagement of the state in production and marketing activities, liberalization/agricultural reforms historically poorly executed and weak institutional framework in many countries. Finally, challenges related to Sustainability such as adaptation and mitigation to climate change, conservation of biodiversity, Social sustainability, and Competition for land.

Among these challenges, lack of infrastructure raised as one source of coffee quality problems. Therefore, specifically National Quality Infrastructure in production and primary processing activities of coffee value chain is the focus of this study. Through these activities of coffee value chain, Poor implementation of standards, lack of accreditation practices, performing inspection and testing with none calibrated instruments and uncertified personnel, improper calibration, adjustment and maintenance of coffee processing machines are the major sources of quality

problems of coffee. Hence, this study was designed to investigate the above mentioned sources of quality problems resulted from lack of NQI or low performance of NQI thereby forward ways and means that would help actors in the production and primary processing activities of coffee value chain to improve the problems.

1.3 Basic research questions

To address stated problems and to achieve the objectives of study, the following basic research questions have been formulated and answered:

1) What are the main and root causes resulting the rejection of coffee products (low quality coffee) that are not fit to the export grades?
2) Which main and root causes are resulted from which elements of Ethiopian NQI performance weakness in the production and primary processing activities of coffee value chain?
3) What is the solution to improve the weakness of Ethiopian NQI performance in production and primary processing activities of coffee value chain to minimize the quality causes?

1.4 Objectives of the study

The general objective of this study is to assess the performance of Ethiopian NQI elements (standards, metrology, conformity assessment (testing, inspection and certification) and accreditation) in production and primary processing activities of coffee value chain in order to improve quality of coffee to increase competitiveness in global market.

Whereas the specific objectives of the study are:

- To identify main and root causes for the lack of quality coffee products that are not fit to the export grades.
- To assess for which lack of Ethiopian NQI elements or weak performance of Ethiopian NQI elements in production and primary processing activities of coffee value chain would these main causes are happening.
- To propose solutions to solve these causes by upgrading the performance of Ethiopian NQI in production and primary processing activities of coffee value chain.

1.5 Significance of the study

The study provides benefits for the coffee sector in identifying the extent NQI elements are performed in the production and primary processing activities of coffee value chain and in

identifying the area for improvements. Ethiopian NQI authoritative bodies by themselves benefit from this research to identify their weaknesses and to improve them. Other sectors can also benefit from this research in pushing to focusing on their aspects of NQI elements and initiating them to identify their weak practices of NQI through conducting research and improve it. Moreover, this study will use as an input for other researchers conducting related research.

1.6 Scope of the study

The scope of the study is limited to assess the performance of Ethiopian NQI elements (standards, metrology, testing, certification and accreditation) in production and primary processing activities of coffee value chain only. Also, the study focus on green coffee only. Implies, the study does not consider roasted and ground coffee.

1.7 Limitation of the study

The main limitation of this study is unavailability of literatures related to the NQI and its elements. Specially related articles and any related literatures conducted on NQI elements contribute in the coffee value chain are not available in order to develop concurrent literature reviews and research gap analysis. So the research mostly depended and limited to reports, guidelines and books. Also, confidentiality of data and lack of coded data from respective bodies are the others limitation of the study.

1.8 Organization of the study

The study is organized in eight chapters. The first chapter begins with an introduction and background of the study. Statement of the problem and objective of the study are discussed in this chapter. Chapter two is literature review that discusses about the fundamental concepts of NQI and its elements, coffee defects, coffee value chain maps and general overview of the existing situation of NQI of Ethiopia. This chapter gives the theoretical background of the thesis work.

Research design and methodology of the study is the third chapter in which major data collection techniques are discussed and the overall framework of the study is presented. In chapter four, the collected data is presented and analyzed to come up with main source of quality problems of coffee product of Ethiopia. Also, this chapter is at where each element of NQI performance in production and primary processing activities of coffee value chain is investigated and discussed very well. The newly proposed working framework to alleviate the problems is presented in chapter five. Finally, in the last chapter, the conclusions, recommendations and future research directions have been presented.

CHAPTER TWO

2 RELATED LITERATURE REVIEW

2.1 Definition of NQI

A variety of definitions of National Quality Infrastructure (NQI) have been provided in the literature as follows and it has been considered as an approach to infrastructure for quality. National Quality Infrastructure (NQI) is the institutional framework that establishes and implements the practice of standardization, including conformity assessment services, metrology, and accreditation [1], [8], [11]. According to Keller and Kellermann (2014), the term "quality infrastructure" (QI) refers to the policy and institutional framework that governments establish to provide evidence that products and services meet the requirements set by regulatory authorities and the market place. In this report QI framework describes a way of measuring, standardizing, assessing and certifying the products and services businesses produce. Racine in his book has defined the term national quality infrastructure as the complete chain of public and private institutions required to establish and implement the standardization, metrology, inspection, testing, certification, and accreditation services needed to ascertain that products and services meet defined requirements, whether demanded by authorities or the market [12]. To sum up, the definition of QI is therefore seen as the totality of the policy, legal, regulatory and administrative frameworks and the institutional arrangements required to establish and implement standardization, metrology, accreditation and conformity assessment services (inspection, testing and product- and system certification) necessary to provide acceptable evidence that products and services meet defined requirements [13].

Even though, total NQI is differently defined by different researchers, their definition all focuses on the same concept explained in different ways. They commonly focus on the terms such as standardization, testing, inspection, certification and accreditation as elements of NQI that are the base for attaining quality products and services.

2.2 Elements of NQI

There are five major terms; standardization, metrology, testing, certification and accreditation commonly considered as elements of national quality infrastructure and these are presented detail as follows:

2.2.1 Standards

Standards are documents that describe the important features of a product, services or systems and, the essential requirements that they must meet or they are documents which establish technical specifications, criteria, methods, processes, or practices which are measurable and have voluntary character. In turn, standards as a technical regulation is a document issued by an authorized body that details product characteristics, production methods, including administrative provisions, for which compliance is mandatory [14], [15], [16], [17]. According to Keller and kellermann (2014) and Aldaz-Carroll (2006), public and private standards are presented. Public standards are normative and voluntary documents developed by technical committees through a consensus process that is open to all stakeholders and published by recognizing standards organizations at national, regional or international level for general use. Private standards are developed by specific interest groups or organizations such as sectoral organizations, including non-governmental organizations, business associations and major retailers for their own explicit purposes [18].

Aligning the national standards with international requirements, such as the World Trade Organization's Agreement on Technical Barriers to Trade, helps to access the global market share. In other words, harmonizing national standards with regional and international trade partners is a key step in supporting global NQI integration, though it can be highly technical and does not happen overnight. To do so, National Standards Bodies should use three closely linked strategies to harmonize their standards: adopting international standards, influencing international standardization activities, and coordinating with trade partners to adopt regional standards appropriate to the region's needs [11]. Such standards are a way for small and medium enterprises (SMEs) in developing countries to gain access to markets that are more profitable. The requirement of global buyers combines the carrot and the stick: The international standards and certification schemes embed knowledge which helps the local SMEs to upgrade (pull). At the same time, it requires that SMEs innovate to fulfill the requirements (push) [16].

Standards might be barriers to foreign markets for small firms or they can complicate access for suppliers of large corporations. A first problem is the lack of awareness and information about local firms regarding opportunities and specific requirements of international buyers. Another barrier is the cost of the certification process, which normally includes a profound organizational change process within the firm [16]. While the adoption of certain environmental and labor

standards may be a useful strategy for product differentiation for certain firms, it may not be efficient for the whole sector and may block existing comparative advantages.

Therefore, to tackle this situation the national standards body plays an important role in determining which standards the country should adhere to the base on the existing economic environment and goals. According to many good practices across the world, limited set of technical regulations is developed by the government to protect consumers' health, safety, and the environment, often by designated regulatory agencies under the ministries, with no involvement of the national standardization body. Moreover, reviews of technical regulations should ensure that they do not impose technical barriers to trade and unnecessary constraints to businesses [11].

2.2.2 Metrology

Metrology is the science of correct and reliable measurements. No testing would be possible unless the characteristics of the product or service in question can be measured in a way which compares them against a physical or chemical reference of known values. Therefore, adequate methods for measuring the properties of products and services are fundamental to the quality assessment process [14], [15]. The main purpose of "Metrology – in short" is to increase awareness of metrology and to establish a common metrological understanding and frame of reference both in Europe, and between Europe and other regions throughout the world. This is particularly important with the increased emphasis on the equivalence of measurement and testing services for quality of life, environmental protection and trade and in particular where technical barriers to trade are caused by metrological impediments.

Metrology covers three main activities:

- The definition of internationally accepted units of measurement,
- The realization of units of measurement by scientific methods,
- The establishment of traceability chains by determining and documenting the value and accuracy of a measurement and disseminating that knowledge.

For some purposes, a distinction is made between scientific metrology (development of primary measurement standards or primary methods), industrial metrology (proper maintenance and control of industrial measurement equipment including calibration of instruments and working measurement standards), and legal metrology (verification of instruments used in commercial transactions, according to criteria defined in technical regulations) [1], [11], [15], [19].

Legal metrology originated from the need to ensure fair trade, specifically in the area of weights and measures. Legal metrology is primarily concerned with the measuring instruments which are themselves legally controlled, and the main objective of legal metrology is to assure the citizens of correct measurement results when used in official and commercial transactions. People using measurement results in the application field of legal metrology are not required to be metrological experts and the government takes responsibility for the credibility of such measurements. Legally controlled instruments should guarantee correct measurement results: under working conditions, throughout the whole period of use and within given permissible errors. Therefore, requirements are laid down in national or regional legislation for legal metrology measuring instruments and measurement and testing methods including pre-packaged products.

A traceability chain is an unbroken chain of comparisons, all having stated uncertainties. This ensures that a measurement result or the value of a standard relates to references at the higher levels, ending at the primary standard. An end user may obtain traceability to the highest international level either directly from a National Metrology Institute or from a secondary calibration laboratory, usually an accredited laboratory.

Calibration is a basic tool in ensuring the traceability of a measurement is the calibration of a measuring instrument, measuring system or reference material. Calibration determines the performance characteristics of an instrument, system or reference material. It is usually achieved by means of a direct comparison against measurement standards or certified reference materials. A calibration certificate is issued and, in most cases, a sticker is provided for the instrument.

The four main reasons having an instrument calibration are to establish and demonstrate traceability, to ensure readings from the instrument are consistent with other measurements, to determine the accuracy of the instrument readings and to establish the reliability of the instrument i.e. that it can be trusted. Calibration laboratories help firms to ensure that their equipment allows them to manufacture products in accordance with buyer requirements. To play a credible role in the conformity assessment system, testing and calibration laboratories and inspection bodies must display many of the same characteristics as certification bodies, notably, impartiality, objectivity, and confidentiality. Objectivity relies heavily on the procedures guiding the evaluation process, the equipment used, and the skills and qualifications of staff. Equipment and measurement systems must be calibrated to other internationally accepted metrological references to ensure traceability [11]. In modernizing a metrological framework, it is important to conduct needs and gap

assessment of the measurement standards currently in place, what they cover, whether they meet requirements and at what level of accuracy. A new approach for the selection of equipment and reference standards needs to be applied in market economies. Metrological needs should be determined by conducting a thorough and realistic demand survey [1].

2.2.3 Testing and inspection

Testing evaluates the performance of measurements with certain instruments and devices to assess a product or process according to a specified procedure. Testing is the determination of the characteristics of a product, a process or a service, according to certain procedures, methodologies or requirements. The aim of testing may be to check whether a product fulfills specifications such as safety requirements or characteristics relevant for commerce and trade. It is carried out widely, covers a range of fields, takes place at different levels and at different requirements of accuracy. Testing is carried out by laboratories, which may be first, second or third-party laboratories. First-party laboratories are those of the producer, second-party laboratories are those of the customer, whilst third-party laboratories are independent from both the producer and the customer. In return, inspection is similar but involves less sophisticated instruments or no instruments at all. In other words, they provide evidence that a product, process or service meets the requirements of a standard or technical regulation [18], [14] [20]. Manufacturers, purchasers or an independent third party can provide this evidence; implies, this service provider can be public or private. In developed economies, governments mostly leave conformity assessment to the private sector, whereas in developing economies where governments have initially been establishing these services, the trend is for them to withdraw as soon as private sector service providers can take over [18].

2.2.4 Certification

Through assessments, certification confirms conformity with the requirements defined in the written standards. Recognition can be achieved by using standards and assessment procedures which are implemented worldwide (ISO-Standards, Codex Aliment Arius recommendations, etc.) [18] [19]. According to Racine (2011), internationally recognized certification has enabled the company to access more sophisticated buyers who can settle their accounts on time. It has also allowed its buyers to charge a higher price for its product and has facilitated the export procedure.

2.2.5 Accreditation

To satisfy the need for confidence in the conformity assessment service, organizations are established at an international and national level to ensure that the act of traceability and testing is conducted in a proper manner. The National Accreditation System provides the services at the national level that establishes the truthfulness of measurement standards, certification and testing in industry and government [11]. Also, it is needed to assess training and experience of the testing personnel, it ensures that the traceability of national measurement standards is conducted in an appropriate manner, it checks whether the act of testing is comparable to that of similar test organization; in short, it attests and make impartial verification to the competence of the conformity assessors or, to use the proper name, it accredits. Such verification is done by authoritative accreditation bodies that are impartial in relation to both the conformity assessors and their clients, and which normally operate in a nonprofit distributing manner [8].

2.3 Definitions and concept of value chain

The value chain is a concept from business management that was first described and popularized by Michael Porter in 1985 in his book. The value chain is defined by Porter (1985) as the internal processes or activities a company performs "to design, produce, market, deliver and support its product". He further suggests that "a firm's value chain and the way it performs individual activities are a reflection of its history, its strategy, its approach to implementing its strategy, and the underlying economics of the activities themselves." He categorizes these activities into primary and support activities. The primary activities are dedicated to creating and delivering products as well as after-sales assistance. The support activities can be described as all the activities that help to increase the effectiveness or efficiency of the primary activities.

Shark and Govinadarajan (1993) describe value chain as "value creating activities all the way from basic raw material source from component suppliers through to the ultimate end-use product delivered into the final consumer's hand". According to them the value chain starts with the value creating processes of suppliers, who provide the basic materials and components. This continues with all value creating processes of different classes of buyers and eliminates in the disposal and recycling of materials [22].

United Nations Industrial Development Organization (UNIDO) (2009), defined value chain as a concept which can be simply described as the entire range of activities required to bring a product

from the initial input-supply stage, through various phases of production, to its final market destination. The production stages entail a combination of physical transformation and the participation of various producers and services, and the chain includes the product's disposal after use. As opposed to the traditional exclusive focus on production, the concept stresses the importance of value added at each stage, thereby treating production as just one of several value-adding components of the chain. The macroeconomic landscape, policies, laws, regulations, standards and institutional elements such as research and innovation, human resource development and other support services from the environment in which all activities take place and therefore are also important actors and activities in the value chain.

Kaplinsky and Morris (2001) describe value chain 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 [24]. Considered in its general form, it takes the shape as described in figure 2.1. As can be seen from this, production per see is only one of a number of value added links. Moreover, there are ranges of activities within each link of the chain. In the real world, of course, value chains are much more complex than this. For one thing, there tend to be many more links in the chain. In addition to the manifold links in a value chain, typically intermediary producers in a particular value chain may feed into a number of different value chains.

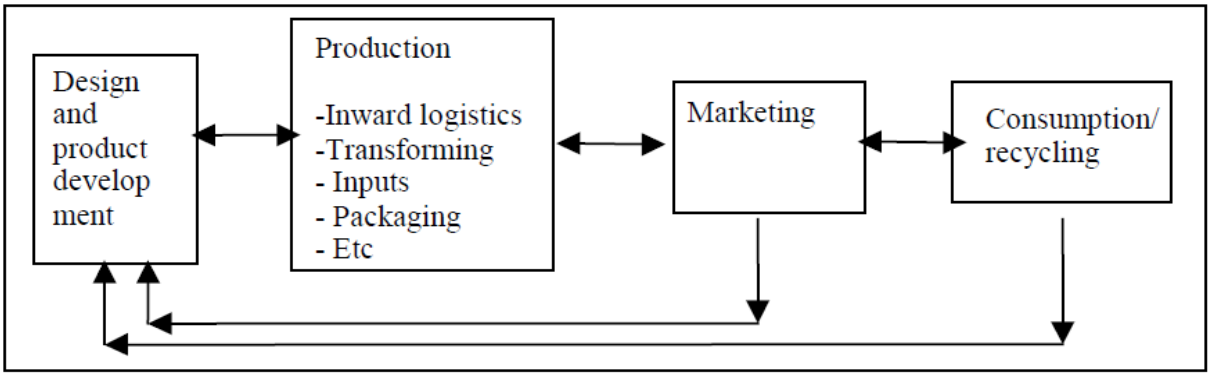


Figure 2.1: Four links in a simple value chain.

Source: [24]

Moreover, according to Anna and Tina (2010), value chain is defined as the interlink of activities and actors that realize the various steps of primary production of raw material to the manufacturing, branding and retailing of a consumer-ready product.

Porter (1986) went even further by linking up the value chains between firms to form what he called a value system. In this way, a value system integrates a firm's value chain, a firm suppliers' value chains and firm customers' value chains. However, in the current context the linkage between multiple firms' value creating processes has more commonly become known as the value chain. As this name implies, the primary focus in value chains is on the benefits accruing to the participants, especially companies: effective value chains generate profits.

2.4 Coffee value chain maps

Simplified structures of the coffee value chain maps are developed by different researchers. Their value chain maps are developed through two approaches, which are by considering value chain actors or main value chain activities. These structures had a similarity in their contents of value chain activities such as production, primary processing, trading or import, secondary processing and retailing; and similarities in contents of value chain actors such as producers, processors, traders, exporters, importers and trailers. Also some of the researchers were trying to include value adding activities under each main value chain activities as summarized below.

In its journey from tree to cup, coffee passes through the hands directly or indirectly of several players in the commodity chain. This value chain runs threadlike through a number of sequential steps, supported tangentially by production networks like machine manufacturers and transport services, all of which are essential to getting the finished product to its destination. According to Jha *et al*. (2011), growers, processors, exporters, importers, roasters, distributors and retailers from the normal categories of those involved, with repetitive handler groups (except for producers and roasters) being inserted in the chain in some cases. The value chain map developed by these researchers is presented as follows in figure 2.2.

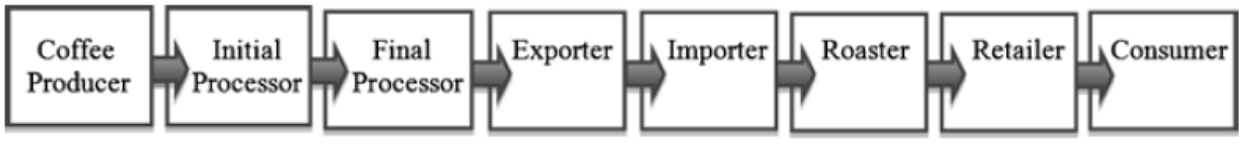


Figure 2.2: The coffee commodity chain map based on value chain actors

Source: [26]

In Kenya farmers, especially smallholders, are mostly involved in production. The value adding activities at production stage includes land preparation, fertilizing, spraying, tools maintenance and harvesting. For large farms, facilities maintenance and irrigation constitute additional activities. At the farm level, producers receive extension services and relevant inputs from Coffee Research Foundation (CRF) and from private sector traders. Once the coffee cherries are harvested, they are transported to the factories for processing (dry or wet processing) and subsequently to commercial millers for milling and grading. After the milling and grinding process the seed or bean obtained are dried the appropriate moisture contents. Then the coffee beans pass through the grading process. The graded beans are passed to the marketing agents who market them for auction at the Nairobi Coffee Exchange (NCE). Traders consequently purchase from the auction and sell to the exporters [22]. He also developed coffee value chain map for Kenyan in figure 2.3 below, that could represent the above explanation in his study.

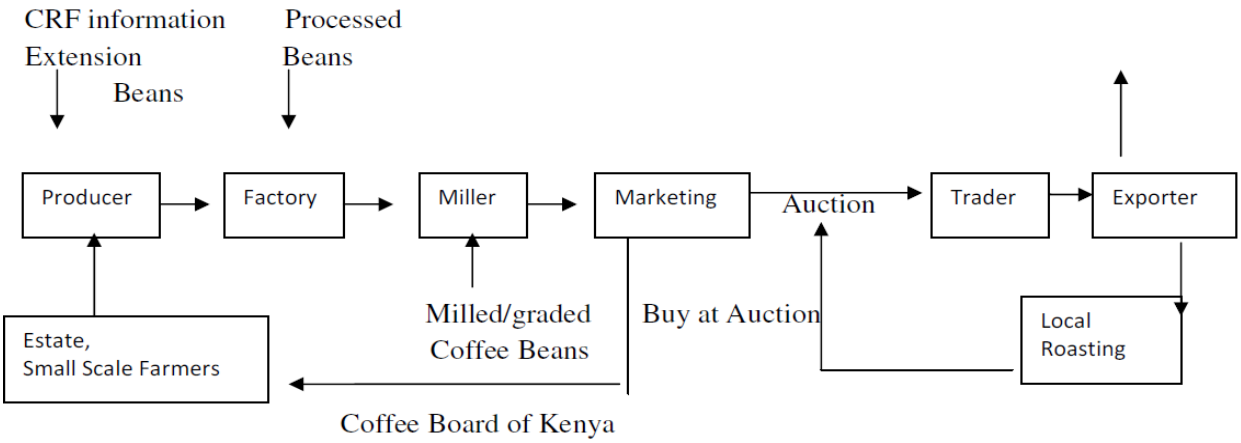
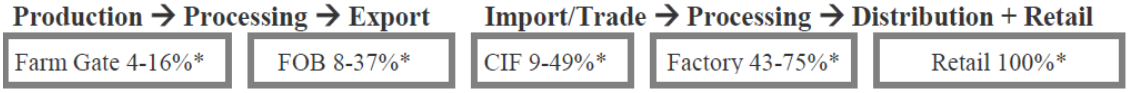


Figure 2.3: Coffee value chain in Kenya based on value chain actors.

Source: [22]

Anna and Tina (2010) developed value chain map depending on value chain activities by dividing it into two groups, which are in coffee producing countries before export and in coffee importing countries after import. Their coffee value chain map is presented as follows in figure 2.4.



* Percentage of final retail value.

Figure 2.4: Coffee value chain map developed based on coffee value chain activities

Source: [25].

Similarly Birhanu *et al.* (2013) developed a structure that have main activities and detail value adding activities in the Ethiopian coffee value chain as presented in figure 2.5 below.

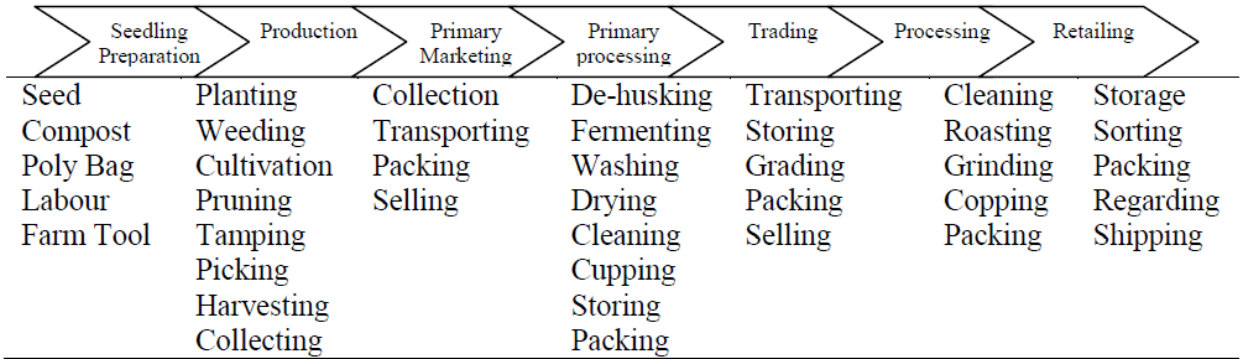


Figure 2.5: Coffee value chain map depending on main coffee value chain activities

Source: [5].

Accordingly, since this study focuses on Ethiopian coffee value chain, the researcher found out that coffee value chain map developed by Birhanu *et al.* (2013) for Ethiopian coffee is better to use for this study to analysis the performance of Ethiopian National Quality Infrastructure in production and primary processing activities of coffee value chain depending on the data collected. More than the map is developed for Ethiopian coffee, it has detail of value adding activities in each of main coffee value chain activities which can use for further investigation.

2.5 Constraints to NQI

Constraints to the successful development and implementation of NQI include overly restrictive, mandatory, top-down standards; political conflicts of interest and interference; lack of harmonization with international standards; limited financing; and lack of qualified personnel [11]. These are discussed as follows:

2.5.1 Overly Restrictive, Mandatory, Top-down Standards

While most products and services in Organization for Economic Cooperation and Development (OECD) countries need only comply with voluntary standards, this concept remains foreign to many developing countries, where thousands of products must comply with mandatory technical regulations with no clear impact on social welfare. Often technical regulations are imposed from the top down, with little involvement of industry and other stakeholders. Such a process tends to produce regulations that can be overly prescriptive and do not comply with international trade requirements.

Such overly restrictive and mandatory technical regulations stifle trade. Countries should minimize such restrictive measures to only what is necessary for safety and health. Restrictive measures also stifle innovation and make it difficult for firms to develop or import new products that do not meet existing and often outdated standards.

2.5.2 Political Conflicts of Interest and Interference

In some countries, the NQI system is centrally controlled by the state and the same institution is responsible for the conducting standard development, certification, and accreditation activities, posing a significant conflict of interest. If the entire process is completely controlled by one organization, the overlap of commercial and regulatory functions and the discretionary powers of the organization to control the certification market creates considerable conflicts of interest.

Developing an effective NQI system requires separation of functions, often accompanied by changes in the legal status, autonomy, and governance structure of NQI bodies. However, removing political interference and conflicts of interest can be very difficult, because existing institutional heads have a stake in maintaining the status quo. Moreover, existing NQIs are often tied to political economy considerations, discouraging reform.

2.5.3 Limited Financing

Particularly in developing countries, funding constraints, combined with a failure by the government to appreciate the importance of the NQI, can limit the resources available for reform. NQI upgrading requires a significant time and financial investment. The funding needed for the development of a standardization system alone, including expertise transfer, development of technical committees, and purchase of information technology. Most of the operating costs of the standards body must also be covered by the government. Although membership fees and sales of standards generate income, it is unlikely to be sufficient to cover operating costs in most small economies and in economies where demand for voluntary standards remains low.

At the firm level, limitations in time and financing impede implementation of an NQI system. Implementation time depends on many factors, including the level of complexity of the company, level of quality in production, the skill level of personnel, and the degree of management commitment to upholding standards.

2.5.4 Limited human capacity

An effective NQI system and the quality of the services offered are directly dependent upon the quality of a firm's human capital. Companies in many developing countries lack technically qualified personnel and cannot provide competitive salaries to attract and retain skilled staff.

In more technical areas like metrology, specialized personnel are needed to guarantee the reliability of an NQI system. To ensure accurate measurement, well-equipped laboratories, as well as scientific personnel with specialized training and research experience, are needed. Similarly, the objectivity of the accreditation and conformity assessment processes largely depends on the quality of the technical staff.

2.6 Fair quality Green Coffee for Reference

Coffee is a general term for fruits and seeds of plants of the genus Coffea, generally cultivated species, as well as products from these fruits and seeds in different stages of processing and use, intended for consumptions [27]. Green coffee is the raw beans (seeds) found as products from coffee plants. Fair quality of wet and natural dry processed Arabica and Robusta presented in figures 2.6 to 2.9 below [28].

Figure 2.6: Arabica Washed Wet Processed Fair Quality

Figure 2.7: Robusta Washed Wet Processed Fair Qualit

Figure 2.8: Arabica Natural Dry Processed Fair quality

Figure 2.9: Robusta Natural Dry Processed Fair Quality

2.7 Green Coffee Defects and their Definitions

There are so many green coffee defects that can affect raw and cup quality of green coffee. According to Wintgens (2004) [28], some of these defects are presented with their definition and pictorial description as follows:

Figure 2.10**:** Dark brown beans

Dark brown beans: Brown to black marked bean, shriveled, crinkled and ragged. Scarred by the Antestia attack or blight whilst immature.

Figure 2.11: Amber beans

Amber bean: Smooth yellowish coffee bean, usually semi-trains lucid.

Figure 2.12: Elephant beans

Elephant beans: unusual large bean, spherical in shape.

Figure 2.13: Triangular beans

Triangular beans: Triangular in transversal section.

Figure 2.14: Pea beans

Pea beans: coffee beans practically oval in form.

Figure2.15: Flaky beans

Flaky beans: usually very thin beans, light ragged, flaky in appearance and small in size.

Figure 2.16: Immature beans

Immature beans: small, "boat-shaped" bean with a wrinkled surface. Final color of beans ranges from a metallic green to dark green or almost black with a glossy silverskin, depending on the drying conditions. The bean has a very adherent silverskin. Cell walls and internal structure are not fully developed. The beans are smaller than mature beans.

Figure 2.17: Black beans

Black beans: Coffee bean of which more than 50 % of the external surface and interior is black. Coal-like aspect and dull color with a granules external surface and often small-sized beans. Adherent silverskin, undesirable appearance, enlarged center-cut, slightly shrunken and often "boat- shaped".

Figure 2.18: Withered beans

Withered beans: Beans that are light in weight and wrinkled.

.

Figure 2.19: Blotchy beans

Blotchy beans: Coffee bean showing Irregular greenish, whitish or sometimes yellow patches.

Figure 2.20: Foxy beans

Foxy beans: Beans with foxy (oxidized reddish to light-brown) silver skin. The reddish visual color is particularly noticeable in the center-cut. Regular surface structure, normal size and shape. Mainly silver skin is affected.

Figure 2.21: Pulpier nipped beans

Pulpier nipped beans: Wet-processed bean cut or bruised during pulping, often with brown or blackish marks resulting from with brown or blackish marks resulting from secondary microbe attacks.

Figure 2.22: Beans in parchments

Beans in parchment: coffee bean entirely or partially enclosed in its parchment (endocarp).

Figure 2.23: Dried coffee cherries

Dried coffee cherries: dried fruit with outside envelopes containing the beans.

Figure 2.24: Beans fragments

Beans fragments: fragments of coffee beans With volumes of less than half a whole bean.

Figure 2.25: Broken beans

Broken beans: Fragments of beans with half a volumes equal to or greater than whole bean.

Figure 2.26: Spongy beans

Spongy beans: Whitish-colored bean

Figure 2.27: White floater beans

White floater beans: Bean that floats in water a

with a corklike consistency. Can be indented with a finger-nail.

because of its very low density when compared to healthy bean. White in color and more bulky than the normal bean.

Figure 2.28: Mouldy beans

Figure 2.29: Slightly insect damaged beans

mouldy beans: Coffee beans Which show mould growth which is visible to the naked eye. Releases typical mouldy odor.

Insect damaged beans: Beans with three or less holes or tunnels, beans with more than three holes and tunnels and beans with one or more alive or dead insects shown in figures 2.20, 2.21 and 2.22 respectively. Diameter of the holes larger than 1.5 mm.

Figure 2.30: Heavily insect damaged beans

Figure 2.31: Insect infested beans

Figure 2.32: Piece of parchments

Figure 2.33: Piece of husks

Piece of parchment: Fragment of dried endocarp (parchment). Parchment is often spotted by pulp pigment in dry processed coffees.

Piece of husk: Fragment of the dried external envelope (pericarp). Husk and parchment often knit together.

2.8 Previous studies on coffee quality and gap analysis

2.8.1 Previous studies

Quality is an important attribute of coffee. In table C1 under **Appendix C**, different studies conducted in different situations that could influence coffee quality positively or negatively were revised. All are summarized as follows.

To summarize, the first three consecutive studies from the table C1 focusing on the impact of shade and shade intensity on both raw and cup qualities of coffee. The first study conducted by Muschler (2001) compared coffee quality of *Coffea arabica* L. vars. Caturra and Catimor 5175 under different levels of shade in a low-elevation, sub-optimal environment for coffee in Costa Rica. As a result, he found that fruit weight and bean size increased significantly when shade intensity was increased. Also, he suggested a stronger shade benefit for Catimor than for Caturra. According to his blind tasting experiment, consistent shade also induced improvements in appearance of green and roasted coffee as well as in acidity and body of the brew for both varieties, except aroma of the brew were neutral for Caturra and slightly negative for Catimor.

Adugna *et al.* (2011) investigated growth and productivity differences between coffee plants growing under shade trees with direct sunlight. From the comparison he found out those coffee plants grown under shade trees were protected against high soil temperatures and low relative humidity, had improved photosynthesis and increased leaf area index, and produced larger and heavier fruits with better bean quality than those grown in direct sunlight.

In a similar way, to analyze the effects of shade on physical and sensorial cup quality of Coffea arabica L. CV. Caturra KMC, a study carried out by Aske *et al.* (2009) in Timana´ and Oporapa in Huila state, Colombia under shade cover variation while minimizing the variability of the environment, agronomic management and post-harvest processing. Their results showed that in Oporapa, situated at high altitudes, shade had a negative effect on fragrance, acidity, body, sweetness and preference of the beverage, while no effect was found on the physical quality. In Timana´, situated at lower altitudes, shade did not have a significant effect on sensorial attributes,

but significantly reduced the number of small beans means improved physical quality. Also, this study revealed the occurrence of berry borer was lower at high altitudes and higher under shade.

Moreover, Peter *et al.* (2011) investigated coffees from denser shade scored higher quality than lower levels of shade.

The second five consecutive studies next to the first three studies revised in the table C1 revealed influence of climate change on coffee production and quality. Joel (2014) studied the ways that climate change impacts Colombia and Ethiopia. Their study specifically investigated that there was an increase of coffee leaf rust and the drastic population increase of the coffee berry borer (insect feeds on the berries of coffee plants) due to increased temperature in these both countries that were negatively impact coffee production and quality.

On the other hand, Davis *et al*. (2012) were used distribution data to perform bioclimatic modelling and examine the future distribution with the HadCM3 climate model for three emission scenarios (A1B, A2A, B2A) over three time intervals (2020, 2050, 2080). The results of the models shown that a profoundly negative influence on indigenous Arabica. In a locality analysis the most favorable outcome is a 65% reduction in the number of pre-existing bioclimatically suitable localities, and at worst an almost 100% reduction, by 2080. In an area analysis the most favorable outcome is a 38% reduction in suitable bioclimatic space, and the least favorable a 90% reduction, by 2080. Based on known occurrences and ecological tolerances of Arabica, they suggested that bioclimatic unsuitability would place populations in peril, leading to severe stress and a high risk of extinction.

The review article made by Camargo (2010) generally shown that climatic factors such as adverse air temperatures happened during different growth stages of coffee plants could affect the productivity. Solar radiation and relative humidity also influenced many physiological processes of the coffee trees. Intergovernmental Panel on Climate Change (IPCC, 2007) report that the global temperature is supposed to increase 1.1ºC to 6.4ºC, So that this suggested researchers as a cause for a strong decrease in the coffee production in Brazil.

Moreover, Juliana *et al.* (2012) investigated that Environmental factors such as temperature, rainfall, altitude and latitude strongly influenced the quality of the coffee. The chemical variable acid-5-cafeiolquinic, and the environment variable's humidity index and temperature were factors

discriminated the drinking quality of sun-dried coffee while the temperature was mostly contributed to the discrimination of peeled coffee quality. In general, they investigated that the higher the altitude, the higher the quality of coffee and in lower latitudes, the influence of altitude on producing the best quality coffee was lower.

At final, Susana *et al.* (2003) found out that espresso coffee quality depends upon extraction temperature used in preparing it. Among the investigated water temperature (88, 92, 96 and 98^{o}C) on the final quality of three types of espresso coffee (Arabica, Robusta natural and Torrefacto blend), 92^{o}C was the optimal water temperature for Arabica and Robusta natural blend, and 88^{o}C for Robusta Torrefacto blend espresso coffee.

The next to the five studies discussed above under climate change, six consecutive studies from the table C1 are dealing with the influence of coffee quality arising from poor pre-harvesting and post-harvesting practices. According to Birhanu *et al.* (2013), the causes for the poor quality of Ethiopian coffee are mainly associated with harvesting and post-harvesting practice including collection, dry and wet processing, storage and transportation.

In the article review made by palmiro and Franca (2016) the quality of coffee beans depends on optimized protocols of cultivation, ripe berry collection, removal of the outer fruit layers by dry or wet processing and moisture reduction. Also storage and shipment represent two steps where bean quality needs to be preserved by preventing fungal contamination that may impact the final product and form mycotoxins, mainly ochratoxin A.

As a study conducted by Mohammedsani (2015) on coffee samples from Machera agricultural center in Hararge, Ethiopia, the combined effect of harvesting and post-harvest processing methods significantly influenced bean size and roast volume change. His further investigation shown that the effect of harvesting significantly influenced all roasts, raw and cup quality attributes except odor, while post-harvest processing methods was significantly influenced all unwashed coffees' quality parameters, except odor and all washed coffees' raw quality parameters non-significantly.

Anwar (2010) and Mekonen (2009) investigated that which coffee processing methods (wet, semi-washed and sun dried) have better attributes of coffee quality depends on samples taken from Sidama and Yirgacheffee types. As a result wet method significantly improved coffee quality than

the others two practices and resulted in better overall quality, citric, and spicy taste for Sidama and citric floral with more acidity for the Yirgacheffee coffees. Dry processed coffee had more viscous and mouth full body, flavor and creamy test while the semi-washed coffee had intermediary result. In general, they concluded that coffee quality improvement due to processing techniques followed the descending order of washed, semi-washed and sun dried. According to Anwar (2010), based on field survey obtained from coffee farmers in Jimma zone, compost application, mixing up of differently harvested coffee during selling, availability of inappropriate storage, drying materials used for drying and age of coffee in the store also were investigated as a source on coffee quality problems.

The research conducted on coffees from the highland area of Rio de Janeiro state in Brazil revealed that Ochatoxin A (metabolite produced by Aspergillus and Penicillium species that is nephrotoxic and carcinogenic to humans) contamination of coffee resulted from samples that were harvested directly from the soil. Also Ochtoxic A levels between different ripe stages of coffee's fruits were not significant [38].

The rest of the studies presented in the table C1 next to the six studies discussed above on the influence of coffee quality arising from poor pre-harvesting and post-harvesting practices are generally summarized as follows. Coffee verities, location and maturation investigated as source coffee quality. According to Mekonen (2009), Coffee genotypes in Ethiopia such as 9744 and 9718 were a superior at Awada; 9718, 979 and 85294 were the best Sidama types at Korke; and Yirgacheffee types 9744, 9718, and 9728 were the best in physical, cup quality and character. In other hand, maturation clearly favored the development of high-quality flavor in the coffee brew, but a subclass of green coffee can generate high-quality coffee flavor irrespective of maturation [40].

Finally, diseases were investigated as source of coffee quality problems. According to Anwar (2010), disease prevalence in coffee field were affected the coffee quality. On the other hand, the study conducted in three major coffee growing districts (Abaya, Bule Hora and Kercha) of Borena and Guji zones, revealed that high occurrence, distribution and contamination of Coffee Berry Disease (CBD) caused by C. kahawae in the study areas that threatened coffee production [7].

2.8.2 Research gaps

After all, as discussed above in different studies concerning on different aspects that can influence coffee quality positively or negatively are conducted throughout the world. To summarize, among these studies some of them investigated that shade as one factor affected coffee quality. Its effect studies in different form such as comparing of coffee quality under shade and in direct sunlight, and under denser and low levels of shade. The other studies revealed that climate change such as global warming effects on coffee quality and production in existing and future world by using different climatic models. Also, different poor pre-harvesting and post harvesting such as inappropriate application of compost, harvesting ripe and unripe coffee together, harvesting from the ground, poor processing method and poor storage and transportation management are studied as source of coffee quality problems. Moreover, location, slope position, genotypes (coffee varieties), maturation and prevalence of disease such Coffee Berry Disease are investigated as another source of coffee quality problems. However, national quality infrastructure (NQI) or each of its elements are not considered as source of coffee quality through all these studies.

To say more, even though all the above parameters were studied by different researchers as the source of coffee quality that can influence positively or negatively, no one could considered influence of lack of national quality infrastructure (NQI) or low performance of NQI on coffee quality in any activities of coffee value chain. Moreover, each of the above studies throughout of its parts did not consider any NQI elements (standards, metrology, test, certification and accreditation) influence on coffee quality through all activities of coffee value chain separately or together. This is missed at national level as well as at international level. Therefore, this research is aimed to focus and conduct on the performance of NQI in production and primary processing of coffee value chain in Ethiopia in order to achieve the qualified coffee products for the local and export markets aimed to satisfy customers, and enables to increase export quantity to gain more foreign currency.

2.9 Background of Ethiopian National Quality Infrastructure

2.9.1 Authoritative bodies for Ethiopian National Quality Infrastructure

The National Quality Infrastructure (NQI) guarantees reliable industry standards and norms in order to ensure high-quality products are available for Ethiopian consumers and the export sector. The NQI organizations take international standards and guidelines as their point of reference, for example to certifying Ethiopian products. In that way, the Ethiopian industry is supported in increasing its competitiveness in international markets. Now a days, since the Ethiopian economy is experiencing strong growth and is also becoming increasingly active in international markets, demands for good quality of products, services and processes are increasing. To answer this demand, the country needs a well-functioning quality infrastructure so that international standards and industrial norms can be enforced. Therefore, the Ethiopian Government is reforming the NQI. This reform is supported by the German development cooperation. Also the reform was made to comply with the rules of the World Trade Organization (WTO), by reconstructing Quality and Standards Authority of Ethiopia (QSAE) into four separate organizations in February, first 2011 and put them under the direction of the Ministry of Science and Technology [1]. To list, they are an Ethiopian Standard Agency (ESA), Ethiopian Conformity Assessment Enterprise (ECAE), Ethiopian National Metrology Institute (ENMI) and Ethiopian National Accreditation Office (ENAO). The Ethiopian parliament also has adopted the NQI reform, which is now being implemented. The new structure meets WTO requirements. Better quality products and services increase the consumers' standard of living and the competitiveness of the Ethiopian economy.

Ethiopian Standard Body has undergone several structural and name changes since its first birth back in 1970, and Ethiopian Standard Agency (ESA) was established as per the latest restructuring, as per Ethiopian Council of Minister Regulation No. 193/2010. ESA was the National Standards Body (NSB) of Ethiopia, responsible for developing, publishing and maintaining national Ethiopian Standards. It represents Ethiopia in the international standardization affairs - member of the ISO and other international and regional standardization bodies. It also, in collaboration with concerned regulatory bodies, develops compulsory / mandatory Ethiopian Standards and Regulations which are to be approved by the National Standardization Council. Besides, it carries out promotional activities, training and technical supports to facilitate for the implementation of standards. It is the owner of and administers certification schemes and the National Standard Mark, and also is responsible for the administration of National Quality Award System [41].

The National Metrology Institute (NMI) of Ethiopia is established by the Council of Ministers regulation No. 194/2010 since 10th February 2011. The Institute has a responsibility to develop a national metrology system compatible with the international metrology system and ensure technology transfer in the sector, establish and implement a system that enables to compare Ethiopian National Measurement Standards and Certified Reference Materials with international Measurement Standards and to maintain and disseminate them, support education and research activities in the field of metrology, build national capacity for maintenance of scientific instruments and provide maintenance services, and provide technical training, consultancy and information services on scientific equipment with a view to supporting users to carry out their duties. National calibration services are also given by this institute [42].

The Ethiopian Conformity Assessment Enterprise (ECAE) was established as a federally owned public Enterprise, governed by the Ministry of Science and Technology to organize robust Certification, Inspection and Laboratory testing Services. ECAE is at present the major conformity assessment organization in the country, providing inspection, testing and certification services to public and private industries and it is the only national certification body which has certification capabilities in the areas of the System Certification (ISO 9001) and Product Certification [1].

Ethiopian National Accreditation Office (ENAO) was established as an autonomous federal government office having its own legal personality with the mandate to accredit the competence of Conformity Assessment Bodies (CABs) to perform specific activities, such as test, calibrations, certifications or inspections as formal third-party recognition. As the national accreditation body, ENAO is responsible to give accreditation services to laboratories (test and calibration), certification and inspection bodies, both domestic and foreign, that operate both within the borders of Ethiopia and outside its borders in countries where either no national accrediting body exists or lacks the capability to accredit in a specific field. Also, it establishes an accreditation symbol which may be used by accredited organizations in accordance with ENAO requirements; conduct surveillance assessments on accredited organizations; maintain and publicize directories of accredited, suspended and revoked organizations; and ensure that relevant regulatory bodies are informed of updates regarding the accreditation status of ENAO's accredited organizations. Moreover, it cooperate with relevant stakeholders to develop integrated and internationally recognized quality infrastructure wherein accredited organizations' services are recognized globally; develop accreditation services that promote, develop and maintain good regulatory

practices; represent Ethiopia's interests in international forums concerning accreditation through bilateral and multilateral agreements, and offer trainings related to accreditation services to bring high level of competency. In turn, ENAO itself shall maintain conformance with ISO/IEC 17011 standards [43], [1].

The four Institutions, which are described above, deal with the so called voluntary parts of NQI. The mandatory part of the new NQI landscape is allowed to put sanctions to substandard activities and fall under the premises of Ministry of Trade (MoT). There are three Institutions under the premises of Ministry of Trade working belongs to these targets. The first is an Inspection and Regulatory Affairs Directorate, which is established to overcome the product and service quality problems and to avoid the problems observed in the prevailing market system. The Directorate shall have four teams, these are Import Export inspection team, market surveillance team, legal metrology team and market intelligence and basic commodity control team. The other premises of MoT are Trade Practice and Consumer Protection Authority, which is established for the purpose of controlling unfair competition in market and to benefit consumers by getting a good quality product and service in fair price. The Technical Regulation Coordination Directorate is the final premises of Ministry of Trade to discuss, which is established to avoid the coordination problem among different regulatory bodies. The Directorate shall be responsible to MoT and it shall form a forum where all stakeholders shall take part and evaluate their performance [1].

2.9.2 Ethiopian National Quality Infrastructure in coffee sector

2.9.2.1 Ethiopian National Standard Agency's standards for coffee

As stated above, the Ethiopian Standard Agency is responsible to develop and publish Ethiopian standards. Accordingly, this agency developed and published Ethiopian standards for the coffee sector. According to the data collected from secondary sources, a total of 31 lists of standards are available at the Ethiopian Standard Agency on coffee sector only. Among these standards, 17 standards are adopted from ISO standards and the rest 14 are Ethiopian self-standards. All of the adopted standards mainly focus on final products (green coffee and roasted ground coffee). Among the adopted ISO standards 15 standards are focused on green coffee only, which are discussed about how to sampling coffee in bags, guide to storage and transport, size's analysis, determination of caffeine content, moisture contents, insect damaged beans, and loss in mass at 70 and 105^{o}C, olfactory and visual examination and determination of foreign matter and defects, etc. The rest two

standards from the adopted ISO and one from national standard (ES) are focus on roasted ground coffee and roasted coffee beans that are not considered under this study, which are stated about how to determine moisture contents with two different methods (Karl Fischer and loss in mass at 103^{o}C) and about the specification of roasted coffee beans and roasted ground coffee.

Ethiopian own standards (ES) are 14 in number. Out of these, 13 standards are discussed about the way to assess quality of dry coffee cherry, green and instant coffee, method of green coffee packing and sampling, instant and green coffee specifications, arrival and export of green coffee classifications, guide to preparation of green coffee, etc.

Since the researcher identified that defect point is the main causes of the coffee quality problem from data analysis in chapter 4, the study tended to focus on what types of defects and at which main activities of the coffee value chain the problems happened. Therefore, among the adopted ISO and ES standards listed in tables A1 and A2 under **Appendix A**, some standards that are highly related to any aspect of defects is also presented detail under this appendix for clarity. But due to confidentiality the others are not allowed to preset the detail.

2.9.2.2 Awareness creation made by Ethiopian National Accreditation Office

Ethiopian National Accreditation Office was established in 2011. It is a third body that accredits the certified organizations, products, laboratories, personnel, etc. depending on their willingness (it is not mandatory). According to the secondary data collected from this office, awareness creation is made in many different sectors including coffee sector from 15/04/2004 to 29/06/2009 E.C in different regions and places of the county. Also the manager and one of the group leader of the office explained that there are organizations, laboratories, personnel and products accredited from different sectors such as health centers, commodity products, leather industries, etc. However, there are no any organizations, laboratories, personnel, systems, products etc. are accredited by the Ethiopian accreditation office from coffee sector. The total awareness creation made by the office in time interval mentioned above, including coffee sector is presented in table B1 under **Appendix B**.

ENAO sets minimum requirements for the operation of inspection bodies, calibration and testing laboratories in detail on its website. On the other hand, ISO 15189 vertical assessment form for medical laboratories, ISO/IEC 17025 vertical assessment form for testing/calibration/verification laboratories, ISO/IEC 17025 checklist for testing/calibration/verification laboratories, ISO/IEC

17020 checklist for inspection bodies, checklist for completeness of application and resource review, and activities' witnessing that are used during accreditation process are also available on the website [43].

2.9.2.3 Conformity assessment made by Coffee Quality Inspection and Certification Association (coffee Liquoring Units)

Coffee Quality Inspection and Certification Association is one of the conformity assessment body that can certify coffee products to be exported. Implies, it is the final conformity assessment body which is responsible for certifying the export coffee products at a national level. This center checked for mainly two quality parameters for both sun-dried and washed coffee. The first parameter is raw quality. This includes moisture content, screen greater or less than fourteen, defect point, odor and appearance. Screen is the percentage amount of the coffee products remaining on the screening sieve of 14mm size (diameter if it is circular) during sieving. Appearance is the overall raw quality (color, shape and make) when it is observed by inspectors. The second parameter is cup quality. Cup quality includes cup cleanness, acidity, body, and character (flavor). Most of the time sun-dried coffee prepared for grade 4 and 5, while washed coffee is for grade 1 and 2. The above parameters, their results marking and defect classifications are presented in the following tables 2.1, 2.2 and 2.3.

Table 2.1: Result marking classification

Raw Quality		**Cup Quality**				**Overall Quality**
Defect point	Odour	Cup cleanness	Acidity	Body	Flavor	
Good	Clean	Clean	Pointed	Full	Good	Good
Fair/Good	Trace	Light	Medium pointed	Medium Full	Fair/Good	Fair/Good
Average	Light	Moderate	Medium		Average	Average
Reject	Strong	Strong	Light		Reject	Reject

Table 2.2: Defect points classification for sun-dried coffee

	Ranges

Grade	Good	Fair/ Good	Average	Reject
4	26 – 30	31 – 38	39 – 45	> 45
5	46 – 60	61 – 75	76 – 86	> 86

Table 2.3: Defect point classification for both sundried and washed coffee

Grade	**Ranges**	
	Accepted	Rejected
1	0 – 4	> 4
2	5 – 12	> 12
3	13 – 25	> 25
UG	< 50 % defective	≥ 50% defective

2.9.2.4 Calibration made by the Ethiopian Metrology Institute on coffee sector

The Ethiopian National Metrology Institute give different trainings and perform activities of calibrations and maintenances for the organizations around the countrywide. Three systems are used by this institute to perform its day to day activities. These are permanent (customers bring their instruments to the institute's laboratories), on site (at a working place of customers) and mobile (by traveling place to place using their own trucks) systems.

The experts of this institute explained that in coffee sector only calibration of balances, sieves and moisture testers are provided. According to the data collected from daily recording books of permanent, on site and mobile activities, ENMI calibrated and certified a total of 4739 balances for 829 industries, 307 sieves for 34 industries and 172 moisture testers for 106 industries in 2009 E.C for all sectors, including coffee sector. Since the institute does not code them separately, it is difficult to preset the coffee sector data alone. Due to confidentiality, it is impossible to present the detail of the data under appendices.

CHAPTER THREE

3 RESEARCH DESIGN AND METHODOLOGY OF THE STUDY

3.1 Research Design

As shown in the figure 3.1 below, the research problem had been identified through literature review and existing situation coffee sector. To come up with a solution to this problem, appropriate research questions and objectives were carefully defined. To answer these research questions and to achieve the research objectives an appropriate methodology in which secondary and primary data were collected and analyzed were developed. Since the research conducted by considering the coffee value chain, an appropriate selection of coffee value chain map for the study was made from the reviewed literature. During this review, also the originality of this research was confirmed and the research gaps were identified based on the problem. By analyzing the collected data, the major Ethiopian coffee quality problems and at which main activities of coffee value chain these quality problems were happening were identified. Then after, NQI performance was assessed in the main activities of coffee value chain at where those major coffee quality problems were happening. Finally, based on the analysis and assessment results, clear understanding of the present status of Ethiopian NQI performance was found-out and an appropriate solutions were proposed followed by constructive conclusions and recommendations.

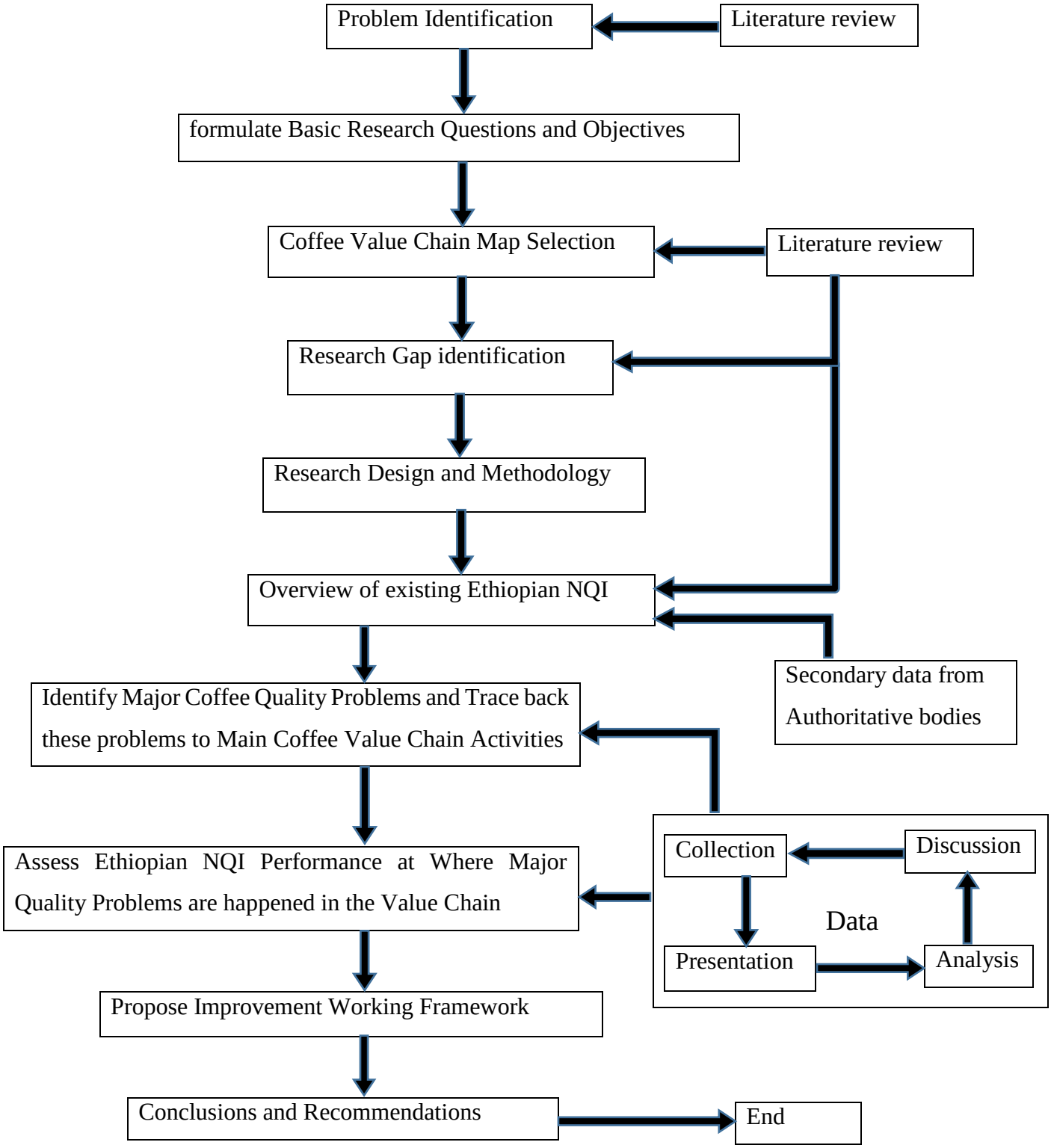


Figure 3.1: Research Design and flow Framework

3.2 Methodology

To assess the performance of Ethiopian NQI elements (standards, metrology, testing, certification and accreditation) in production and primary processing activities of coffee value chain, mainly coded secondary data such as list of standards, guidelines, procedures, annual reports, recorded data while performing assessment, etc. is collected from the respective bodies (Ethiopian Standard Agency, Metrology Institute of Ethiopia, Ethiopian Conformity Assessment Body and Ethiopian Accreditation office) . Also, secondary data are reviewed from reports, books, articles, websites and guidelines to form literature part. Primary data also collected through interviews and observations.

3.2.1 Data gathering techniques

I. The first technique is collecting secondary data. Mainly the research depended on Secondary data that are collected from the responsible bodies for Ethiopian NQI elements. This data includes a list of standards, guidelines, procedures, annual reports, documented files during works, etc. Specially, recent consecutive eight months coded secondary data of 2009 E.C from 'Coffee Quality Inspection and Certification Association (CLU)' were used as base for NQI performance assessment. This conformity assessment body is the final responsible body to confirm and certify the quality of Ethiopian export coffee at national level. The data collected from this institution were included both sun-dried and washed coffee fitted to export or not (in tons) and the reasons why they were felled.

II. Interviews were also used to collect primary data for clarity of secondary data and to gain certain additional information from selected respondents such as experts of NQI, coffee quality experts, managers of coffee sectors, coffee traders, technicians of machines etc. These interviewees were selected by their own managers depending on three criteria: that are having specialization in the specific area, having long time experience, and having deep knowledge and better performance confirmed by the managers during their work.

    Four experts of coffee production and processing activities including one manager and two group leaders of these activities were interviewed. These interviews were done to identify the relationship between NQI elements and currently existed root causes of coffee defects as well as to rank this relationship through Likert scale by considering which lack of or weakness of NQI elements were responsible for those existed root causes of coffee defects.

    The researcher also interviewed six interviewees from NQI experts, including one manager in each: two from Standard Agency working on developing standards; two from Metrology Institute working on calibration of dimensions, balances, moisture testers, temperature etc.;

two from Conformity Assessment Body working on assessing defects and counting, taking samples, testing cup quality etc. and two from Accreditation Office working on giving training, assessing competency organizations in testing, calibrations, and their laboratories as well through checklists. These interviews were included what they are performing in the main coffee value chain activities and their weakness through all value chain activities, especially in coffee production and processing.

Two coffee traders that have long time trading experience, having their own warehouses and transportation vehicles was selected, and interviewed about the storage condition and transportation systems in the coffee sector.

Also, three processing machine operators were selected and interviewed about their machines' adjusting, calibration and maintenance systems, and in how long time intervals these are done.

III. Observations were used as one of the techniques during the research. This is used to find information that are not dug out by interviews and secondary data, and to confirm the reality of information found from secondary data and interviews. The observations mainly include design and building of warehouses, storing (pilling) style of coffee in the warehouse, inspection and testing practices of warehouses, vehicles, conformity assessments of coffee quality, laboratories etc. These observations were made at coffee warehouses located in Addis Ababa city as well as the vehicles. Also, laboratory of agriculture for soil testing was observed.

3.2.2 Data Analysis

Responses of the interviews, information gained from observations were added to the secondary data collected from the respective bodies and it is used as an input for the data analysis. During the analysis, quantitative and qualitative analysis are used. The quantitative data are used to identify the main and root causes through comparing the quality measuring parameters listed in figure 4.1 based on number of quality problems score under these parameters. These causes are traced back (categorized) to coffee value chain activities to identify the main activities resulted with higher number of root causes (coffee quality defects). Then these main activities, with higher number of defects were used to assess the performance of Ethiopian NQI elements. Finally, this analysis ended up with finding out that which lack of NQI elements or weak performance of NQI elements are needing improvement through qualitative analysis based on data obtained from interviews and observations to upgrade coffee quality. During the analysis Excel 2013, tables, charts, figures, cause and effect diagram are used as tools.

CHAPTER FOUR

4 DATA PRESENTATION AND ANALYSIS

4.1 The major coffee quality problems in Ethiopian coffee value chain

According to the defect point classification standards presented in chapter 3 under the topic of 'Conformity assessment made by Coffee Quality Inspection and Certification Association', the Coffee Quality Inspection and Certification center (CLU) inspected and certified the coffee products that are ready to export. Accordingly, in the last eight months (02/01/2009 to 01/09/2009 E.C) the coffee products presented to export is 122,453.6 tons (81,265.2 tons sun-dried and 41,188.4 tons washed). Among this amount of products, 28, 470 tons (18,450 tons sun-dried and 10,020 tons washed) failed to export requirements. The amount of coffee products failed to export are presented in detail with its specific grades and the reason why it is failed for both sun-dried and washed coffee in the following tables 4.1 and 4.2. The reasons why these coffee products fell to export also presented in figures 4.1 and 4.2 in comparison form.

Table 4.1: Sun-dried coffee grades and reasons of rejection (population size = **2709** samples)

Grades	Samples failed due to Moisture content	Samples failed due to Screen ≥14	Samples failed due to Defect point	Samples Failed due to Odour	Samples failed due to Appearance	Samples failed due to Overall Result
1	Ranges from 9.5 to 11.3%	Greater than or equal to 95%	24		Rejected	Rejected
2			3	Stinky 2		
3			5			
4			112	Trace 18 Mouldy 1		
5			451	Trace 34 Mouldy 22 Naphtha 2 Solid smell 1		

Under Grade		≥ 92%	22			
Total	**0**	**0**	**617**	**80**	**All rejected**	**All rejected**

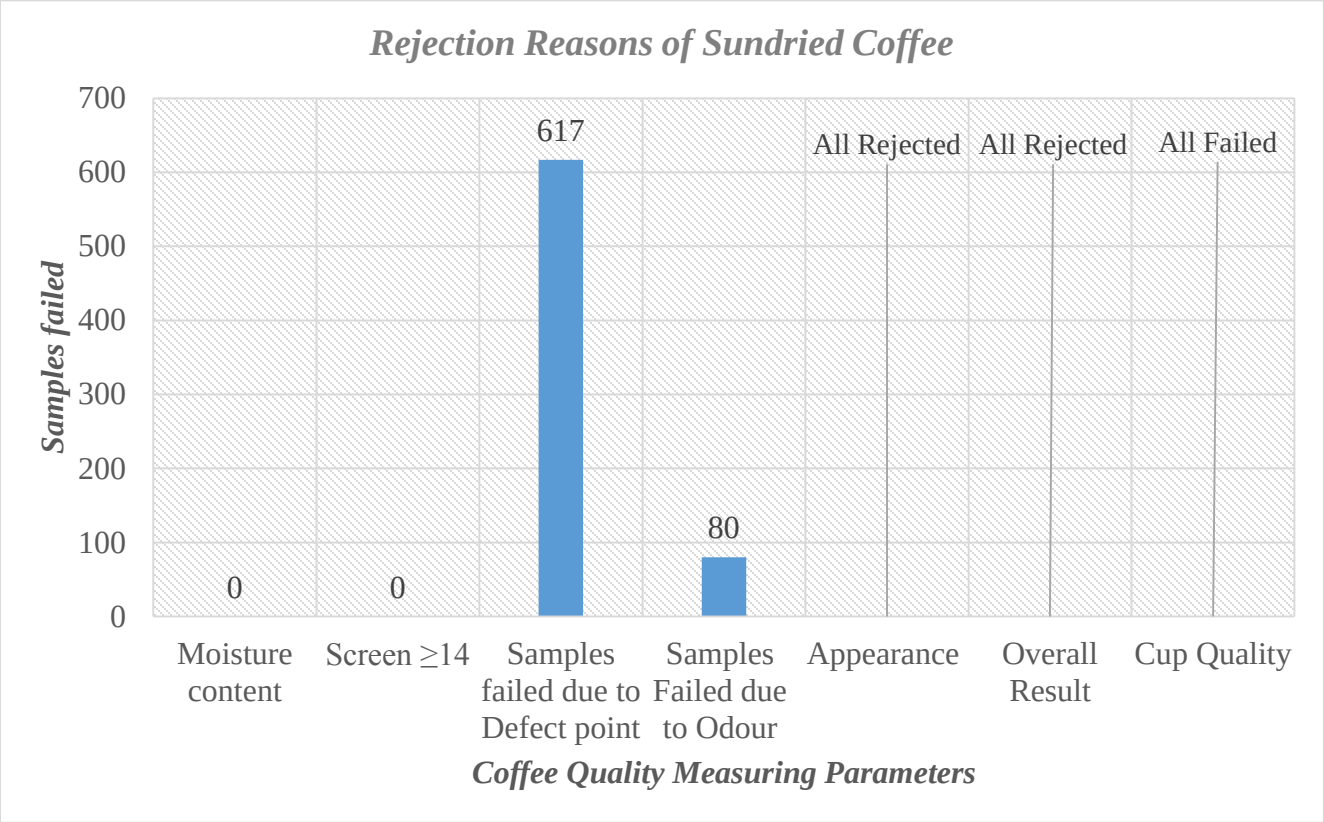


Figure 4.1: Comparison chart of rejection reasons of sundried coffee

From the above table 4.1, most of the samples failed due to defect point (defect count) in the sample. One sample represents or taken from 300 bags (30 tons) on average. Therefore, a total of 617 samples failed due to defects. On the other hand, out of 617 samples failed by defects 80 samples also failed by different types of odors. According to the conformity assessment manager and inspection experts, most of the time cup quality depends on raw quality. Implies, coffee products failed by raw quality also failed by cup quality. Also, they said that most of the time moisture content and screening fulfil the requirements of the export. In the same way on the table 4.2 below 334 washed green coffee samples failed due to defect point. Among these, 13 samples also failed by two types of odors.

Table 4.2: Washed coffee grades and reasons of rejections (population size = **1373** samples)

Grades	Samples failed due to Moisture content	Sample failed due to Screen ≥14	Samples failed due to Defect point	Samples Failed due to Odour	Samples failed due to Appearance	Samples failed due to Overall Result
1	Ranges from 9 to 11.1%	Greater than or equal to 95%	20		Rejected	Rejected
2			311	Stinky 12 Naphtha 1		
Under Grade			3			
Total	**0**	**0**	**334**	**13**	**All rejected**	**All rejected**

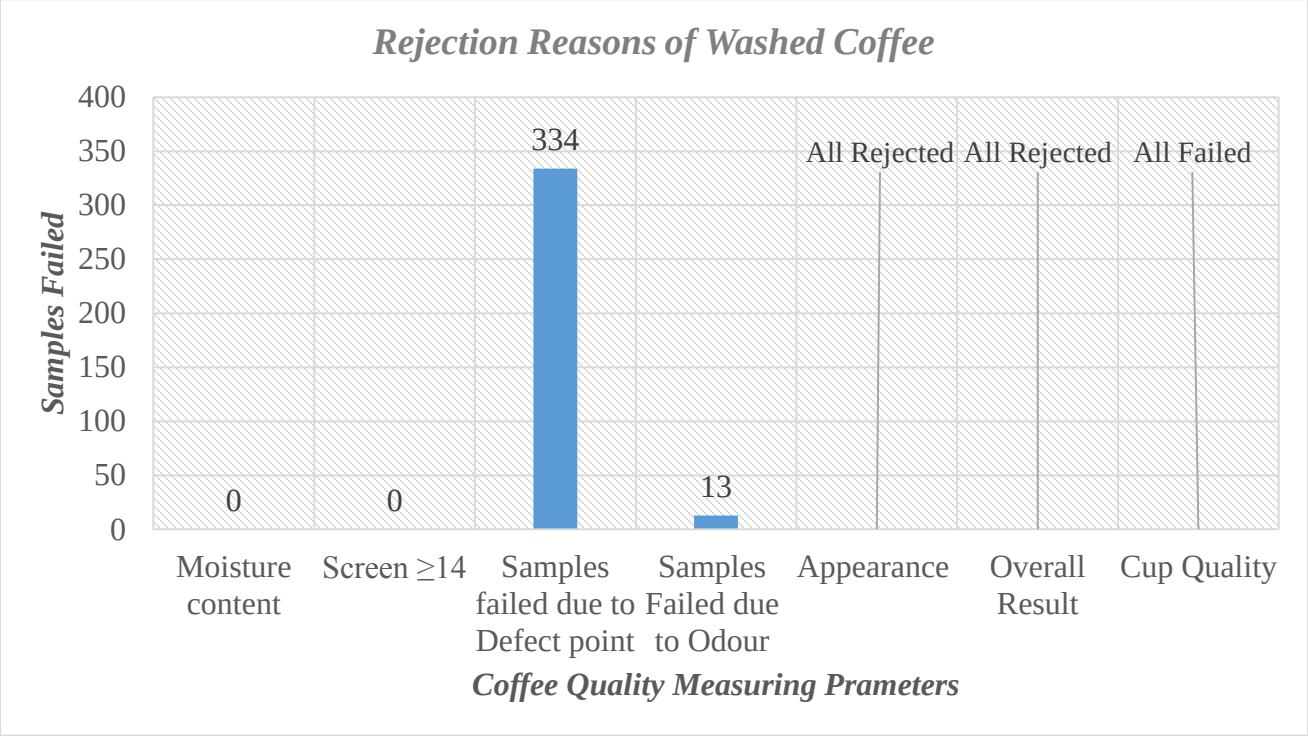


Figure 4.2: Comparison chart of rejection reasons of washed coffee

As presented above, different parameters such as raw quality (moisture content, screen, defect point, odor and appearance) and cup quality (cup cleanness, acidity, body and flavor) are assessed by a conformity assessment body to confirm the quality of the green coffee to export depending

on the standards. Depending on this data, among these parameters the main and the most quality problems of coffee products are raised from different types of defects listed in table 4.3 below. According to Ethiopian Standard Agency (2001), these defects have mainly three categories such as foreign matters, fragments of coffee and defective beans. Also, the main defects and their root causes are presented as follows in figure 4.3 by using cause and effect diagram depending on this agency's standards.

Table 4.3: List of defects resulting defect point

Defective Beans	**Foreign Matters**	**Fragments of Coffee**
Immature beans	Stones	Broken beans or bean fragments
Insect damaged beans	Wanza	Pulpier nipped beans
Black beans	Sticks	Piece of parchments or husk fragments
Beans in parchment	Earth aggregates	
Withered beans		
Dried coffee cherries		
White and yellow beans		
Dark brown beans		
Elephant beans		
Triangular beans		
Amber beans		
Spongy beans		
Pea beans		
Flaky beans		
Mouldy beans		
Foxy beans		
Blotchy beans.		

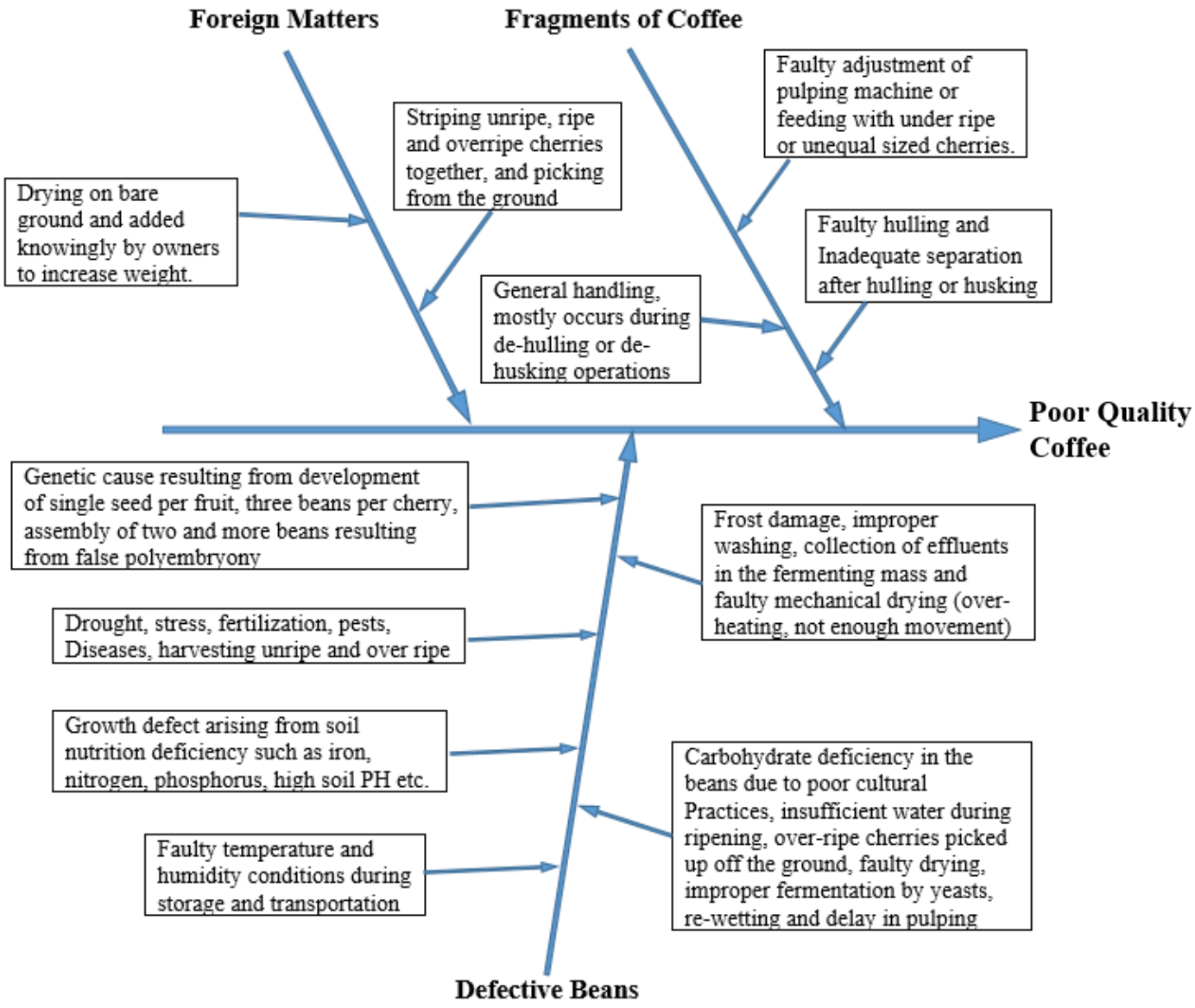


Figure 4.3: Cause and effect diagram for main and root causes of defects of coffee products.

The manager and conformity assessment experts (inspectors) explained that all these types of defects existed frequently during the quality assessment. Also the researcher observed the same thing during conformity assessment is performed by inspectors. During the assessments of defects, the inspectors separate each types of defect from one sample of coffee beans by pouring it on the table. After separating it, they count each types of defects separately and give them their corresponding defect point according to table A3 under **Appendix A**. Then they decided whether that sample is failed or not. If the sample is failed the whole lot from which the sample is taken also failed and vice versa.

4.2 Trace back the major coffee quality problems into the main activities of coffee value chain

As discussed in chapter 2 under the value chain map topic, Ethiopian coffee value chain map developed by Birhanu *et al*. (2013) presented on figure 2.5 that had seven main activities including seedling preparation, production, primary marketing, primary processing, secondary marketing, secondary processing and retailing was selected for this study by the researcher. This map is selected for the following three reasons; the map is developed based on Ethiopia's coffee value chain activities, based on the Ethiopia's coffee supply chain and have lists of sub-activities for each main activities of coffee value chain. Reviewed literatures revealed that all of quality problems of coffee products existed in these main activities of coffee value chain.

When those defects identified in table 4.3 and on fish bone diagram in figure 4.3 above were traced back to the main value chain activities, most of them are dropped under two main coffee value chain activities (production and primary processing). According to Wintgens (2004), eighteen defects of coffee listed as immature beans, insect damaged beans, black beans, withered beans, white and yellow beans, dark brown beans, elephant beans, triangular beans, amber beans, pea beans, flaky beans, foxy beans, blotchy beans etc. are happened under production activity. Also Wintgens listed sixteen of coffee bean defects such as insect damaged beans, black beans, beans in parchment, dried coffee cherries, white and yellow beans, spongy beans, mouldy beans, foxy beans, blotchy beans, broken beans, a piece of parchments, husk fragments, bean fragments, pulpier nipped beans, stinker beans etc. is existed under primary processing activity. The detail of these categorizations of defects to their respective six main activities of value chain was made by the researcher as follows in tables 4.3, 4.4 and 4.5 below.

Table 4.3: Categorize defective beans into appropriate main coffee value chain activities

Lists of Coffee Defects	**Main Coffee Value Chain Activities**						
	Seedling Preparation	Production	Primary Marketing	Primary Processing	Secondary Marketing	Secondary Processing	Retailing
Defective beans							
Immature beans		✓					
Insect damaged beans		✓	✓	✓	✓	✓	
Black beans		✓	✓	✓	✓	✓	
Beans in parchment				✓			
Withered beans		✓					
Dried coffee cherries				✓			
White and yellow beans		✓	✓	✓	✓	✓	
Dark brown beans		✓					
Elephant beans	✓	✓					
Triangular beans	✓	✓					
Amber beans		✓					
Spongy beans			✓	✓	✓	✓	
Pea beans	✓	✓					
Flaky beans	✓	✓					
Mouldy beans				✓	✓	✓	
Foxy beans		✓		✓			
Blotchy beans.		✓	✓	✓	✓	✓	
Total	**4**	**13**	**5**	**9**	**6**	**6**	
Relative rank	**5th**	**1st**	**4th**	**2nd**	**3rd**	**3rd**	

From table 4.3 above, for defective types of coffee beans, production is at where majority coffee beans defects are existed followed by primary processing activity. This shows that the main sources of coffee quality problems (defects) were located at these two main activities of coffee value chain.

Table 4.4: Categorize foreign matters into appropriate main coffee value chain activities

Lists of Coffee Defects	**Main Coffee Value Chain Activities**						
	Seedling Preparation	Production	Primary Marketing	Primary Processing	Secondary Marketing	Secondary Processing	Retailing
Foreign matters							
Stones		✓		✓			
Wanza		✓		✓			
Sticks		✓		✓			
Earth aggregates		✓		✓			
Total	**0**	**4**	**0**	**4**	**0**		
Relative rank	**2nd**	**1st**	**2nd**	**1st**	**2nd**		

In a similar way, table 4.4 above shown that production and primary processing were taken the first place by scoring a high number of foreign matters types of defects that leaded the researcher to focus on them.

Table 4.5: Categorize fragments of coffee into appropriate main coffee value chain activities

Lists of Coffee Defects	**Main Coffee Value Chain Activities**						
	Seedling Preparation	Production	Primary Marketing	Primary Processing	Secondary Marketing	Secondary Processing	Retailing
Fragments of coffee							
Broken beans or bean fragments		✓	✓	✓	✓	✓	
Pulpier nipped beans				✓			
Piece of parchments or husk fragments				✓		✓	
Total	**0**	**1**	**1**	**3**	**1**	**2**	
Relative rank	**4th**	**3rd**	**3rd**	**1st**	**2nd**	**2nd**	

Once again, in similar manner table 4.5 shown that the majority fragment types of defects are existed in primary processing.

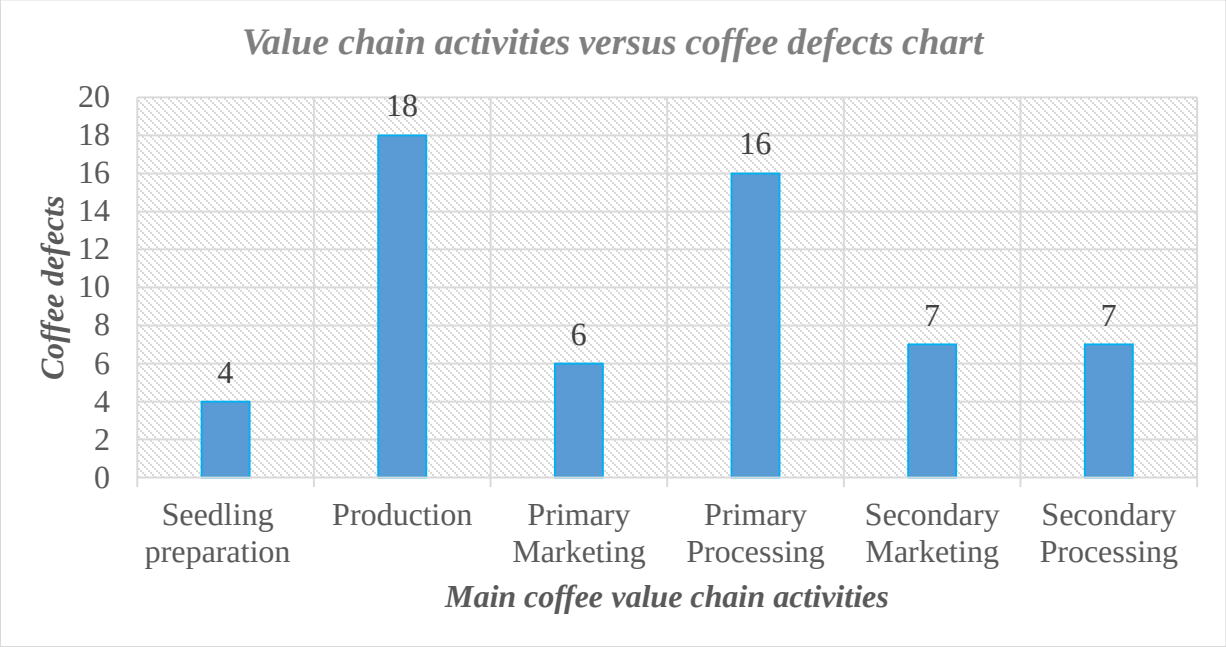


Figure 4.4: Main coffee value chain activities versus aggregate number of coffee defects

To summarize, in the figure 4.5 above the aggregate of each total result of the three consecutive tables 4.3, 4.4 and 4.5 shown that from the lists of main coffee value chain activities, production took the first place followed by primary processing with 18 and 16 number of defects respectively. These were followed by secondary marketing and secondary processing that are scored 7 numbers of defects. Finally, primary marketing and seedling preparation were taken the last ranks in descending order of their number of defects i.e. 6 and 4 respectively. Depending on these ranks, the researcher underlined production and primary processing as the first main sources of coffee quality problems much more than others main activities of coffee value chain. Therefore, in the next topic the focus of this analysis tended to consider these two main activities only in assessing performance of Ethiopian NQI in Ethiopian coffee value chain. Implies that, the research did not consider the rest of main coffee value chain activities afterwards.

4.3 Ethiopian National Quality Infrastructure Performance in Production and Primary Processing Activities of Coffee Value Chain

Among the main activities of the selected coffee value chain map, production and primary processing were identified by the researcher as main sources of coffee quality problem depending on the data collected, analyzed and discussed by relating it to literature. Therefore, under this topic the researcher has going to assess performance of NQI in these two main coffee value chain activities. During considering the two main activities, the whole lists of defects categorized under these two activities in tables 4.3, 4.4 and 4.5 under topic 4.2 were called once again to this topic to make the assessment. Accordingly, eighteen number of defects for production and sixteen number of defects for primary processing were identified. All of these defects were used to assess NQI performance in production and primary processing activities specifically. To do so, further analysis was made based on these defects to identify other farther root causes of each listed defects that are simple to relate with each element of NQI. According to Wintgens (2004), these farther root causes of each defects were identified and stated. These are presented by the researcher as follows in tables 4.6, 4.7 and 4.8 below, including further analysis by relating these root causes with NQI elements based on interviews' answers and observations. These relations are ranked by the researcher using Likert scaling method based on the responsiveness of NQI elements for the existence of these root causes of coffee defects.

The responsiveness of NQI elements for the existence of root causes of each coffee defect were ranked in tables 4.6, 4.7 and 4.8 below, by using the numbers defined below based on Likert scale concept:

1 = Strongly Agree

2 = Agree

3 = Neutral (Neither agree nor disagree)

4 = Disagree

5 = Strongly Disagree

Note: *1 represents the NQI elements ranked by one are strongly responsible for the existence of the respective root causes of the defects, means that those elements of NQI are not available in that area so that they cannot surmount their responsibility. This results lack of performance.*

Number 2 represents NQI elements are slightly responsible for the existence of the corresponding root causes of the defects that resulting weak performance of that NQI elements. In other hand, 4 represents that the corresponding NQI elements are slightly not responsible for the existence of the respective root causes of the defects. Implies, that NQI elements are available on that specific area, but sometimes it fall in implementations. Finally, number 5 represents the corresponding NQI elements are strongly not responsible for the existence of the corresponding root causes of the defects. This means, insure totally these NQI elements are not responsible

Table 4.6: Relate the root causes of each defect existed in production activity to its responsible NQI elements and rank the responsiveness/performance

Defects	**Root causes**	**NQI elements**			
		Standard	**Metrology**	**Conformity assessment**	**Accreditation**
Occurred under production only					
Immature beans	Growing problems (drought, stress, fertilization, pests and diseases). Beans from cherries picked prior to ripening.	1	1	2	1
Withered beans	Stressed trees. Underdeveloped fruit due to drought.	5	5	5	5
Dark brown beans	Cherries attacked by the Antestia bug which pierce and suck the juice from immature fruit. Also caused by over-ripe cherries.	4	5	2	1
Elephant beans	Genetic cause consisting of an assembly of two or more beans resulting from false polyembryony.	5	5	5	5
Triangular beans	Genetic cause resulting from the development of three beans per cherry.	5	5	5	5
Amber beans	Supposed iron deficiency in the soil and/or a high soil PH.	4	1	1	1
Pea beans	Genetic cause resulting from the development of single seed with the fruit. The second bean having aborted.	5	5	5	5
Flaky beans	Growth defect arising from nutritional deficiency	4	1	1	1

Among the coffee defects, immature beans are occurred due to root causes listed in table 4.6 above and other additional root causes stated by the interviewees such as need of earning money early due to financial shortage, thinking that harvesting earlier enhance more money, theft problem, carelessness and expensiveness of labor to pick red cherries at each stage of ripeness than stripping ripe, unripe and overripe together. According to the coffee experts interviewed, lack of standards at coffee cherries level that can make cost differences for different quality cherries, weakly performing inspection of pests and diseases by the coffee owners (farmers) that have not full inspection knowledge and have not inspection certificate from any known body, lack of testing of soil nutrition contents of coffee lands located at different areas of the county to use appropriate fertilizers, and lack of accreditation were stated as major sources of immature beans. Also dark brown beans are sourced from the same inspection and accreditation problems of immature beans except lack of standards. Since some of immature beans and withered beans resulted from the drought, which is the natural phenomena, it is difficult to connect them with NQI elements instead the experts connected them with lack of irrigation.

As root causes of the defects are shown, elephant, triangular and pea beans have resulted from genetic problems. Therefore the interviewees connected these problems with research rather any NQI elements.

Finally amber and flaky beans are defects sourced from soil nutrient deficiency. The coffee experts related these problems with lack of soil nutrition contents testing, specifically on coffee growing lands. Even though Ethiopia had soil testing laboratories, specifically they are not testing coffee land soils as well operators of the laboratories are not accredited by formal authoritative bodies. Availability of standards are not the issue for these defects rather than its implementation.

Table 4.7: Relate the root causes of each defect existed in both production and primary processing activities to its responsible NQI elements and rank the responsiveness/performance

Defects	**Root causes**	**NQI elements**			
		Standard	**Metrology**	**Conformity assessment**	**Accreditation**
Existed in both production and primary processing					
Insect damaged beans	The cherries or beans are attacked by the pests.	4	5	2	1
Black beans	Attacks by pest diseases, carbohydrate deficiency in the beans due to poor cultural Practices, insufficient water during ripening, over-ripe cherries picked up off the ground, immature beans affected by faulty drying (i.e. high temperatures), beans/cherries subjected to over-fermentation by moulds/yeasts and subsequent drying, & poor drying or re-wetting.	4	2	2	1
Foxy beans	Over-ripe, delay in pulping, over fermentation in presence of free skins, frost damage, improper washing, collection of effluents in the fermenting mass and faulty mechanical drying (over-heating, not enough movement).	4	2	2	1
Blotchy beans.	Faulty drying or re-wetting after drying, often due to broken parchment.	4	2	2	1
White and yellow beans	Discoloration of the surface due to bacteria of the *Coccus* genus during storage or transport. Generally associated with coffee from old crops. Also caused by rewetting after drying.	4	5	2	1
Stones	Drying on bare ground and added knowingly by owners to increase weight.	4	5	2	1
Wanza	During picking and drying on bare ground. Added knowingly by the owners to increase weight.	4	5	2	1

Sticks	Striping unripe, ripe and overripe cherries together. drying on bare ground	4	5	2	1
Earth aggregates	Drying on bare ground and picking from the ground.	4	5	2	1
Bean fragments or broken beans	General handling, mostly occurs during de-hulling or de-husking operations.	4	2	2	1

Based on the interviews, as seen from the table 4.7 above, the availability of standards has low responsibilities for the existence of all root causes of defects except its implementation. Though the actors in coffee production and primary processing activities are aware of standards, guidelines and procedures, they are weak in its implementation due to carelessness.

The weak performance of metrology is also responsible for the existence of some root causes of black beans, foxy beans, blotchy beans and bean fragments/ broken beans. Machines in coffee processing industries used for mechanical drying, de-husking and de-hulling operations are not calibrated, maintained and adjusted by Metrology Institute of the county rather it calibrated, maintained and adjusted by machine operators that have not authority and standardize references to calibrate the machines and have not certificate from known body for maintaining and adjusting these specific machines.

The weak performance of conformity assessment, and carelessness sourced from unavailability of cost variance depending on quality cherries took high responsibilities for the existence of all root causes of the defects. According to interviewees, inspection of pests, diseases, ripeness, drying level, fermentation level and proper washing are performed by usual inspectors such as farmers, labors, vehicle drivers, etc. that are not certified by any authoritative (known) body in these specific areas. Lack of soil nutrition testing of coffee lands is also resulted improper use of fertilizer through poor cultural practices. Lack of cost differences considering quality cherries difference is leading the owners (farmers) to carelessness for quality of cherries and selfishness to add foreign matters such as stones, wanzas, sticks and earth aggregates to earn more money through weight rather than quality.

Lack of accreditation is another problem for the existence of all root causes of the defects listed in table 4.7 indirectly. As discussed in chapter 2, there is no anyone accredited from the coffee

sector by ENAO. The same thing is revealed here by interviewer with that of chapter 2. All the machine operators, inspectors and soil testing laboratories and personnel discussed above were not certified, means not accredited indirectly with that specific area by ENAO.

Table 4.8: Relate the root causes of each defect existed in production activity to its responsible NQI elements and rank the responsiveness/performance

Defects	**Root causes**	**NQI elements**			
		Standard	**Metrology**	**Conformity assessment**	**Accreditation**
Existed only under primary processing					
Spongy beans	Undue moisture absorption during storage or transport leading to deterioration by enzymatic activities	4	5	2	1
Mouldy beans	Faulty temperature and humidity conditions during storage and transportation.	4	1	1	1
Piece of parchment or husk fragments	Inadequate separation after hulling or husking.	4	2	2	1
Pulpier nipped beans	Faulty adjustment of pulping machine or feeding with under ripe or unequal sized cherries.	4	2	2	1
Beans in parchment	Faulty hulling and separation of the parchment and an accidental de-pulping by crushing before drying.	4	2	2	1
Dried coffee cherries	May occur accidentally due to the presence of small cherries and faulty sorting. Incorrect husking allows small pods through and they are not always removed.	4	2	2	1

According to experts on coffee production and processing activities, still the availability of standards are not the issue for all root causes of coffee defects existed in primary processing activity listed in table 4.8 above, rather than weakness of its implementation.

Lack of metrology for measuring instruments of temperature and humidity condition in the storage and during transportation is stated as major sources of moldy beans. Weak metrology performance in calibrating, maintaining and adjusting machines that are used for hulling, husking, separation of the hull and parchments from coffee beans, and sorting different sizes of cherries were raised as another sources for the existence of the rests of the root causes of the defects except root causes of spongy and moldy beans. These are happened because of calibrations, maintenances and adjustments of the machines were performed by operators of the machines that are not certified by known bodies in these specific areas and have not standardize calibration references.

Lack of conformity assessment performance in the root causes of moldy beans and weak performance of conformity assessments through all the rests of the root causes of defects listed in table 6.3 were raised by the interviewed coffee experts. Lack of testing practices and instruments for temperature and humidity conditions during coffee storage and transportation are the stated reasons for the existence moldy beans. Instead of this, inspections were done by uncertified inspectors to perform these activities. In the rests of all root causes of defects listed in table 4.8, weak performance of inspections and testing during calibration, maintenance and adjustments of machines, during sorting different sizes of cherries and separation of coffee beans from hulls, husks and parchments are the other problems for coffee defects. These performance weaknesses were happed due to uncertified (usual) inspectors and testers (machine operators) for these specific areas were performed all of these activities.

As presented at last right hand side column of table 4.8, through all the root causes of the defects, lack of accreditation performance was observed. All inspections, testing, calibrations, maintenances and adjustment activities are performed without any consideration of accreditation.

To summarize, availability of standards, guidelines, and procedures are not the problems to perform any activities in coffee production and primary processing of the coffee value chain, except lack of standards for coffee cherries grading to enhance different costs, considering cherries' quality and helps to decrease carelessness of farmers resulted from same cost for all quality types of cherries. Even though standards, guidelines and procedures are available, its implementation's performance is very weak due to lack of deep awareness of it, carelessness and poor management.

Under metrology, weak calibration performance of soil testing laboratories; preforming calibrations, adjustments and maintenances of mechanical drying, husking, hulling and sorting machines by machines' operators that have not certificate, authority and standardize references of calibration from authoritative and known bodies in these specific activities; and using simple inspection of temperature and humidity during coffee storage and transportation instead of careful testing of them by calibrated measuring instruments were found as certain sources of root causes of coffee defects.

On the other hand, lack of testing of soil nutrition contents specifically in coffee growing lands, and lack of testing of temperature and humidity during coffee storage and transportation were the sources of coffee defects. Also weak performance of inspections of pests, diseases, ripeness, drying level, fermentation level, proper washing, proper separation of coffee beans from husks and hulls were resulted from usual inspectors such as farmers, labors etc. that are not certified by any known body in such specific areas are other problems the researcher found.

Finally, lack of accreditations performance were found in any activities of calibrations, adjustments, maintenances, inspections and testing in coffee production and processing as well as personnel performing all of an activities discussed above.

CHAPTER FIVE

5 PROPOSED SOLUTION TO THE PROBLEMS

As seen from results and discussions of chapter four, there are so many gaps between Ethiopian NQI institutes and coffee sector to work together. Still now most elements of NQI performing few activities of calibrations, inspections, testing and certifications on the final products of green coffee except the availability of standards in most of coffee value chain activities. These resulted in lack of NQI elements' performance and weak performance of NQI elements in two main activities of coffee value chain (production and primary possessing) that are contributing to the existing root causes of coffee quality defects. Among annual coffee production quantity of the county (Ethiopia), most coffee products' quality failed to achieve coffee grades of the county for both local and export markets due to these defects. So that the rejected coffee in quality supplied to the local market.

To overcome these problems, the researcher tried to draw working framework for existing situations to show the gaps and develop the new working framework to fill those gaps. The existing working framework is drawn to show each of an activity performed and NQI elements' performance level that are practiced only in coffee production and primary processing activities of coffee value chain. The newly developed framework replaced certain activities of an existing one by other activities, included another additional activities and replaced the existing NQI elements' performing system by newly improved systems. These two working framework are presented in figures 5.1 and 5.2 as follows within its detail explanation.

5.1 Existing Working Framework

As presented in figure 5.1 below, during cultivation of coffee trees, fertilizers (composts) are used arbitrarily in the coffee lands without knowing soil nutrition contents. Since the soil nutrition contents are specifically unknown, it is difficult to avoid (fill) soil nutrition deficiency. So that certain coffee quality defects presented in three tables of chapter five are existed due to these deficiency. Also, pests and diseases are inspected in the usual way by uncertified and unaccredited personnel that can lead to faulty results and controlling systems.

During harvesting, inspections are taking place by uncertified and unaccredited farmers to know whether the cherries are appropriately ripe or not. In addition to this, though the farmers are experienced in separating the ripe cherries from unripe, they are stripping under ripe, ripe, overripe and dry cherries together instead of picking separately due to the same costs are enhanced for all types of coffee cherries.

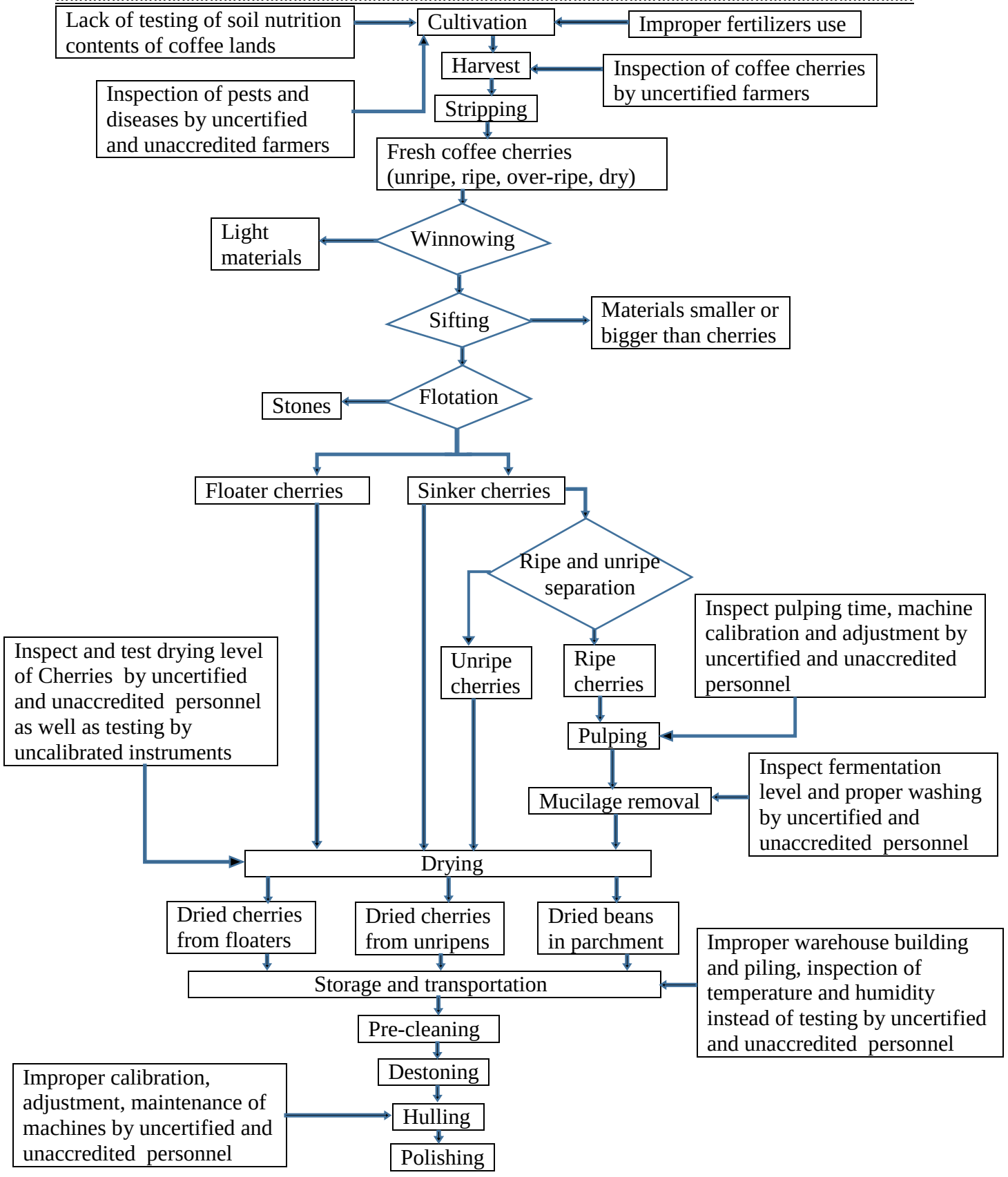


Figure 5.1: Existing working framework of production and primary processing activities

Since the farmers collected different ripening stages of cherries together, the cherries' buyers and processors are obligated to invest money for different separating techniques such as sifting, flotation, ripe unripe separation, etc. rather than investing in picking techniques through farmers that can enhance to prevent these in early stage.

During pulping and mucilage removal processes, inspections of appropriate times to stay in pulping, fermentation level and proper washing as well as calibrations and adjustments of pulping machines are performed by uncertified and unaccredited personnel (machine operators, labors etc.) that have not standardize calibration references and an authority from known bodies in these aspects. Also drying level of coffee inspected and tested by using usual way (using tooth grasping), uncalibrated moisture testing instruments, and uncertified and unaccredited personnel.

Finally, storage and transportation systems are very weak. As seen from the figure 5.1, inappropriate warehouse building (not fit to the standards), piling systems (put on the ground, in touch to the wall, pilled until near to roof etc.), and inappropriate temperature and humidity of the warehouses during storage. Inspections of warehouse temperature and humidity are taking place by uncertified and unaccredited personnel instead of testing it with calibrated test instruments. Also, temperature and humidity are not considered well during transportation. On the other hand, hulling processes are performed by not well calibrated and adjusted machines that are calibrated, adjusted and maintained by uncertified and unaccredited machine operators.

5.2 Proposed working framework

The researcher tried to develop a new working framework instead of the existing one to solve certain problems within it. As seen from the figure 5.2 below, during cultivation activity, it is better to test soil nutrition contents of coffee lands specifically by calibrated and accredited laboratories, and certified and accredited personnel before fertilizers use. Then, following by appropriate fertilizer use to fulfil nutrition deficiencies in appropriately planned time cycles. In a similar way, inspection of pests and diseases have to perform by certified and accredited personnel following by taking appropriate controlling action in the specified time cycle.

During harvesting inspection of ripeness of coffee cherries have to take place by certified and accredited personnel (owners or labors) by known certifying and accrediting bodies (ECAE and ENAO). Then after, it is better to harvest the ripe coffee cherries by *picking* techniques instead of *stripping* to find better quality of cherries to enhance more money by achieving higher grades.

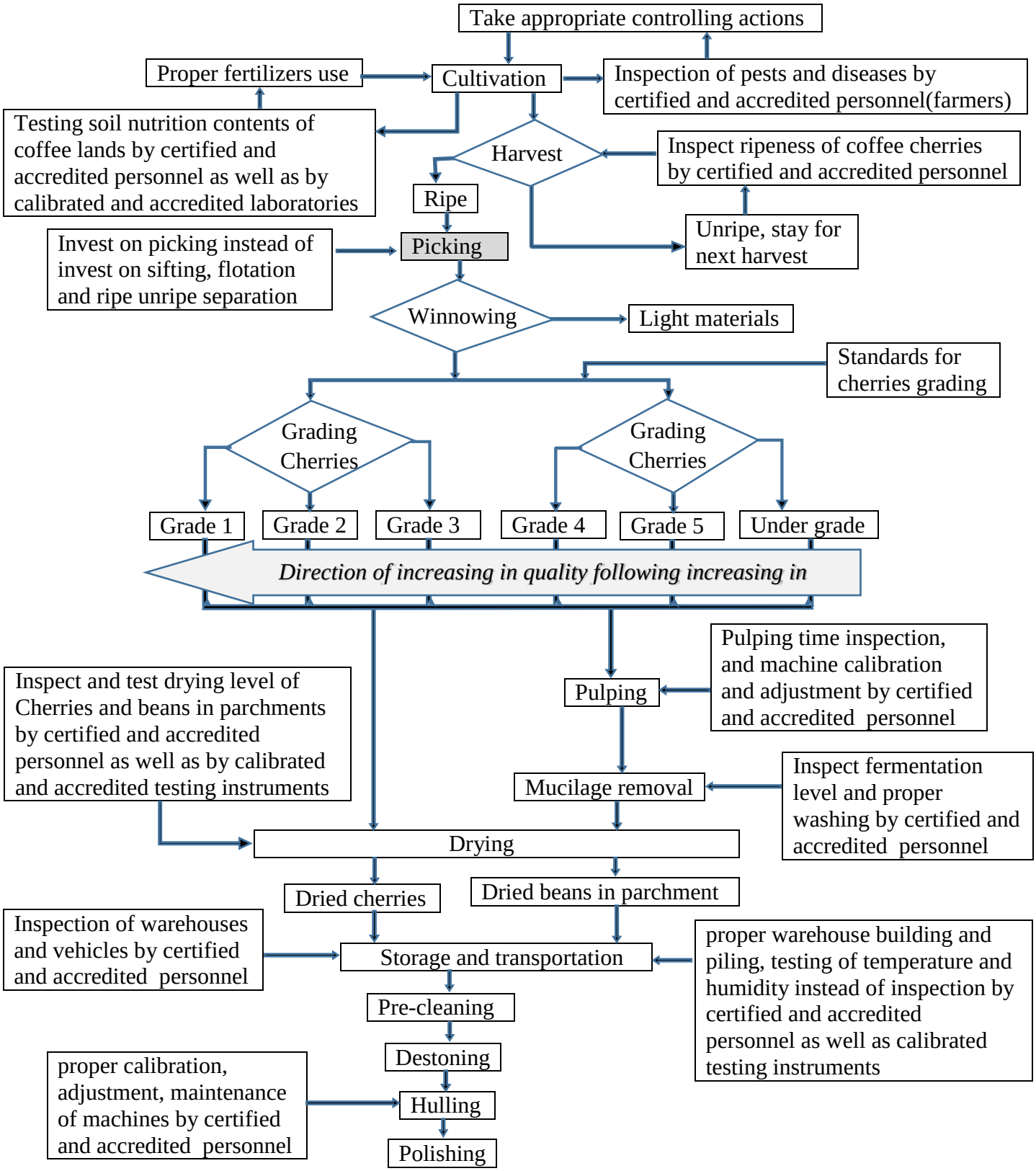


Figure 5.2: New developed working framework of production and primary processing activities

By developing grading standards of coffee cherries that can help to categorize them to different quality grades, it is possible to push farmers to picking only ripe cherries instead of stripping of unripe, ripe, overripe and dry together in order to gain more money by supplying higher graded coffee cherries. This system also changes an investing practice on sifting, flotation and ripe unripe separation in existing framework into investing on picking techniques indirectly through paying appropriate costs for different grades of cherries. Moreover, this system can develop early preventive strategy in place of later maintenance to obtain qualified coffee.

During pulping and mucilage removal, it is better to calibrate, adjust and maintain pulping machines by certified and accredited personnel, and it is better to perform inspection of staying time in pulping, fermentation level and proper washing during mucilage removal by certified and accredited personnel as well. Drying level or moisture contents of coffee have to test in any stage of processing to follow up its appropriate drying by calibrated moisture testers as well as by certified and accredited personnel from known certifier and accreditor bodies instead of inspection by usual ways (grasping by tooth, use uncalibrated moisture testers etc.).

Finally, appropriate warehouse buildings following the standards, proper piling of the coffee during storage (avoiding piling on the ground, piling until near the roof, in touch with wall, etc.), testing the temperature and humidity of the warehouses with calibrated testing instruments instead of usual inspection practices, and inspect warehouses and vehicles to check its freeness from any types of pests, water linkage, odd odor etc. as well as it is better to perform these testing and inspection practices by certified and accredited personnel. Also during hulling calibration, adjustment and maintenance of machines have to be performed by certified and accredited personnel from well-known and authoritative bodies in these specific fields.

CHAPTER SIX

6 CONCLUSION AND RECOMMENDATION

6.1 Conclusion

This study has assessed the performance of Ethiopian National Quality Infrastructure elements (standards, metrology, conformity assessment and accreditation) in production and primary processing activities of coffee value chain. This is done based on eight months secondary data collected from CLU and primary data gathered from interviews and observations. The results of the study showed that ENQI elements are weak in performance in both production and primary processing activities of coffee value chain.

From the findings of the study, since standards are available in all activities of production and primary processing, it is not responsible for the existence of root causes that resulted coffee quality defects, except lack of standards for coffee cherries grading and weak implementation of the whole standards. Lack of metrology performance is seen in calibrating soil nutrition contents testing laboratories of coffee lands, and in calibrating testing instruments of temperature and humidity during storage and transportation. Also weak metrology performance is identified in calibrating, adjusting and maintaining machines used during pulping, hulling and husking, and in calibrating moisture testers used for measuring the drying level or moisture contents of coffee. In conformity assessment lack of testing performance is revealed in soil nutrition contents tests of coffee lands, and in temperature and humidity tests during storage and transportation as well as weak performance of inspection and certification in most activities of production and primary processing, except in natural phenomena and genetic problems that causes coffee quality defects. Finally, lack of accreditations performance is seen through all activities, except problems related to drought and genetic causes as well.

In order to solve the current problems within the performance of ENQI elements in production and primary processing activities of coffee value chain, the researcher proposed a new working framework. This framework is unique from the existing in incorporating the two organizations (NQI body and coffee sector) to work cooperatively; in replacing poor activities by better one (stripping by selective picking); cost investments are shifted from corrective maintenance to preventive (shift investment on sifting, flotation and ripe unripe separation to selective picking); and grading system are inserted at cherries level. NQI elements incorporated with activities in production and primary processing. And the researcher hopes that when this framework is used by two (NQI body and coffee sector) cooperatively in their own aspects, the performance of NQI elements improves, coffee defects decrease and the quality of coffee products increase.

6.2 Recommendation

In view of the findings and conclusion of the study, the following recommendations are made to be considered by the four Ethiopian National Quality Infrastructure Authoritative bodies (ESA, ENMI, ECAE and ENAO) and Ethiopian coffee value chain actors, specifically actors in production and primary processing activities in order to achieve better quality of coffee products by minimizing the root causes of coffee defects.

- ✓ Since the newly developed working framework can help the two (NQI body and coffee sector) to work cooperatively in their respective responsibilities in production and primary processing activities, it is recommendable to use it.
- ✓ The coffee sectors, specifically the actors in coffee production and primary processing activities have to work with ESA to develop standards for grading coffee cherries; work with ENMI in calibrating and certifying machines used for pulping, hulling and husking, instruments used for temperature and humidity testing during storage and transportation, and soil nutrition contents testing laboratories; work with ECAE in a practices needed inspection, testing and certification through all activities performed in newly proposed working framework; and work with ENAO in accreditation of personnel participating on calibration, testing, inspection, soil testing laboratories, etc. and the testing laboratories themselves.
- ✓ Finally, beyond creating awareness, giving training, make announcements, etc., it is better that these four NQI authoritative bodies have to go distances such as establishing their office in a place coffee production and primary processing takes place, show usage of their service in practice by performing it on selected model actors, like Metrology Institute they have to asking and moving to them to give services, etc. to reach and serve the coffee sector (actors in coffee production and primary processing activities) instead of waiting this sector to come a distance to them to get their services.

6.3 Future research direction

Due to largeness of the coffee value chain activities, and budget constraints, this study cover only production and primary processing activities among all main activities of Ethiopian coffee value chain to assess the performance ENQI elements. Since this research is limited to defect point, and depend only on production and primary processing activities of coffee value chain to assess performance NQI elements, it is not fully enough to alleviate quality related problems of coffee products and to improve the existing performance of NQI elements through all coffee value chain. Therefore, assessing the performance of ENQI elements by considering other parameters rather than defect point that can result quality problems of coffee to failed grades, and the other main activities of coffee value chain (seedling preparation, primary and secondary marketing, secondary processing and retailing) are an interesting future research direction. Also, assessing the performance of ENQI elements in other sectors rather than coffee is open for future research work as well.

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APPENDECIS

APPENDIX: A

Table A1: Adopted ISO standards

ES ISO 4072:2001	Green coffee in bags – sampling
ES ISO 8455:2001	Green coffee in bags – Guide to storage and transport
ES ISO 4150:2015	Green coffee or raw coffee – Size analysis – Manual and machine sieving
ES ISO 760:2012	Determination of water – Karl Fischer method
ES ISO 4052:2002	Coffee – Determination of caffeine content
ES ISO 6667:2001	Green coffee - Determination of insect damaged beans
ES ISO 4149:2001	Green coffee – Olfactory and visual examination and determination of foreign matter and defects
ES ISO 6673:2001	Green coffee - Determination of loss in mass at 105^{o}c
ES ISO 9116:2001	Green coffee – Guidance in method of specification
ES ISO 2015:2015	Green coffee – Defect reference chart
ES ISO 1446:2012	Green coffee – Determination of moisture contents
ES ISO 8460:2002	Instant coffee – Determination of free flow and compacted bulk densities
ES ISO 3726:2002	Instant coffee – Determination of loss in mass at 70^{o}c under reduced pressure

ES ISO 11292:2002	Instant coffee – Determination of free and carbohydrate contents method using high performance anion with exchange chromatography
ES ISO 6669:2001	Green and roasted coffee – Determination of free flow bulk density of whole beans
ES ISO 11817:2012	Roasted ground coffee – Determination of moisture content – Karl Fischer method
ES ISO 11294:2012	Roasted ground coffee – Determination of moisture content – method by determination of loss in mass at 103**ºc**

Table A2: Ethiopian standards

CES 22	Green Coffee – Specification
ES 589:2001	Coffee And Its Products – vocabulary
ES 590:2001	Green Coffee - Quality Assessment
ES 591:2001	Green Coffee- method of Packing
ES 592:2001	Junfel (Dry Coffee Cherry) - Quality Assessment
ES 593:2001	Green Coffee - Guide to Preparation
ES 594_2001	Green Coffee - Arrival and Export Classification
ES 595:2001	Washed Coffee Process (Wp) - Guide to Coffee Waste disposal
ES 784:2002	Green Coffee Bags - Jute (Textile Fiber) Bags – Determination of metals
ES 785:2002	Green coffee bags – Jute, yarn rove and fabrics – Determination of added oil content

ES 792:2002	Instant Coffee - Quality Assessment
ES 793:2002	Instant Coffee – Specification
ES 794:2002	Instant coffee – Sampling
ES 788:2002	Roasted Coffee Beans And Roasted Ground Coffee – Specification

ES ISO 8455:2001; Green coffee in bags – Guide to storage and transport

Conditions for putting into storage and storage characteristics

Green coffee before begging should be free from sings of insect infestation, rodent contamination, mould and other contamination. Coffee beans should be sufficiently dry so as not to be unnecessarily vulnerable to subsequent moulding, yet not so dry as to cause unnecessary bean breakage. The bags in which the dry coffee is stored should be inspected before use to assure that they are odour free, free from signs of insects' infection, rodent contamination and other contamination, and physically sound. Green coffee intended for storage after being bagged for export should be moved with minimum delay to well ventilated, well maintained storage area or facilities. The air temperatures and the relative humidities surrounding bagged coffee in store should be sufficiently constant and low enough to ensure that original quality of the bagged coffee is presented throughout the duration of storage.

Condition for storage

Exterior of storage facilities

- ✓ Spills should be cleaned up promptly.
- ✓ Waste, dunnage, and refuse should be removed promptly.
- ✓ Equipment should be stored in a manner so as not to provide harborage for rodents, insects or birds.
- ✓ There should be no poor drainage areas which could provide a breeding place for insects or other pests.
- ✓ There should be pest control program for the surrounding grounds and regular inspections of the area. A recognized pest control agency should be employed.
- ✓ Hard surface areas should be kept in a broom clean condition.

Interior (buildings) of storage facilities

- ✓ Building should be structurally sound. Free of leaks, rodents and birds proof.

- ✓ All pipes that are subject to condensation should be adequately insulated.
- ✓ Buildings should be kept in a bloom clean condition, there should be clean-up program both for spills and for routine cleaning to avoid accumulation of dirt and debris on the roof.
- ✓ Cargo spillage should be removed immediately.
- ✓ Rubbish should remove and disposed of property.
- ✓ An adequate bird, rodent insect and other pest control program should be maintained, supervised by a recognized pest control agency.
- ✓ There should be regular inspection of building in support of the clean-up program by a person in authority.
- ✓ Any toilet facilities should be separated from the coffee storage area, totally enclosed and maintained in a sanitary condition.

Transportation facilities

During island transport to and from storage facilities, the bagged green coffee should be protectively covered to prevent stray contamination and weather damage. All inland transport vehicles should be inspected a person in authority before loading green coffee to assure that they are in sanitary condition, defined as the absence of filth (fragments of insects, hair of rodents, etc.), mould, chemical contamination and weather damage.

According to ES ISO 4149, any foreign matter other than green coffee beans, fragments of coffee and defective beans are described as green coffee bean defects.

Table A3: assessment of defects for dry processed coffee

Defects	Defect-points
Foreign matter	
Small earth aggregate, small stone or small stick, each (<4.75mm)	3
Medium earth aggregate, medium stone, medium stick, each (>4.75mm<8.0mm)	5
Large earth aggregate, big stone, big stick, each (≥8mm)	10
Wanza (Cordia abysinica) or other seed, each	10
Fragments of coffee	
Broken beans, each (> ½ bean size)	0.2
Piece of parchment or husk fragment, five.	1
Bean fragment, ten (< ½ bean size)	1
Defective beans	
Immature beans, each	0.2
Blotchy beans, each	0.25
Partly black beans, each	0.5
Bean in parchment, each	0.5
Insect damaged or infested beans i. badly each ii. slightly each	 0.5 0.2
White or yellow beans each	1
For every each spongy beans	1
Withered bean, each	1
Dried coffee cherry, each	2
Black bean, each	1
Foxy bean each	0.2
Mouldy bean each	10.0

Green coffee quality assessment for wet processed coffee shall be done in the same way as in the dry processed coffee using table 4.3 above for defects.

The following are major defects in the wet processed green coffee:

- ✓ Stinker beans
- ✓ Foxy beans
- ✓ Immature beans
- ✓ Pest damage beans
- ✓ Pulp nipped beans
- ✓ Broken beans

Table A4: Jenfel defect points

No.	Defects	Points
1	Black Jenfel each	1
2	One large piece of husk, empty pod, immature or withered jenfel	3
3	One large stone (≥8mm in size)	5
4	One medium sized stone (5mm - 8mm in size)	2
5	Two small stones or pieces of hard earth (≤ 5mm)	1
6	One large stick (2cm - 4cm in length) bare bean each	5 1
7	One wanza	5
8	Two insect damaged cherries	2
9	Five slightly insect damaged cherries	1
10	Twigs and leaves each: Small Medium Large	 2 3 5
11	Ferrous material nails or other metals each	5
12	Cereals each	2
13	Mouldy (white) jenfel	6
14	Animal dung each	5
15	Other foreign matter each	5

Table A5: defect reference chart (ES ISO 10470: 2015)

The following coefficients for sensorial concern are used in the chart:

- ✓ 0 = no influence
- ✓ 0.5 = medium influence
- ✓ 1 = serious influnce

Name of defect	Definition or characteristics of defect	Loss of mass	Sensorial concern
1 Defects associated with foreign matter			
1.1 Stones	Stone of any size found in a green coffee lot	1	0
1.2 Sticks	Twig of any size found in a green coffee lot	1	0
1.3 Soil agglomerate	Granulated lump of soil particles	1	0
1.4 Metallic matter	Metallic particles such as those found on the drying area after drying the coffee and/or after degradation of the industrial equipment	1	0
1.5 Foreign matter other than described	Foreign matter such as cigarette stubs, plastic particles, bag particles, strings	1	0
2 Defects associated with non-bean matter coming from the coffee fruit			
2.1 Bean in parchment (pergamino)	Coffee bean entirely or partially enclosed in its parchment (endocarp)	0,5	0
2.2 Piece of parchment (pergamino)	Fragment of dried endocarp (parchment)	0,5	0
2.3 Dried cherry (pod)	Dried fruit of the coffee tree, comprising its external envelopes and one or more beans	0,5	0
2.4 Husk fragment	Fragment of the dried external envelope (pericarp) NOTE These are divisible into small, medium or large fragments.	0,5	0
3 Defects associated with irregular beans			
3.1 Malformed bean; shell and ear	Coffee bean whose abnormal shape makes it clearly distinguishable NOTE This category includes: — shell: malformed bean presenting a cavity; — ear: malformed bean with ear shape. Both originate from the elephant bean.	0[a]	0,5[a]
3.2 Bean fragment	Fragment of a coffee bean of volume less than half a bean	0,5	0,5
3.3 Broken bean	Fragment of a coffee bean of volume equal to or larger than half a bean	0,5	0,5
3.4 Insect-damaged bean	Coffee bean damaged internally or externally by insect attack	0	0,5
3.5 Insect-Infested bean	Coffee bean harbouring one or more dead or alive insects at any stage of development	0[a]	0,5[a]
3.6 Pulper-nipped bean; pulper-cut bean	Wet-processed coffee bean, cut or bruised during pulping, often with brown or blackish marks	0[a]	0,5 NOTE Sometimes a fermented flavour may appear.

Continued (table A5)

Name of defect	Definition or characteristics of defect	Loss of mass	Sensorial concern
4 Defects associated with visual appearance			
4.1 Black bean and partly black bean	Coffee bean whose interior is partly or totally black (endosperm)	0	1
4.2 Black-green bean	Unripe coffee bean, often with a wrinkled surface, with dark green almost black colour and a glossy silverskin	0	1
4.3 Brown bean ("ardido")	Coffee bean with a range of colours: very light brown-reddish, brown-black, yellowish green to dark reddish brown, and dark-brown internally (endosperm) NOTE 1 When roasted and infused, it produces an unpleasant sour taste (stinker). NOTE 2 This is not to be confused with the foxy silverskin bean ("melado"), which is internally a normal green colour revealed by gentle scratching of the surface, and produces no off-flavour in the cup.	0	1
4.4 Amber bean	Coffee bean with yellow colour, usually semi-transparent	0	0,5
4.5 Immature bean; "quaker" bean	Unripe coffee bean, often with a wrinkled surface, having a greenish or metallic silverskin; cell walls and internal structure are not fully developed	0	0,5 NOTE Sometimes a fermented flavour may appear.
4.6 Waxy bean	Coffee bean with translucent waxy appearance and a range of colours from yellowish green to dark reddish brown, the latter being the most typical; the cell and surface have a decayed fibrous appearance	0	0,5 NOTE Sometimes a fermented flavour may appear.
4.7 Blotchy bean; spotted bean	Coffee bean showing irregular greenish, whitish or sometimes yellow patches	0	0,5
4.8 Withered bean	Coffee bean which is wrinkled and light in mass	0	0,5
4.9 Spongy bean	Coffee bean of consistency analogous to that of cork (i.e. whose tissue can be indented by pressure of fingernail); it is generally whitish in colour	0,5	0,5
4.10 White bean	Coffee bean with a whitish surface	0	0,5
5 Defects mostly evident in cupping			
5.1 Bean producing stinker or fermented flavours	Bean with a normal appearance but a very unpleasant flavour is detected in the cup (like fermented, sour, stinker or rotten fish) NOTE On being freshly cut or scratched, the bean presents a very unpleasant odour.	0	1
5.2 Bean producing other current off-flavours	Bean has a normal appearance but in the cup unpleasant musty, foul, dirty, earthy, woody, Rio, phenolic or jute-bag-like flavours can be detected	0	1

[a] Defects mostly affecting roasted whole bean quality.

APPENDIX: B

Table B1: Awareness creation report (date in E.C)

No	Awareness creation region	Date	Awareness creation issues	Place	Participants
1	Tigray	15/05/2004	General awareness	Mekele	42
		2-3/04/2007	ISO/IEC 17020፡ 17025፡ ISO 15189	Aksum	60
		6-7/4/2007	ISO/IEC 17020፡17025፡ ISO 15189		60
		9-10/2008	ISO/IEC 17020	Humera	20
		19-20/04/2009	ISO/IEC 17025	Mekele	33
		22-23/2009	ISO/IEC 17020	Mekele	31
2	Amhara	22/05/2004	ISO/IEC 17011 General awareness	Bahirdar	77
		1-2/08/2005	ISO/IEC 17011 General awareness	Bahirdar	48
		9-10/04/2007	ISO/IEC 17020	Dessie	20
		12-13/05/2007	ISO/IEC 17020፡17025፡ ISO15189	Bahirdar	60
		2/7/2008	ISO/IEC 17020 General awareness	Amhara region council	138
		3-04/06/2008	ISO15189	Debrebrehan	20
		6-7/04/2007	ISO/IEC 17020፡17025፡ ISO15189	Dessie	60
		7-8/05/2007	ISO/IEC 17020፡17025፡ ISO15189	Gonder	60
		15/16/2007	ISO/IEC 17020፡17025፡ ISO15189	Debremarkos	60
3	Oromia	10/11/2004	ISO/IEC 17011 General awareness	Adama	104
		14- 15/10/2005	17011 General awareness	Adama	48
		8/01/2005	17011 General awareness	Jimma	43

		18/19/06/2006	17011 General awareness	Jimma	43
		10/01/2005	17011 General awareness	Jimma	41
		21-22/07/2007	ISO/IEC 17020፡17025፡ ISO15189	Adama	60
		26-27/05/2008	ISO/IEC 17025	Bishoftu	20
		28-29/06/2008	ISO/IEC 17020	Adama	20
		1-2/09/2007	Annual working conference	Bishoftu	86
		17-25/10/2007	ISO/IEC 17011	Bishoftu office workers	44
		28-29/6/2009	ISO/IEC 17025	Bishoftu	25
		27-28/09/2008	Annual conference	Adama	86
	South nations and nationalities	27/07/2004	ISO/IEC 17011 General awareness	Hawasa	110
		26-27/03/2005	ISO/IEC 17025	Hawasa	20
		20-21/04/2009	ISO/IEC 17020	Hawasa	20
		11/12/11/20	ISO/IEC 17025፡ ISO15189	Hawasa	40
		24-25/07/2007	ISO/IEC 17020፡17025፡ ISO15189	Hawasa	60
5	Afar	17-18/04/2006	ISO/IEC 17011 General awareness	Logia	41
6	Benishangul gumz				37
7	Gambella	15-16/5/2009	ISO/IEC 17011 General awareness	Gambella	48
8	Harare	22-23/04/2009	ISO/IEC 17025	Harar	20

9	Diredewa city administration	22/09/2004	ISO/IEC 17011 General awareness	Diredewa	83
		24-25/10/2005	ISO/IEC 17011 General awareness	Diredewa	45
		26-27/04/2009	ISO/IEC 17025	Diredewa	20
10	Addis Ababa city administration	24-04/2004	ISO/IEC 17011 General awareness	Addis Ababa	83
		29/05/2004	ISO/IEC 17011 General awareness	Addis Ababa	78
		24/06/2006	ISO/IEC 17011	Bishoftu mikirbet	43
		01-02/4/2009	ISO/IEC 17011	Bishoftu mikirbet	43
		26/27/10/2005	ISO/IEC 17020	Addis Ababa	20
		12/09/2005	ISO/IEC General awareness	Addis Ababa	72
		7-8/04/2008	ISO/IEC 17065	Addis Abasba	20
		11-12/04/2008	**ISO/IEC 17024**	**Addis Ababa**	**20**
		11-12/04/2008	ISO/IEC 17020	Addis Ababa	20
		9/10/06/2008	ISO/IEC 17025	Addis Ababa	20
		14-25/04/2007	ISO/IEC 17025	Addis Ababa/for cherera	25
		16-17/04/2007	ISO/IEC 17025	Addis Ababa/for cherera	25
		12/12/2008	Forest certification	Addis Ababa	20

		14/02/2008	ISO/IEC on changed documents	Addis Ababa	24
		02/10/2008	ISO/IECon changed documents	Addis Ababa	24
		26/27/05/2008	ISO/IEC	Addis Ababa	
		11/12/09/2008	ISO/IEC 17025	Addis Ababa	20
11	World accreditation day	1/10/2004	Addis Ababa	Addis Ababa Hilton	110
		1/10/2005	Addis Ababa	Harmeni	101
		1/10/2006	Addis Ababa	Elilli	108
		2/10/2007	Addis Ababa	Washington hotel	143
		2/10/2008	Addis Ababa	Elilli	82
12	Annual conference	18/08/2006	Bishoftu		86
		27-28/09/2008	Annual conference	Adama	86
		27-28/09/2008	Annual conference	Adama	86

APPENDIX: C

Table C1: Summary of previous studies on coffee quality

Author	Year	Title	Objective and Method	Finding
R. G. Muschler	2001	Shade improves coffee quality in a sub-optimal coffee-zone of Costa Rica	Caturra and Catimor types of coffee Arabica investigated under different levels of shade intensity increased from 0% to more than 80% under unpruned *Erythrina poeppigiana* in a low-elevation, sub-optimal environment.	Fruit weight and bean size increased, appearance of green and roasted coffee as well as in acidity and body of the brew for both varieties improved, aroma of the brew was neutral for Caturra and slightly negative for Catimor.
Adugna D., Bote and Paul C.Struik	2011	Effects of shade on growth, production and quality of coffee (Coffea arabica) in Ethiopia	Growth, productivity and quality of beans of coffee plants growing under shade trees were compared with those of coffee plants growing under direct sun light.	Improved photosynthesis and increased leaf area index, produced larger and heavier fruits with better bean quality, and maintain high coffee yields in the long term.
Aske Skovmand Bosselmann, Klaus Dons, Thomas Oberthur, Carsten Smith Olsen, Anders Ræbild and Herman Usma	2009	The influence of shade trees on coffee quality in small holder coffee agroforestry systems in Southern Colombia	The study was conducted on shade cover variation within two study areas, while minimizing the variability of the environment, agronomic management other than shade, and post-harvest processing. The study used principal component analysis as descriptive, and mixed linear model and a paired t-test as statistical tools.	At high altitudes, shade had a negative effect on fragrance, acidity, body, sweetness and preference of the beverage, while no effect was found on the physical quality. At lower altitudes, shade did not have a significant effect on sensorial attributes, but significantly reduced the number of small beans. The occurrence of the berry borer higher under shade.
Joel Iscaro	2014	The Impact of Climate Change on Coffee Production in Colombia and Ethiopia	In Colombia, an increase in rainfall threatens the health coffee plants. While in Ethiopia, rapidly increasing temperatures kill the plants at an alarming rate.	As a result, new threats have arisen in both Colombia and Ethiopia. Coffee leaf rust and the coffee berry borer are now a much more significant threat to coffee production than they ever were before.
Aaron P. Davis, Tadesse Woldemariam, Susana Baena and Justin Moat	2012	The Impact of Climate Change on Indigenous Arabica Coffee (Coffea arabica): Predicting Future Trends and Identifying Priorities	The authors' model is the present and future predicted distribution of indigenous Arabica, and identify priorities in order to facilitate appropriate decision making for conservation and monitoring. This study establishes a fundamental baseline for assessing the consequences of climate change on wild populations of Arabica coffee.	The model's output show profoundly negative influence on indigenous Arabica by the reduction of pre-existing bioclimatic suitable localities and areas.
Marcelo Bento Paes De Camargo	2010	The Impact Of Climatic Variability And Climate	This review article covers some aspects of the coffee crop responses under current climatic conditions	High temperatures cause extremely overheating of leaves, faster plant growth that will lead to lower

		Change On Arabic Coffee Crop In Brazil	and analysis of the impacts of climate variability and future climate scenarios issued from the Intergovernmental Panel on Climate Change (IPCC) would have in the agro-climatic zoning in Brazil. Also, it analyzes the effect of adaptive solutions.	coffee fruit quality, excessive fruit ripening, against fruit quality during the summer and physiological stresses, such as the reduction of photosynthetic efficiency are certain findings of the review.
Juliana Neves Barbosa, Flávio Meira Borém, Marcelo Ângelo Cirillo, Amauri Alves Alvarenga and Helena Maria Ramos Alves	2012	Coffee Quality and Its Interactions with Environmental Factors in Minas Gerais, Brazil	Correlations between environmental factors, chemical compounds and sensory quality of participants of the Minas Coffee Quality Contest were made through Principal Component Analysis and Bi plot Graphics.	The results showed discriminations of high and low scores as a result of environmental variables, demonstrating a strong influence of temperature, rainfall, altitude and latitude on the quality of the coffees studied.
Peter Läderacha, Thomas Oberthürb, Simon Cooka, Marcela Estrada Iza, Jürgen A. Pohlanc, Myles Fisherd and Raul Rosales Lechugae	2010	Systematic agronomic farm management for improved coffee quality	The paper aimed to illustrate the benefits of systematically targeting management practices on coffee quality. Colombia (Concordia and Piendamo states) and Mexico (El Encinal and Axocuapan states) were study sites. Slope aspect, coffee varieties, times of harvest, and shade level impacts on coffee quality are investigated.	In general, higher-slope positions giving higher scores for quality, quality characteristics differed between varieties in different sites, Coffees from denser shade scored higher quality than lower levels of shade. Early harvest gave better coffee than late harvest.
Susana Andueza, Laura Maeztu, Lucı´a Pascual, Carmen Iba´n˜ez, M Paz de Pen˜a and Concepcio´n Cid	2003	Influence of extraction temperature on the final quality of espresso coffee	The study aimed to investigate the effects of water temperature (88, 92, 96 and 98°C) on the final quality of three types of Espresso Coffee (Arabica, Robusta natural and Torrefacto blend) in order to select the optimal temperature. Analysis of variance (ANOVA), Tukey's t-test and SPSS version 10.0 software package were used as a tools.	92°C was the optimal water temperature for Arabica and Robusta natural blend Espresso coffees while 88ºC for Robusta Torrefacto blend espresso coffee.
Birhanu Beshah, Daniel Kitaw and Tirufat Dejene	2013	Quality and Value Chain Analyses of Ethiopian Coffee	The study based on data collected from secondary sources. Quality deterioration and value addition along the coffee value chain are investigated.	The causes for poor quality are mainly associated with harvesting and post-harvesting practice including collection, dry and wet processing, storage and transportation. Also profit due to value addition is neglected.
Palmiro Poltronieri, and Franca Rossi	2016	Challenges in Specialty Coffee Processing and Quality Assurance	This review article described the challenges faced by the coffee industry to guarantee quality from production to roasting and brewing.	To tackle coffee quality problems reviewed, use of antagonistic strains for fungal protection, to apply enzymatic hydrolysis to dissolve the mucilage and to add

			The results of studies on microbial populations on coffee and the differences found in fungi, yeasts and bacteria composition among the investigations, are summarized.	starter strains to speed up the wet coffee processing, and innovative technologies may be applied to protect the stored coffee beans from fungal contamination are reviewed as a solution from different studies.
Mohammedsani Amin	2015	Effect of Harvesting And Postharvest Processing Methods on The Quality of A Hararghe Coffee (Coffea Arabica L.) Genotype In Mechara, Eastern Ethiopia	The study was conducted to evaluate different harvesting and postharvest handling methods on the inherent quality characteristics of a Hararghe coffee genotype.	The results indicated that harvesting influenced roast, raw and cup quality attributes except odor. Similarly postharvest processing methods was influenced all coffee quality parameters, except odor of unwashed coffee significantly and all raw quality parameters of washed coffee non-significantly
Mekonen Hailemichael Salla	2009	Influence of Genotype, Location and Processing Methods on the Quality of Coffee (Coffea Arabica L.)	The study focus on identifying suitable coffee genotypes with best quality attributes for the Sidama and Yirgacheffee types and to study the effect of environment and processing method on their inherent quality. Two-way analysis of variance (ANOVA) and SAS computer software version 9.0 are used as statistical analyzing tools.	The results shown that coffee genotypes such as 9744 and 9718 were a superior at Awada; 9718, 979 and 85294 were the best Sidama types at Korke; and Yirgacheffee types 9744, 9718, and 9728 were the best in physical, cup quality and character. Coffee quality improvement due to processing techniques followed the descending order of washed, semi-washed and sun dried, indicating the alternative options to be practiced under specific conditions.
Maria Heloisa Paulino De Moraes and Rosa Helena Luchese		Ochratoxin A on Green Coffee: Influence of Harvest and Drying Processing Procedures	The study was aimed to evaluate ochratoxin A contamination in green coffee as a result of different harvesting, drying operations and from fruits of different ripening stages. Coffee samples from the highland area of Rio de Janeiro state in Brazil, which is traded in the domestic market. German Official Method, randomized model of factorial experiments and Tukey-test were used as analyzing tools.	As a result, different samples taken from Varricüa˜o" coffee containing coffee from ground and others contained by ochratoxin A. Ochatoxin A contamination levels between different ripe stage fruits were not significant ($P > 0.05$). The contaminated samples had in common the fact that they were harvested directly from the soil.
Anwar Abasanbi Abadiga	2010	Assessment of Coffee Quality and Its Related Problems in Jimma Zone of Oromia Regional State	The study was conducted to assess the impact of pre and post-harvest process practices on the quality of both wet and dry processed coffee, to identify the inherent quality of coffee, and investigating socio	Disease prevalence in coffee field, compost application, mixing up of differently harvested coffee during selling, the availability of storage, drying materials used for drying and age of coffee in the store

			economic technical and institutional factors related to coffee quality problems in the zone. SPSS version 14.0, binary logit model, general linear model, statistical analysis software version 9.2 and chi-square were used as analyzing tools.	revealed as a source of quality problems. Also wet processing method resulted in higher mean value for good cup and physical quality attributes than dry processing method.
Philippe Montavon, Eliane Duruz, Gilbert Rumo and Gudrun Pratz	2003	Evolution of Green Coffee Protein Profiles with Maturation and Relationship to Coffee Cup Quality	The study conducted by incubating green coffee aqueous suspensions under anaerobic and aerobic conditions, then by followed the losses of free CGAs, the evolution of protein profiles, the release of free amino acids and sensory profiles of the maturation stages.	Maturation clearly favored the development of high-quality flavor in the coffee brew, but a subclass of green coffee can generate high-quality coffee flavor irrespective of maturation. Also unripe beans were found more sensitive to oxidation of chlorogenic acids than ripe. Aerobic incubation also triggered the digestion of the 11S seed storage protein and the release of free amino acids.
Abdi Mohammed and Abu Jambo	2015	Importance and Characterization of Coffee Berry Disease (Colletotrichum kahawae) in Borena and Guji Zones, Southern Ethiopia	Field survey was conducted in three major coffee growing districts (Abaya, Bule Hora and Kercha) during 2012 cropping season to determine the incidence, severity and prevalence of CBD. The Statistical Analysis System (SAS) Version 9.2 software and Statistical Package for the Social Sciences (SPSS) 16.0. Ink models were used as data analyzing tools.	The study revealed high occurrence, distribution and contamination of Coffee Berry Disease in the study areas. CBD was prevalent in all the surveyed districts with the overall mean incidence and severity of 49.3 and 14.7%, respectively.