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Comparative analysis of the Productivity and Efficiency of Cluster and Individual farming in West Arsi and East Shoa zones of Oromia

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Abstract

The main objective of this study was to compare the productivity and efficiency of clustered and individual farming; to identify factors affecting clusters farming practice and to know the view/perception of farmers for clustered farming approach in West Arsi and East Shoa zones. To conduct the study, primary data was collected from 367 randomly selected household heads through semi-structured questionnaire. Secondary data were also collected from different sources including CSA, ZOANR, DOANR, and from published and unpublished sources to supplement primary data. In this study both descriptive statistics and econometric analysis were employed. The primary data was analyzed using descriptive statistics and stochastic efficiency decomposition method to decompose TE. Stochastic Frontier approach (SFA) was used for its ability to distinguish inefficiency from deviations that are caused by factors beyond the control of farmers. The productivity of wheat per hectare was 47.17 and 39.042 quintal for cluster and individual farming respectively which is statically significant at 1% level. The productivity of Maize per hectare was 46.42 and 25.982 quintal for cluster and individual farming respectively which is statically significant at 1% level. The productivity of Teff per hectare was 16.076 and 11.043 quintal for cluster and individual farming respectively which is statically significant at 5% level. The study result revealed that the mean of TE was about 78.46%, 70.22% and 64.64% of for wheat, teff and maize production respectively for cluster farming and 69.25%, 58.22% and 53.58% for wheat, teff and maize production respectively for individual farming as the Cobb-Douglas functional form indicate that. As the result of research analysis indicates that, the cumulative sum of farmers' perception towards the compatibility of cluster farming with the socio-economic situational circumstances was 4.093 suggesting farmers perceive positively that it was compatibility with their socio-economic situational circumstances. The likelihood of farmers to practice cluster farming positively influenced by Sex of HH, age of HH, nearest market center, distance to FTC, participation on field visit and participation in social organization in West Arsi zone whereas their likelihood to practice cluster farming positively influenced by cultivated land, access to extension, participation on field visit and perception of farmers in East Shewa zone. The study suggested that farmer adoption decisions are affected by above mentioned factors and policies addressing each decision process and cross-cutting issues are required to improve farmer participation in cluster farming. In addition, the study suggested the need for policies to discourage land fragmentation and promote education, extension visits, participation in field visit, and strengthening social network of farmers, increase wealth of farmers and changing farmer's perception towards cluster farming to increase participation of farmers in cluster farming in both zones.

Keywords: *Cluster and Individual farming, Productivity, Technical efficiency, Stochastic Frontier approach, and probit model.*

Introduction

Background and Justification

Ethiopia is one of the fastest growing non-oil economy countries in Africa. The country is heavily reliant on agriculture as a main source of employment, income and food security for a vast majority of its population. In GTP-II period, agriculture will remain the main driver of the rapid and inclusive economic growth and development. It is also expected to be the main source of growth for the modern productive sectors. Therefore, besides promoting the productivity and quality of staple food crops production, special attention will also be given to high value crops, industrial inputs and export commodities (NPC, 2016).

Agriculture is the foundation for Ethiopian economy, and the overall economic growth of the country is highly linked to the success of the agriculture sector. Agriculture accounts for about 36% of the country's Gross Domestic Product (GDP) in 2018.Our country has undertaken various measures to improve food security situation of the rural community. One of the strategies that the country has undertaken to reduce food insecurity and enhance rural development in the rural area is the establishment and strengthening agricultural clusters.

Agriculture is the backbone of Ethiopia's economy. It contributes 36.2 percent of the country's gross domestic product (GDP) and 72.7 percent of employment and 70 percent of export earnings (Getachew, *et al*., 2018).

Vegetables are sources of vitamins, minerals and income for those involved in production and marketing (Reddy and Kanna, 2016). According to Degafe (2013), Ethiopia has a good potential for the production of high-value export vegetable product. The vegetable production ranges from home gardening, smallholder farming to commercial farms (ATA, 2014). Ethiopia has comparative advantage in vegetables production due to suitable and favorable climate and cheap labor (EIA, 2012). Vegetables are grown by commercial farms and small-scale farmers for food and market since vegetables have a huge domestic market in Ethiopia (EHDA, 2011 and Mebrat, 2014).

Along the same line, lately the Government of Ethiopia has started to implement a cluster-based approach to agricultural development, which holds an impressive potential for transformation. By providing an innovative contribution to the definition of the Ethiopian way to agrarian transformation, the analysis of the cluster-based initiatives provides insights into: the peasantry's changing role in fostering development and structural transformation, the leverage of historical legacies and international influences on the adoption and implementation of the strategy, the developmental state's practice and state-peasant relation (Marcell, 2018).

The country industrial strategy necessitates the establishment of industrial zones for agro-processing industries. Agro-industry can link up or integrate the agricultural sector which is the source of livelihood for the majority of Ethiopians. It can also create sustainable market link by establishing Rural Transformation Centers (RTC) that can improve production and productivity. One of the objectives of GTP-II is establishing Integrated Agro-industrial Parks (IAIPs) to link up the agricultural sector and add value to basic agricultural products (Abiy, 2016).

Agricultural transformation in Ethiopia is deeply embedded in these global trends: the government-led process is mainly outward-oriented and aimed at integrating agro-industrial value chains to spur the conversion of the country into a global leader in manufacturing goods by 2025.One of the most significant strategies designed to achieve this goal is the agglomeration of agricultural and industrial producers into poles, hubs, or clusters, in order to benefit from the service-delivery concentration. The main importance of clustered farming is to transform substance agricultural production in to commercialized and mechanized farming.

The term "cluster farming" usually refers to agglomeration of producer farmers engaged in similar and/or related activities. The production of small scale or individual farming was mainly not demand driven, commercial and mechanized but it was based on producers need for consumption only which is low productivity. Productivity is the output produced per unit of resource used, and it is accordingly a measure of the efficiency with which producers use available resources. Productivity measures are at the core of the discussion of the impact of *reforms* in transition countries, as efficiency improvement was the main motivation for the transformation of agriculture.

National Framework for Agriculture Commercialization Clusters in Ethiopia announced that 21 clusters and 12 commodity types had been chosen, and this information was confirmed by Zegeye Teklu in July 2016. Each cluster is expected to have one primary commodity, and one or two additional rotation crops. The 2011-15 progress report announced the designation of 31 and that an additional 16 were in the works for interventions during 2015 (ATA 2016). The most recent official paper reported that 26 clusters and 10 commodities had been selected, but since a federal strategy has been issued for only 7 commodities, just 14 clusters are being implemented (ATA 2017).

Nine clusters over 114 woreda and 10 commodities have been picked out in the Oromia Region, amounting to a targeted total of 4.6 million hectares and 1.3 million farmers. In 2015-16, five clusters and commodities were given top priority: the maize cluster in the Horro Guduru Wellega, East Wellega, and West Shewa areas; Malt barley cluster in the Arsi and West Arsi areas; Bread wheat cluster in the Arsi, West Arsi and Bale areas; Durum wheat cluster in the Bale area; Teff cluster in the West Shewa, East Shewa (where the Bulbula Park is located), South West Shewa areas (ATA 2017). Out of a total of 739,727 ha of land that had been allocated to these five clusters, 134, 235 ha is the actual surface that they occupy, as reported by the MoANR in August 2016. Oromia apparently reported the highest results for the period: the clusters supplied around;700,000 qt of crops (durum wheat and malt barley) to agro-industries such as the Asela Malt Factory; 800,000 qt of bread wheat have been channeled to the EGTE through unions; five unions delivered 130,000 qt of maize grain to the WFP, the Mama Injera and Consumer Association in Addis Ababa, and other buyers through contractual agreements (ATA 2017).

In general clustered farming or medium farming has the advantage over small scale farming or individual farming on; *economies of scale* of crop cultivation, generate better marketable surplus, release of workers for industries because of since its mechanized farming nature, credit worthiness, administrative convenience, social arguments and technological transfer. Meanwhile the report of ATA indicates only the clustered farming returns greater productivity than individual farming but their efficiency of comparative advantage and partial analysis for each

individual input (i.e. output/land and output/labor) was not done suggesting as there is dearth of current information. In addition factors that influence farmers' decision to practice cluster farming, and their needs were not conducted.

Agricultural commercialization clusters (ACC) strategies predominantly featured by; top-down, output-oriented and control-biased characters of the political practice carried out by the numerous local administration structures, and may lead to capital expropriation, a bad attitude towards work, vulnerability, dependence, off-farm activity reduction, and other negative consequences.

There are no previous studies conducted in the area regarding the importance of cluster farming and factors affecting its practice by farmers and its comparative advantage over individual farming. This study, therefore, aims at identifying factors affecting cluster farming practice by farmers and its importance over individual farming. So, the study aimed to fill the above knowledge gap.

Objective of the Study

- ✓ To compare the productivity and efficiency of clustered and individual farming
- ✓ To know the perception of farmers for clustered farming approach in the study area.
- ✓ To identify factors affecting clusters farming practice in West Arsi and East Shoa zones

Expected Output

- ✓ The productivity and efficiency of clustered and individual farming identified;
- ✓ Farmers perception towards clustered farming approach identified
- ✓ Factors affecting clusters farming practice in the study area identified

Literature Review

Clustering in Agriculture: A Strategy for Transformation in SSA

The term **"cluster farming"** usually refers to agglomeration of producer farmers engaged in similar and/or related activities and manage their farm together, however individual farm not.
The ongoing globalization of trade and production relations is causing a major impact on global peasantries. On the one side, the convergence of rural and urban worlds stemming from these global processes is clearly noticeable in the emergence of agro-industrial schemes. On the other, trade liberalization has also enhanced the creation of global value chains in the agri-food sector, with major implications for agrarian structures in developing countries. The agglomerations of agro-based industries and producers into clusters, agricultural growth corridors and special economic zones, have recently resurfaced in response to these changes, and as a means to transform agriculture. Major impacts have been observed on smallholding farmers in developing countries, whose integration into global and regional value chains shapes the contemporary agrarian question. The current process of agricultural transformation in Ethiopia is deeply embedded in these global trends: the government-led process is mainly outward-oriented and aimed at integrating agro-industrial value chains to spur the conversion of the country into a global leader in manufacturing goods by 2025. One of the most significant strategies designed to achieve this goal is the agglomeration of agricultural and industrial producers into poles, hubs, or clusters, in order to benefit from the service-delivery concentration.

The Need for a Transformation of Agriculture in SSA

In the rapid transformation of labour, production relations, trades, technologies, capital formation and space, observed globally over the last decades in the agri-food sector, farming still remains a problem in many developing countries, particularly in Africa. Despite significant changes, it is still mostly dominated by smallholder farmers (80% according to recent estimates) cultivating small plots with low productivity, high post-harvest loss rates and very low added value generation; nevertheless, agriculture remains an essential sector of the African economy because it employs 50% of the labour force and it constitutes the main source of income for over 60% of the total population, who still lives in rural areas (Moyo *et al.* 2015).
The liberalization of input-supply systems has led to a general increase in input prices and a decrease in credit access due to a tiny contribution by the private sector, which performed below expectations. Positive effects were observed in the decline in rural poverty rates, associated to lower food prices for consumers, and higher market efficiency; but because of the elimination of government financing and credit subsidies, the overall per capita food production has stagnated (Kherallah*et al.* 2000).

Starting from 1995, most African countries have increased their integration into global value chains, both as input suppliers for other countries' export production, and as foreign input acquirers for export production (Conde *et al.* 2015). Most of the agencies for international cooperation and development have noticed that the participation in global value chains has increased foreign capital investments and entailed a growth in productivity and domestic added value in exports for most African countries (AfDB*et al.* 2014).

The greater integration of the continent into global production and trade relations was considered by some to have been responsible for the creation of the urgent need and opportunity for African farmers and governments to take advantage of the new technologies and market opening to boost the transformation of the sector, thus replicating the green revolution experienced by South and East Asian countries during the 1960-90 period (Moyo*et al.* 2015). From an aggregated point of view, compared to other regions, agriculture in Africa achieved very low levels of productivity and competitiveness both in terms of yields and net added value (Webber, Labaste 2010), and the progressive decrease in the incidence of agriculture on the economies was counterbalanced mainly by the increase in the trade service sectors, which showed the lowest labour productivity of the entire economy (Bah *et al.* 2015). Accordingly, many strategies were designed in order to adjust to the changing scenarios, to increase productivity, spur competitiveness and generate positive impacts on economic development and poverty reduction.

The production shifted toward those subsectors and commodities where the country enjoyed a relative advantage and higher income returns, such as oilseeds, fresh fruits and vegetables; foreign enterprises filled the gaps left by lack of capital, and input-supply systems were taken over by multinational corporations. Capital intensity in production and processing activities grew, entailing a higher capital-labour ratio and increased added value share within the agri-food chain (Reardon, Barrett 2000). Technological innovations lead to improved transportation and storage services. Wholesaling, processing and retailing activities imposed specialization and were influenced by the expansion of multinational corporations: many SSA's markets shifted from being dominated by traditional wholesale relations to the use of vertical coordination mechanisms, going from local procurement by each individual store to centralized procurement

through distribution centres (Reardon *et al.* 2009). In addition, contractual exchanges replaced spot markets, and consequently fostered the enhancement of property rights and private standard quality systems (Reardon, Barrett 2000).

Furthermore, the Ethiopian case is particularly interesting for two main reasons. On the one side, agro-based clusters are under implementation in Ethiopia even in areas where the agrarian transition is still in its initial phases. These areas are in fact characterized by very limited surplus accumulation systems, locked land markets, a very limited presence of agricultural workers and post-harvest transformations, and a strongly hampered private enterprise; therefore, the value addition chain needs to be created from scratch. On the other side, the creation of agro-based clusters is a major part of the economic project of the developmental state, which draws its political success and legitimation from an authoritarian relationship with its poor agrarian base. Therefore, in the Ethiopian context the cluster-based approach assumes an additional function which ranges from controlling the factors of production, leading agrarian change, monitoring development patterns and controlling the rural area in terms of politics. In order to approach the study of agro-based clusters, the following sections will briefly present: the theoretical framework underpinning clusters' models, comparative advantage and success determinants; the most debated issues regarding the integration of smallholder farmers into agro-based clusters in developing countries; and the role assigned to governments by mainstream literature concerning cluster creation.

Clustering: Models, Comparative Advantage and Success Determinants

The integration between different economic sectors represented by agro-industrial ventures, the focus on global value chains, the shift in political economy orientation, and the technological and organizational changes which characterized the early 1990s, created a fertile context for the re-emergence of the agglomeration approach in economic theory, and for its application to development theory. In fact, Porter (1998: 22) remarked that, in spite of increasingly faster communication, lower transportation costs and global accessibility to markets, within the global economy, proximity still constituted a crucial variable in the creation of competitive advantage and achieving economic success, especially in a developing country.

The "cluster" term usually refers to agglomerations of companies engaged in similar and/or related activities. Since clusters can vary greatly depending on a number of variables (shape, organizational form, location, objectives, components, complexity, productive sector, *raison d'être*, etc.), contemporary business literature has formulated different models in order to approach their analysis. One of the most influential works, in *The Second Industrial Divide* Piore and Sabel (1984) defined clusters as districts of small companies able to compete with Fordist mass production, thanks to the efficient combination of flexibility and specialization. The peculiarity of clusters is represented by the fact that, thanks to a correct mix of cooperation and competition, cluster companies are able to retain the productive flexibility that is typical of craftsmen and necessary on one hand to respond to the variable demand of a large consumer base, and on the other to attain the specialization and organizational capacities of larger companies.

From a collective efficiency perspective, the cluster's performance is closely linked to the level of cooperation achieved by the companies and, consequently, to the presence of joint actions and collective institutions. These may come in the form of local business associations, producer or service organizations and others, and can usually perform a wide range of functions that foster integration: vertical and horizontal coordination; regulation; representation of the cluster's interests *vis-à-vis* government and state institutions; provision of technical and benchmarking services, information and managerial advice to meet quality and safety standards, and assistance to reach global markets (Nadvi 1999). Cooperation is mentioned, although with much less emphasis, also from the of flexible specialization perspective issued by Pior and Sabel (1984), who attribute cluster success mainly to company relation with the market. The flexible application of increasingly productive technology and the creation of regional institutions to strengthen the connection between trades are indeed considered vital for success. Therefore, the impact that governments and policy support may bring has been widely accepted as a crucial issue. Particular attention also to the government's role towards implementing cluster development will be given in the analysis of the Ethiopian case. For these reasons, one of the following subchapters will be entirely dedicated to the examination of the most pertinent literature and contributions.

Clustering in Developing Countries: Integrating Smallholding Farmers into Agro-Based Clusters

Agro-based (or agribusiness) clusters may be defined as: the concentration, specialization and interconnection of producers, agro-industries, traders, service providers, institutions and other private and public actors engaged in a particular field (sometimes including universities, research institutes, associations and customers), linked by externalities and complementarities within a value-enhancing production chain, to address common challenges, increase cooperation, innovation and competitiveness (WB 2012). Since the 1990s, industrial and agro-industrial cluster-based projects diffusion has increased rapidly in developing countries, in response to changing production and trade relations: as pointed out by Clark *et al.* (2015) and Gálvez-Nogales (2010), this emergence has affected particularly SSA, as a way to promote innovation and enhance regional development. Indeed, although trade liberalization opened up new market and business opportunities, global economy and international competition forced local firms in developing countries to perform by global standards in terms of costs, quality, response speed and flexibility. Value chain integrations, specialized firm agglomeration, the creation of growth corridors and poles of competitiveness were some of the strategies pursued by enterprises and governments in developing countries, in order to cope with these new challenges.

Besides those specific challenges and opportunities created by the globalization processes, the rationale for clustering in developing countries did not differ significantly from the one found in more developed economies: to generate externalities, to increase productivity, to enhance mutual cooperation, to foster innovation, to reduce costs, to lobby policy reforms, to attract investors and to improve accessibility to inputs (WB 2012). In addition, given the particular conditions of less developed economies, merging similar industries can also help small-scale firms to upgrade, it can generate agrarian transition mechanisms, it can foster mobilization, break down investments into less risky steps, it can entail higher wages for rural workers and give a greater contribution to regional economic growth (WB 2012).

Underdeveloped economies are indeed characterized by limited critical masses, weak infrastructures, limited factor conditions, dominance of informal relations and very small-scale firms and farms, poor capacity building and institutional support. For these reasons, trade relationships between developed and developing countries, as shaped by the neoliberal-framed global agri-food system, have been defined unequal and unbalanced: with the former playing a decisive role in innovation, product design and standard definitions, and the latter group struggling to adapt to specifications and standards set elsewhere (McCormick, Oyelaran-Oyeyinka 2007). In global value chains, these trade relationships shape production patterns in both groups of countries, and tend to concentrate value-adding activities in richer and more favorable settings. Accordingly, since the 1990s the cluster approach has been promoted by the international donor community and many developing countries' governments, in order to replicate in disadvantaged settings, the conditions that promote a more equal distribution of value-adding activities along the global value chain.

The agricultural sectors were the ones to be more heavily affected by the evolution in trade patterns and production relations associated with global economy. In addition, given the weak manufacturing development and the mainstream focus on rural development and poverty reduction strategies which characterized the 1990s and 2000s, the new interest toward agglomeration and value chain schemes pervaded donor and government policy agendas regarding agriculture (Clark *et al.* 2015). Clustering in agriculture was expected to stimulate value-adding activities in the agricultural value chain: to promote cultivation pattern aggregation, to foster post-harvest and processing activities, and to improve producer-consumer connections. These changes were in turn expected to boost agrarian transition, rural development and economic growth.

Agro-based clusters existed already in the 1960s and 1970s, when the production of export commodities was concentrated in spot areas led by large-scale farms and a highly interventionist state, within a traditional model of agrarian transition based on agricultural surplus extraction (Gálvez-Nogales 2010). Thereafter, some clusters for non-traditional agricultural export commodities were established during the 1980s and associated with rural development goals. But a rapid hike in the expansion of agro-based clusters was seen in developing countries since the 1990s and throughout the last decades, as a consequence of the aforementioned transformation in the agri-food global system. From focusing initially on traditional and non-traditional export commodities, since the 2000s clusters have shifted to include staple crops for both national and international markets (Clark *et al.* 2015).

As pointed out by recent studies on the topic, agriculture clustering in developing countries is challenged by a number of factors: smaller firm/farm size, lack of a critical mass of firms/farms available for aggregation, informal relationships and organization, weak internal connections, lower-value product and service predominance, and poor market connections (Gálvez-Nogales 2010). With regard to SSA, underdeveloped trade networks, abundance of labour with a negative influence on market pooling effects, scarce contribution by higher education institutions for, unsubstantial political support, weak service providing institutions, large-scale industries in disarray due to rapid liberalizations, low-performing SMEs offering low-quality products, and natural resource mismanagement, further complicate the development and upgrading of clusters, and their competitiveness in global markets (Gálvez-Nogales 2010; Zeng 2008). Given these

premises, the success of agro-based clusters in developing countries is most likely profiting from a significant support by public policies aimed at setting the appropriate context where those involved can cooperate, compete and innovate (Gálvez-Nogales 2010).

The Transformation Agenda: Enhancing Production and Productivity

To «enhance the capacity of key stakeholders to achieve agricultural transformation» (ATA 2016: 16), the Agricultural Transformation Agency (ATA) was established in December 2010 after two years of extensive study of the agricultural sector in Ethiopia, conducted by the Ministry of Agriculture and Rural Development (MoARD) together with the Bill & Melinda Gates Foundation. The ATA was created thanks to Meles, who sought to create a new flexible and internationally-oriented institution to sustain the Ministry in the development of an efficient strategy for agricultural transformation. The ATA was established by Regulation n. 198/2010 under the supervision of an Agricultural Transformation Council chaired by the Prime Minister and deputy-chaired by the State Minister of MoARD, and it was assigned the following objectives: «1. to identify systemic constraints of agricultural development, through conducting studies, and recommend solutions in order to ensure sustainability and structural transformation, and support the application of same; 2. to support the establishment of strong linkages among agricultural and related institutions and projects in order to ensure the effectiveness of agricultural development activities» (FDRE 2011: art. 9). At the beginning of the GTP I period, the Council prepared an Agricultural Transformation Agenda intended to provide a coordinated approach to remove all obstacles holding back the sector's development and to support Ethiopia's transition to a middle-income country status by 2025. In the first phase of inception (2011-15) the ATA was expected to contribute to all the GTP I agricultural targets, including doubling staple crop production and increasing value addition by 8%. In the subsequent phases (2016-20 and 2021-25) the Agenda aimed at integrating agriculture with other market issues and economic sectors; the final phase (2026-30) was intended to complete the transition (ATA 2016).

Industrial Parks and Clustering

The overall objectives set by the GTP I and II are linked to the expansion of production, productivity, quality and competitiveness of its manufacturing industry, given its potential development in bringing about a structural transformation in Ethiopia. To ensure a competitive industrial development, the government has focused on creating favorable conditions for investors by investing in human resources, boosting developmental thinking, creating a conducive investment climate, facilitating legal frameworks and organizational structures, and improving infrastructures (FDRE 2016). The light and agro-processing industry constitutes the strategy's backbone and is expected to increase by 21.9% annually during the GTP II period. Detailed development plans have been prepared to promote the development of the textile and garment industry, the leather and leather product industry, the metal and engineering industry, the meat, milk and honey industry, the chemical and construction supply industry, the agro-processing industry, and the pharmaceutical industry. Various strategies were planned, among which the creation of industrial development zones, to support the manufacturing industry's development. Particularly in the case of small- and medium-size firms, Ethiopian entrepreneurs face many obstacles in their ordinary activities, especially when it comes to obtaining credit, protecting minority investors, trading across borders, dealing with construction permits and starting a business (WB 2017).

Clustering in Agriculture

With the GTP I and II, the cluster-based approach has spread also in the GoE's agenda for agricultural development and transformation, with four main programs: the Integrated Agro-Industrial Parks (IAIPs), the Agricultural Commercialization Clusters (ACC), the Livestock Master Plan and the Agricultural Growth Program (AGP). As reported by ZegeyeTeklu, Agribusiness Market Linkage Manager at ATA, clustering in agriculture is made to enhance an effective use of resources and ultimately to increase agricultural producers' production and productivity. Improving production and productivity is consistent with the transformational agenda envisaged by the government and its connected agencies for the agricultural sector, which should shift from subsistence to commercial farming.

Agricultural Commercialization Clusters

If what has been pointed out at the end of the previous section is certainly true – that the smallholder farming sector holds a major role in the industrialization process – it must also be said that the strategy followed to improve peasant sub-sector productivity and marketability, is creating opportunities for a radical change in its core structure. This is to actually say that, through the application of the cluster-based approach within these strategies, smallholder farmers may undergo a transformation in their production and reproduction relations.

According to the ACC framework, and as confirmed also by ZegeyeTeklu, clusters need to be commodity-based and market oriented, and to be established where there are the highest growth prospects. The rationale is to focus on high potential commodities and areas where surplus production is already present, or where there is the possibility to increase this surplus and boost value addition. The ACC has also a special significance for exports since, as he underlined, it allows for more productivity, better quality and traceability of the commodities, and more domestic value addition, which in turn mean an increase in revenues coming from export. The selection process – performed jointly by federal and regional agriculture offices, NGOs and major private sector actors (ATA 2016) - starts with the identification of the commodity, evaluating its production potential, marketability for export or import substitution, and value addition potential;146 other criteria included in the draft of the National Framework for ACC concerned domestic market potential, smallholder farmers coverage and domestic market opportunity. Subsequently, the cluster's location is decided based on the area's production potential and natural resource availability; cluster's size is supposed to vary between 5 and 15 *woreda*. Once they are picked out, clusters are prioritized according to their current and potential production levels, value addition capacity, access to markets and ongoing parallel initiatives. Each cluster is expected to have one primary commodity, and one or two additional rotation crops. The number of selected clusters and commodities vary from one policy paper to another: the unpublished draft of the National Framework for Agriculture Commercialization Clusters in Ethiopia announced that 21 clusters and 12 commodity types had been chosen, and this information was confirmed by ZegeyeTeklu in July 2016. The 2011-15 progress report announced the designation of 31 and that an additional 16 were in the works for interventions during 2015 (ATA 2016). The most recent official paper reported that 26 clusters and 10 commodities had been selected, but since a federal strategy has been issued for only 7 commodities, just 14 clusters are being implemented (ATA 2017).

Nine clusters over 114 *woreda* and ten commodities have been picked out in the Oromia Region, amounting to a targeted total of 4.6 million hectares and 1.3 million farmers. In 2015-16, five clusters and commodities were given top priority: the maize cluster in the Horro Guduru Wellega, East Wellega, and West Shewa areas; the malt barley cluster in the Arsi and West Arsi areas; the bread wheat cluster in the Arsi, West Arsi and Bale areas; the durum wheat cluster in the Bale area; the teff cluster in the West Shewa, East Shewa (where the Bulbula Park is located), South West Shewa areas (ATA 2017). Out of a total of 739,727 ha of land that had been allocated to these five clusters, 134.235 ha is the actual surface that they occupy, as reported by the MoANR in August 2016.Operations concern mainly: an increased adoption of improved inputs and access to credit, linkages with agro-industries, building agro-processing capacity in local factories and strengthening farming contract agreements between farmers and buyers. Primary cooperatives and unions are appointed a major role in collecting production, raw material storage, increasing their agro-processing capacity or linking farmers with industries, finding market opportunities. Huge expectations surround the potentiality of these clusters, in terms of production, productivity, share of marketed products, agro-processing capacity, farmer use of recommended inputs, and revenue from export growth (ATA 2017). Oromia apparently reported the highest results for the period: the clusters supplied around 700,000 qt of crops (durum wheat and malt barley) to agro-industries such as the Asela Malt Factory; 800,000 qt of bread wheat have been channeled to the EGTE through unions; five unions delivered 130,000 qt of maize grain to the WFP, the Mama Injera and Consumer Association in Addis Ababa, and other buyers through contractual agreements (ATA 2017)

Conceptual Framework of the Study

Agricultural productivity in general may be increased in different ways. First, agricultural productivity may be increased through increased use of inputs, usually referred as horizontal expansion. Increasing agricultural productivity using this method requires raising the quantity of inputs used in the production. Though such activities have the potential for productivity enhancement, the method has little application in Ethiopia and other developing countries because of limited resources and restricted access to credit to increase the quantity of inputs. The second method of increasing agricultural productivity is through improving efficiency of resource utilization. Such technique increases productivity by improving the overall efficiency of farmers using the current levels, quality of inputs and existing technology. In this method, efficiency of production could be obtained through the utilization of better farm management practices and removing some existing production constraints and improvement of farm technology. Such technique is termed as transformation method, which is characterized by a shift of production frontier upward (Arega, 2003; Jema, 2006; Walter and Hezron, 2003; Headey *et al*., 2010). Efficiency in production is assumed to be affected by a wide range of factors. From the extensive reviews, the various factors can be grouped into the following six broad categories: (1) demographic characteristic (2) socioeconomic characteristics (3) farm characteristics and (4) institutional factors (5) factors related to marketing characteristics. The factors related to demographic characteristics include age, sex, family size and household size. The factors related to the socioeconomic characteristics include livestock holding, off/non-farm income, education level and family education. The factors related to farm characteristics include the size of farm, number of plots, and experience of farming. The institutional factors include use of credit, extension service, and membership of cooperatives, accessibility of development centers. The

factors related to the marketing characteristics include accessibility of markets and availability of market information, etc.

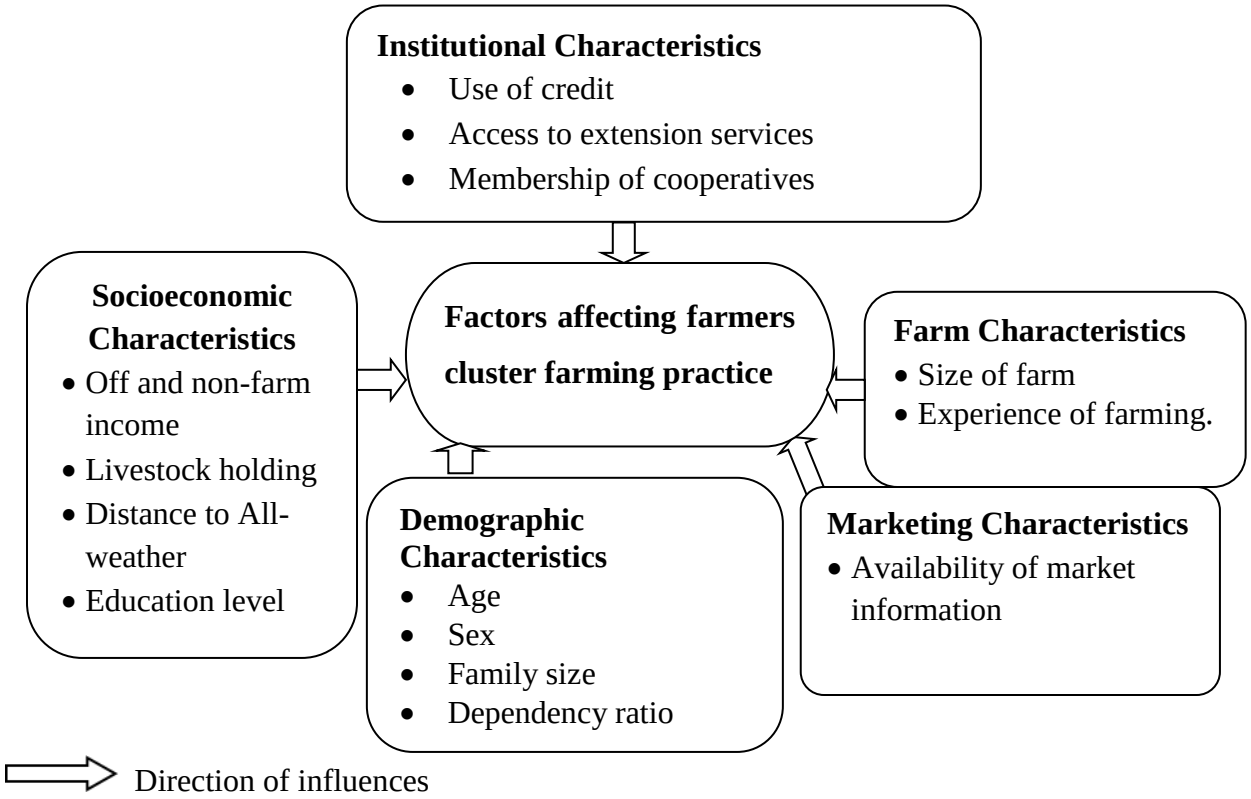

Figure 1: Conceptual framework
Source: Own design from literature reviewed, 2021.

Research Methodology

Description of the study area

These studies were conducted in selected districts of West Arsi and East Shewa Zones. West Arsi Zone found in the south part whereas East Shewa Zone is found in central part of the Oromia National Regional State. West Arsi Zone lies between 6^0 00' N to 7^0 35'N and 38^0 00'E to $40^0$00'E and demarcated by Bale Zone in west direction, Arsi Zone in East direction, Southern Nation Nationality and People Regional State in South direction, and East Shewa Zone in north direction. The Zone has 12 districts. Shashemene is the capital city of West Arsi Zone and located at 250 km from Addis Ababa/Finfinnee towards South direction on Addis Ababa/Finfinnee - Hawassa main asphalt road.

West Arsi Zone encompasses different agro-ecologies namely high land, midland and lowland. In the Zone the high land agro-ecology (47.92%) took more coverage followed by midland (42.50%) and lowland (9.82%) agro-ecologies. The Zone lies within altitude of 1500-3800 meter above sea level (ZoARD, 2016).

The total population in the Zone was 2,290,280 of which 45.50% are male and 50.50% are female. The Zone receives 600mm-2700mm annual rain fall and has a bimodal pattern of rain fall. It also receives 12ºC-27ºC annual temperature per year. The Zone has a total of 1,286,277.50 hectare of land. From the total land, 0.36% is arable land, 29.27% cultivated land, 19.50% forest land, 17.05% grazing land, 4.58% used for construction and 29.26% used for other purposes (ZoARD, 2016).

East Shewa Zone lies between 60 00' N to 70 35'N and 380 00'E to 400 00'E. This zone is bordered on the South by the West Arsi Zone, on the Southwest by the Southern Nations, Nationalities and Peoples Region, on the West by South west Shewa Zone, on the Northwest by North Shewa, and on the Southeast by Arsi Zone. Adama city is the capital city of East Shewa Zone and located at 100 km from Addis Ababa/Finfinne towards South–East direction.

East Shewa Zone has different agro-ecologies which categorized as highland, midland and lowland agro-ecologies. In the Zone, 18.70% of the agro-ecology is high land, 27.50% is midland and 53.80% is lowland. The total population in the Zone was1,275,645 of which 53.26% are male and 46.74% are female. It receives 350mm-1150 mm annual rain fall and has uni-modal nature of rain fall pattern. This Zone also receives 12ºC-39ºC annual temperature per year (ZoARD, 2016).

The Zone has a total of 971,159.21 hectare of land. From the total land, 12.57% is arable land, 47.31% is cultivated land, 4.18% forest land, 14.58% grazing land, 4.89% is used for construction and 12.82% is used for other purposes (ZoARD, 2016).

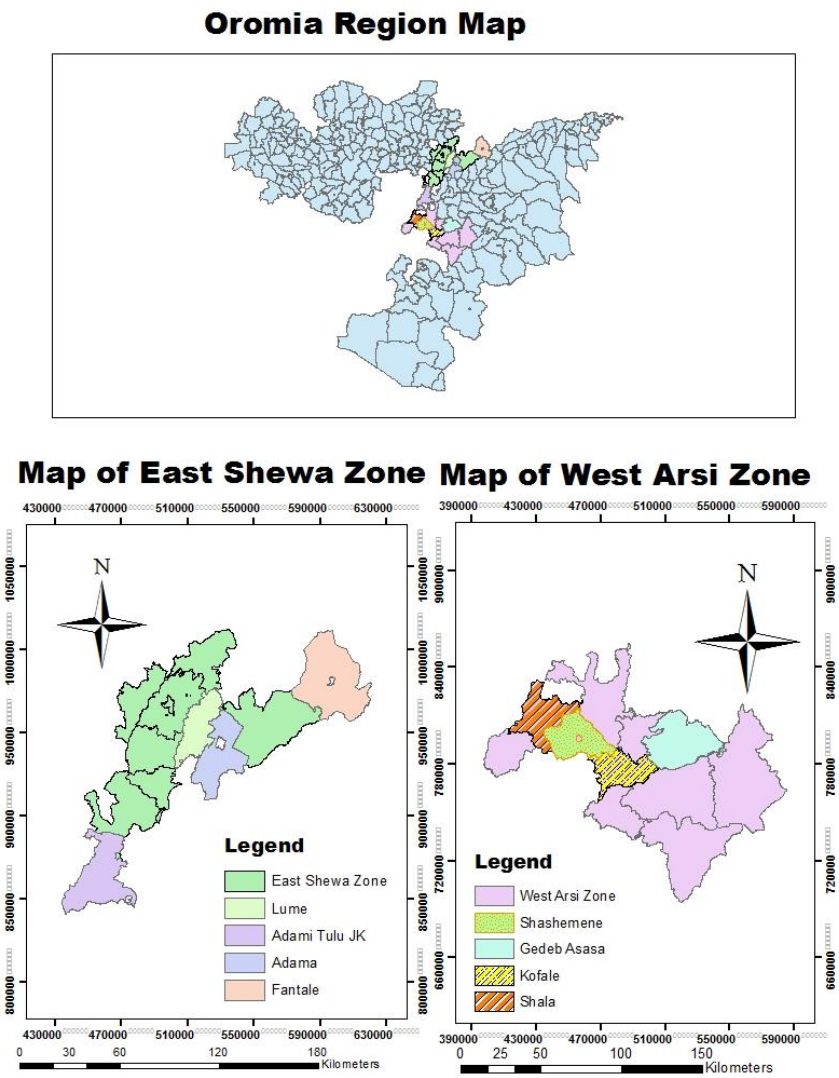

Figure 1: Map of the study area (West Arsi and East Shoa Zones)

Data types, sources and methods of data collection

Both primary and secondary data were used for this study. Primary data generated through cross-sectional survey during 2020/21 production season using semi-structured questionnaire, key informant interviews, and focus-group discussions. The questionnaire were designed and pre-tested in the field for its validity and content, and to make overall improvement of the same and in line with the objectives of the study. To complement the primary data, secondary data were collected from both government and Non-Government Organizations (NGOs). The major sources of secondary data was from both published materials and online resources such as CSA, ATA, FAO data base and West Arsi and East shoa zones agriculture office.

Sampling procedure and sample size

Another criteria required of the households is that they have to grow similar crop i.e. Wheat at West Arsi and maize and Teff at East Shewa zone at least once during the last five years. This is crucial since member homogeneity is the prerequisite for successful cooperation (Hansmann, 2000). The respondents sample selection was focuses on households who have expressed willingness to be part of an agricultural clustered farming without any government intervention.

Two-stage sampling techniques were employed for this study.

1st households stratified into members and non-members of clustered agricultural farming and **2nd** from each stratum equal proportion of sample respondents were selected by using simple random sampling techniques. In general a total of **367** sample respondents were selected from both zones.

Methods of Data Analysis

Both descriptive and inferential statistics was used to analyze the data. Descriptive statistical tools such as average, ratios, percentages, frequencies, etc. were applied to describe household and farming characteristics of the study areas. While inferential statistical such as $\chi 2$, and t-tests will be used to compare households in the two groups in terms of household farming characteristics. Both partial and total factor productivity was used, in addition technical efficiency which is often used to evaluate farm performance was also applied. Factors affecting clustered farming practice and the view of farmers for clustered farming approach was modeled using a two-limit probit model.

Selection of Production Function

The limitation of SFM is to pre-determine a functional form and assume the distribution for technical inefficiency (half-normal, gamma, truncated and exponential) for the evaluation of technical inefficiency. Among the possible algebraic forms of production function, Cobb-Douglas and trans log functions have been the most popularly used models in the most empirical studies of agricultural production analysis. A number of researcher stated that Cobb-Douglas functional form has advantages over the other functional forms in that it provides a comparison between adequate fit of the data and computational feasibility. It is also convenient in interpreting elasticity of production and it solves problems with respect to degrees of freedom. According to Coelli (1995), the Cobb-Douglas functional form has most attractive feature which is its simplicity. But, the Cobb-Douglas functional form imposes severe restriction on the technology by restricting the production elasticity to be constant and the elasticity of input substitution to be unity. Likewise, translog production function imposes no restrictions upon returns to scale or substitution possibilities. However, the function is more complicated to estimate having serious estimation problems. A among these estimation problems, if number of variable inputs adding, the number of parameters to be estimated raise rapidly and also additional terms require cross products of input variables, thus, making a serious multicolinearity and degrees of freedom problems. Even through, Cobb-Douglas production function assumes unitary elasticity of substitution and constant production elasticity; it has adequate representation of technology and insignificant impact on measurement of efficiency (Coelli et al., 2005).

Results and Discussion

Descriptive Analysis for West Arsi Zone

The most dominant crop produced in West Arsi zone was wheat. Analysis of the member of cluster farming practice result showed that from the total 152 sampled households head, 45.39% were member of cluster farming practice while the remaining 54.61% was not member West Arsi zone. The probability of households to practice cluster farming was 44.7%.

Table 1: Member of cluster farming

Are you member of cluster farming?	Freq.	Percent	**Remark**
No	83	54.61	
Yes	69	45.39	
Total	152	100	

Demographic characteristics of sampled households for West Arsi zone

Aged Household head (HH) has the source of good farming experience and able to participate risk involving farm activity than older farmers. The average age of the sample households during the survey period, was about 43.64 years which was less than 65.97 year of average life expectancy for both sex in Ethiopia (WPP,2017). Based on Strock et al., 1991 (as cited in Ermiyas ,2013) this average value of age included in the most economically active age group of 17-50 year.

The average education level of literate sample household heads during survey period was about 6 years with the minimum of zero years (illiterate) and maximum of 12 years. Family size plays an important role in crop production and most farmers depend mainly on family labor. The average family size of the sample households was 9 persons per household (Table 2) which is greater than 4.6 person per household as Ethiopia, based on household size and composition around the world in 2017.

The mean cultivated land holding of the sample household was 1.612 ha. On average, sample household owned livestock of 7.67 TLU. This indicates that the farming system in Ethiopia is mainly based on plough by animal draught power that has created complementarity between crop and livestock production (Table 2).

In general independent sample t test result indicates that there were no significant difference between member of cluster farming and individual farming in all variables except for age and land cultivated implying the absence of significant relationship of above listed variables with membership decision of cluster farming.

Table 2: Socio-demographic characteristics for continues variables of West Arsi zone

Demographic characteristics	Cluster member (n=69)		Individual (n=83)		Total Sample (n=152)		t-value
	Mean	Std. Dev	Mean	Std. Dev.	Mean	Std. Dev	
Age of HH head	42.072	1.1178	44.95	1.1045	43.64	.794	-1.8017
Land price/0.25ha	7413.04	804.2	7521.69	761.91	7472.37	780.66	0.8535
Family size	9.2028	4.327	9.228	3.613	9.217	3.939	0.0404
TLU	7.397	4.8126	7.889	5.225	7.6658	5.0316	0.5985
Grade level	6.50	3.52	5.6987	3.3339	6.059	3.4318	-1.4245
Land cultivated/individual	1.511	.8306	1.696	.9468	1.612	.8977	1.26
Total cost of production/ha	77,002.18	61498.22	195,738	22626.8	141,838.4	74155	16.32

Productivity of wheat in cluster and individual farming

There was variability in technical inputs and output among wheat producing farmers (Table 3). Land, fertilizer, labor, seed, and chemical were included in production function to produce wheat output. This is economic process of producing output from these inputs or uses resources to create output that are suitable for users. On average sample households produced 47.175 and 39.042 quintals of wheat in cluster and individual farming respectively.

Table 3: Productivity of wheat in cluster and individual farming

No	Factor of production	Cluster	Individual	t-value	Remark
1	Yield-wheat/quintal	47.1747	39.042	14.7307	

Wheat stochastic production function for cluster and individual farming

The appropriateness of the stochastic frontier model over the convectional production function can be tested using the statistical significance of the Stochastic Production Frontier Ordinary Least Square parameter gamma, Ý. The positive coefficient of input used implies that as each of these variables is increased, ceteris paribus, wheat output increased, whereas negative sign suggest a situation of excessive (and, hence, inefficient) use in the production in the study area. Statistically significant input suggests that factors explaining cluster and individual farming in study the area.

The estimated value of gamma is equal to 1E+00 for individual farming which is statistically significant at 1% level of significance suggesting that 100% of the variation in output is due to the variation in technical inefficiency among the farmers.

The coefficients of the production function are interpreted as elasticity. The highest coefficient of output to land (0.809) following fertilizer (0.142) in cluster farming whereas its 0.681 and 0.146 for land and fertilizer in individual farming suggesting that land and fertilizer are the main determinants of wheat production in the study area. If there is a one percent increase in the size

of land and amount of fertilizer would increase wheat production by 0.809%, 0.142%, in cluster farming whereas its increases by 0.681%, 0.146%, in individual farming respectively for land and fertilizer. In other words, the increase of these inputs were increase output of wheat production significantly which similar to the returns to scale analysis can serve as a measure of total factor productivity and indicated that there is increasing returns to scale. This implied that there was a potential for wheat producer to continue to expand their production. In other words, a percent increase in all inputs proportionally would increase the total production by 1.21 in cluster farming whereas its 0.79 in individual farming.

Table 4. Estimated Wheat stochastic production function for cluster and individual farming

Variables	**Cluster Production frontier**		**Variables**	**Individual production frontier**	
	ML estimate			ML estimate	
	Coefficient	Std.Err		Coefficient	Std.Err
Intercept	3.781***	0.1992	**Intercept**	3.96***	0. 2023
Ln (land)	0.809***	0.0868	***Ln (land)***	0.681***	0.07501
Ln (labour)	-0.022	0.0412	***Ln (labour)***	-0.005	0.03573
Ln (seed)	0.019	0.0258	***Ln (seed)***	-0.011	0.02215
Ln (fertilizer)	0.142***	0.0420	***Ln (fertilizer)***	0.146**	0. 0627
Ln (chemical)	0.084	0.0548	***Ln (chemical)***	-0.202	0.01858
	Return to Scale= 1.21		**Return to Scale= 0.79**		
γ (gamma)	0.74***			**γ (gamma)**	0.94***
Log likelihood	-7.388				
LR test	1.11			**Log likelihood**	-25.0532
					LR Test 11.68

***, Significant at 1% significance level, Source: Own computation, 2020/21

Estimation of Wheat technical efficiencies of Cluster and individual farming smallholder farmers

The results of the efficiency scores indicate that there were wide ranges of differences in TE among wheat producer households. The result indicated that farmers in the study were relatively good TE in cluster farming than individual farming as presented in table below.

The mean TE was found to be 78.46% and 69.25% for cluster and individual farming respectively, which indicated that, if sample households in the study area operated at full efficiency level, households would have increased their output by 21.54% and 30.75% using the existing resources and level of technology. In other words, it implied that on average sample households in the study area can decrease their inputs by 21.54% and 30.75% for cluster and individual to get the output they are currently getting. There is huge gap among farmers in sample study which ranges 43.59% to 92.49% for cluster farming and 24.30% to 94.79% individual farming. Some literature support that, they argue that larger farmer is more likely to employ improved agricultural technologies, used as a capital base and enhances the risk bearing ability of farmers and hence could be more efficient than small farms due to its advantage of the economic scale and scope associated with larger sizes (Beyene, 2004; Hussein, 2007). This result needs to extension intervention by arrange experience sharing between farmers to reduce the efficiency gap.

Table 5: Estimation of Wheat technical efficiencies of Cluster and individual farming smallholder farmers

Types of farming	Efficiency	Mean	St.dev.	Minimum	Maximum
Cluster	Technical Efficiency	0.785	0.1027	0.436	0.925
Individual	Technical Efficiency	0.693	0.1761	0.243	0.948

Source: Survey data, 2020/21

Analysis of wheat yield gap of cluster and individual farming

In the table below, it was observed that the mean cluster and individual yield difference between sample farmer due to technical efficiency variation was 13.30 qt per ha and 17.33 qt per ha respectively.

Table 6. Yield gap due to technical inefficiency of cluster and individual farming

Type of farming	Variable	Mean
Cluster	Actual qt per hectare	47.17
	TE (%)	0.785
	Potential qt per ha	60.47
	Yield gap (qt per ha)	13.30
Individual	Actual qt per hectare	39.042
	TE (%)	0.693
	Potential qt per ha	56.38
	Yield gap (qt per ha)	17.33

Survey Result, 2020/21

Returns to scale Wheat production

The return to scale (RTS) analysis, which serves as a measure of total resource productivity, is given under below Table. The maximum likelihood estimates (MLE) of the Cobb-Douglas based stochastic production function parameter of 1.211 and 0.79 is obtained from the summation of the coefficients of the estimated inputs (elasticity) of cluster and individual respectively. It indicates that cluster farming practice in study area is stage I of increasing returns to scale for cluster farming whereas its stage II for individual farming where resources and production were believed to be efficient. This means an increase in all inputs at the sample mean by one percent will increase wheat by 1.211 % and 0.79 % respectively in the study area. Some literature support that, they argue that larger farmer is more likely to employ improved agricultural technologies, used as a capital base and enhances the risk bearing ability of farmers and hence could be more efficient than small farms due to its advantage of the economic scale and scope associated with larger sizes (Beyene, 2004; Hussein, 2007).

Table 7: Elasticity and returns to scale of the parameters of stochastic frontier

	Production	
	Cluster	**Individual**
Variables	**Elasticities**	**Elasticities**
Ln (land)	0.809	0.681
Ln (labour)	-0.022	-0.0052
Ln (seed)	0.0198	-0.0108
Ln (fertilizer)	0.1418	0.1457
Ln (chemical)	0.084	-0.0202
Returns to scale	**1.21**	**0.79**

Source: Survey data, 2020/21

Results of the Econometric Model (Factors affecting participation of farmers in clustered farming)

Before running the econometric models, the data was tested against econometric problems like multicolinearity using VIF, heteroscedasticity using Breusch-Pagan test and endogenetity using Durbin-Wu-Hausman chi-square test. The test results indicate that there is no problem of multicolinearity, heteroscedasticity and endogenetity in the model.

The probit regression model was used to analyze the smallholder farmers' cluster farming practices. The model chi square test indicates that the overall goodness-of-fit of the probit model was statistically significant at 1% probability level which in turn indicates the usefulness of the model to explain the relationship between the dependent and at least one independent variable. The result of probit model estimation shows that the factors affecting farmers cluster farming practices significantly influenced by sex of households, Age of Household, nearest market center, distance to FTC, Participation in social, and participation in field visit.

Table 8: Factors affecting farmers' participation in clustered farming

Number of observation=152
LR chi^2(12) = 29.59
Prob > chi2 = 0.0018
Pseudo R2 = 0.1413

Log likelihood = -89.919

	Coefficients	**Robust Std. Err.**	**P>z**	**Marginal effect**
Sex of HH	0.7599***	0.18977	0.000	0.20866
Age of HH	0.0249205*	.0143332	0.082	.00985
Family size	0.0400626	.0341621	0.241	.01584
Education level of HH	0.0363379	.0385125	0.345	.01437
Distance to the nearest market center	0.05304**	.0262586	0.043	.02097
Distance to FTC	0.18989***	0.06921	0.006	0.043
Access to credit	0.3166895	.4822601	0.511	.12581
Access to extension	0.369467	.3216062	0.251	.143815
Access to market information	0.2116207	.3053566	0.488	-.083868
Participation on field visit	0.705102***	.253598	0.005	.274701
Participation in off-farm income	0.4661411	.4260734	0.274	-.1749447
Participation in social organization	0.43257*	0.25815	0.094	0.1149996
Constant	-5.432973	1.468928	0.000	

***, **,*: implies statistical significance at 1%, 5%, and 10% levels, Log pseudo likelihood = --89.919, Pseudo R^2 = 0.1413, Wald chi^2 (12) =29.59, Prob> chi^2 = 0.0018, Predicted probability = 0.447, N = 152.

Sex of HH Head: As the probit model result indicates, being male household head had positive and highly significant influence on the likelihood of cluster farming practices at 1% significance level, suggesting male family heads practices cluster farming than female family head by 20.86%.

Age of HH: As the probit model result indicate that, as households age increases the likelihood of practicing cluster farming increase by 9.8%. This result is in conformity with the finding of Leake.*et al*., (2018).

Distance to the nearest market: Distance of households to the nearest market center was found to influence farmers cluster farming practices positively and statically significantly at 5% probability level. The result was found as per to the prior expectation. The result of probit model depicts that as distance from the home to the nearest market center decreases by one km, the probability of farmers' to practice cluster farming increases by 2.1%, keeping other factors constant. The result revealed that as farmers are located far from market center they are less likely to practice cluster farming. This is in line with the findings of Desale (2017).

Distance to FTC: Distance of households to FTC was found to influence farmers cluster farming practices positively and statically significantly at 1% probability level. The result was found as per to the prior expectation. The result of probit model depicts that as distance from the home to the FTC decreases by one km, the probability of farmers' to practice cluster farming increases by 4.26%, keeping other factors constant. The result revealed that as farmers are located far from market center they are less likely to practice cluster farming. This is in line with the findings of Desale (2017).

Participation in Field visit: As the model result revealed that, participation in different field visit had a positive impact on household's cluster farming practices at 1% level of statistical significance. This implies that the respondent's participation in field visit would increase the probability of household's cluster farming practices by about 27.47%, keeping other factors constant. The probable reason was that the respondent participation in field visit increase their awareness about technologies and create good network which increase practices of cluster farming. Participation in field visit assumes that farmers who have participated in different field visit are more likely to be aware of new practices as they are easily exposed to information. This implies those only participant farmers in different field visit exposure were more likely to practices cluster farming than non-participant farmers. This is in line with the findings of Desale (2017).

Participation in Social organization: As the model result revealed that, participation in social organization had a positive impact on household's cluster farming practices at 10% level of statistical significance. This implies that the respondent's participation in social organization would increase the probability of household's cluster farming practices by about 11.49%, keeping other factors constant. The probable reason was that the respondent participation in social organization increases their awareness about technologies and create good network which increase practices of cluster farming. Participation in social organization assumes that farmers who have participated in different social organization are more likely to be aware of new practices as they are easily exposed to information. This implies those only participant farmers in different social organization exposure were more likely to practices cluster farming than non-participant farmers. This is in line with the findings of Desale (2017).

Perception of farmers regarding to compatibility of cluster farming in line with socio-economics circumstances in West Arsi zone

Positive attitude towards compatibility of cluster farming is one of the factors that can speed up the change process. Positive attitude formation is also a prerequisite for behavioral change to occur. Therefore, it was hypothesized that favorable attitude towards compatibility of cluster farming positively influences the likelihood of farmers to practice cluster farming. This was measured using a summated rating (Likert) scale.

(Düvel, 1991) associates perceptions with the way the attributes of innovations are perceived and he distinguishes between (a) awareness of relative advantages, (b) awareness or concern of disadvantages, (c) the overall prominence or relative advantage of innovation (practice), and (d) the compatibility with situational circumstances. In this study, weighted average of individual positive (advantages) was calculated. As the result of research analysis indicate that, the cumulative sum of farmers perception towards the compatibility of cluster farming with the

socio-economic situational circumstances was 4.093 suggesting farmers perceive positively cluster farming was compatibility with their socio-economic situational circumstances

Table 9: Perception of farmers regarding to compatibility of cluster farming in line with socio-economics circumstances in West Arsi zone

Compatibility of clustered farming with your socio-economic circumstances	Percent
Not compatible	4.35
Less compatible	24.64
Undecided	2.90
Compatible	66.67
Highly compatible	1.45
Total	**100.00**

Descriptive Analysis for East Shewa Zone

The most dominant crop produced by farmer in East Shewa zone was maize and teff which accounts for 60 and 42.86% respectively by cluster. Analysis of the member of cluster farming practice result showed that from the total 215 sampled households head, 49.30% were member of cluster farming with 3.23 year experience.

Table 10: Member of cluster farming in East Shewa zone

Are you member of cluster farming?	Freq.	Percent	**Remark**
No	109	50.70	
Yes	106	49.30	
Total	215	100	

Source: Survey result of 2020/21

Demographic characteristics of sampled households for East Shewa zone

Average age of the overall sampled respondent was found to be 41.82 years. Average age of sample respondents of member of cluster and non-cluster farming was 43.13 and 40.55 years old respectively. The average age of the sample households during the survey period, was about 41.82 years having farming experience 23.15 years which was less than 65.97 year of average life expectancy for both sex in Ethiopia (WPP, 2017). Based on Strock et al., 1991 (as cited in Ermiyas ,2013) this average value of age included in the most economically active age group of 17-50 year. Independent sample t test result shows that no statistically significant mean difference between two group farmers in terms of age indicating absence of association of membership decision of cluster farming and age of sampled respondent households.

The average education level of literate sample household heads during survey period was about 6.4 years with the minimum of zero years (illiterate) and maximum of 12 years. Family size plays an important role in crop production and most farmers depend mainly on family labor. The average family size of the sample households was 6 persons per household (table 11) which is greater than 4.6 persons per household as Ethiopia, based on household size and composition around the world in 2017.

Cultivated farmland was calculated as a sum of owned land, rented-in and shared-in farm land less shared-out farm. It is an effective farm land amount used by sample households to undertake agricultural production. Sample households were found to hold a mean of 1.44 ha of cultivated land in the survey year from total land holding of 1.92ha. Member of cluster and non-cluster farmers held a mean of 1.725 and 1.167 ha respectively. An independent sample t-test comparison also showed that member of cluster farming farmers have superior to non-cluster in terms of their cultivated land holding at 1% probability level. This finding is in line with other study results such as (Ermias, 2013).

On average, sample household owned livestock of 6.345 TLU. This indicates that the farming system in Ethiopia is mainly based on plough by animal draught power that has created complementarity between crop and livestock production (Table 11).

In general independent sample t test result indicates that there were no significant difference between member of cluster and non-cluster farmers of farming practice in terms age, farm experience and educational level in study area (Table 11), implying the absence of significant relationship of above listed variables with membership decision of cluster farming.

Table 11: Socio-demographic characteristics for East Shewa zone

Demographic characteristics	**Cluster member (n=106)**		**Individual (n=109)**		**Total Sample (n=215)**		**t-value**
	Mean	Std. Dev	Mean	Std. Dev.	Mean	Std. Dev	
Age of HH head	43.132	13.22	40.5505	11.29	41.823	12.3215	-1.5409
Farm Experience	24.198	12.902	22.1376	11.587	23.1535	12.268	-1.2327
Family size	7	3.21	6	2.7185	6**	2.9988	-2.2253
TLU	7.189	3.5107	5.5312	3.023	6.3488***	3.369	-3.7152
Grade level	6.536	2.6489	6.3151	2.8523	6.4323	2.7398	-0.5012
Land cultivated	1.725	0.9958	1.166	.8314	1.442***	.9559	-4.4726
Total land holding	2.251	1.3386	1.6058	1.0915	1.924***	1.2590	-3.8802

Source: Survey result of 2020/21

Productivity of Maize and Teff in cluster and individual farming in East Shewa zone

There was variability in technical inputs and output among maize and teff producing farmers (Table 12). Land, fertilizer, labor, seed, and chemical were included in production function to produce maize and teff output. This is economic process of producing output from these inputs or uses resources to create output that are suitable for users. The productivity of Maize per hectare was 46.42 and 25.982 quintal for cluster and individual farming respectively which is

statically significant at 1% level. The productivity of Teff per hectare was 16.076 and 11.043 quintal for cluster and individual farming respectively which is statically significant at 5% level.

Table 12: Productivity of maize and teff in cluster and individual farming in east Shewa zone

Commodity Productivity/ha	Cluster	Individual	t-value
Productivity-Maize/quintal	46.422	25.982	10.73***
Productivity-Teff/quintal	16.076	11.0431	-2.2719**

Source: Survey result of 2020/21

Estimated Teff stochastic production function for cluster and individual farming

The appropriateness of the stochastic frontier model over the convectional production function can be tested using the statistical significance of the Stochastic Production Frontier Ordinary Least Square parameter gamma, Ý. The estimated value of gamma is equal to 0.98 for individual farming which is statistically significant at 1% level of significance suggesting that 98% of the variation in output is due to the variation in technical inefficiency among the farmers whereas the remaining 2% of variation in output is due to the random shocks.

The coefficients of the production function are interpreted as elasticity. The highest coefficient of output to seed (0.30) following fertilizer (0.24) in cluster farming whereas its 0.6 and 0.44 for fertilizer and seed in individual farming suggesting that seed and fertilizer are the main determinants of teff production in the study area. If there is a one percent increase in the amount of fertilizer would increase teff production by 0.24%, 0.60%, in cluster and individual farming respectively. The increase of these inputs were increase output of teff production significantly which similar to the returns to scale analysis can serve as a measure of total factor productivity and indicated that there is decreasing returns to scale. This implied that there was a potential for teff producer to continue to expand their production. In other words, a percent increase in all inputs proportionally would increase the total production by 0.62 in cluster farming whereas its 0.036 in individual farming.

The sum of the partial elasticity of all inputs for cluster and individual farming equals to 0.62 and 0.036% respectively. This means an increase in all inputs at the sample mean by one percent will increase teff output by 0.62% in cluster farming whereas it's by 0.036% in individual farming in the study area. This result was in line with Beyene, 2004 and Hussein, 2007, they argue that larger farmer is more likely to employ improved agricultural technologies, used as a capital base and enhances the risk bearing ability of farmers and hence could be more efficient than small farms due to its advantage of the economic scale and scope associated with larger sizes.

Table 13: Estimated Teff stochastic production function for cluster and individual farming

Variables	Cluster farming frontier		Variables	Individual farming frontier	
	ML estimate			ML estimate	
	Coefficient	Std.Err		Coefficient	Std.Err
Intercept	0.9538**	0.46555	**Intercept**	4.8496***	0.71353
Ln (land)	-0.03119	0.10891	***Ln (land)***	0.146035	0.3085
Ln (labour)	0.114345	0.10629	***Ln (labour)***	-0.2743*	0.1582
Ln (seed)	0.30083***	0.09092	***Ln (seed)***	-0.4375***	0.15736
Ln (fertilizer)	0.24207**	0.1008	***Ln (fertilizer)***	0.60037*	0.32155
	∑β= 0.62				**∑β= 0.036**
γ (gamma)	0.98***				
Log likelihood	-22.9078			***Log likelihood***	-44.567
LR test	0.7			***LR Test 0.34***	

Source: Survey result of 2020/21

Estimated Maize stochastic production function for cluster and individual farming

The appropriateness of the stochastic frontier model over the convectional production function can be tested using the statistical significance of the Stochastic Production Frontier Ordinary Least Square parameter gamma, Ý. The estimated value of gamma is equal to 0.97 for individual farming which is statistically significant at 1% level of significance suggesting that 97% of the variation in output is due to the variation in technical inefficiency among the farmers whereas the remaining 3% of variation in output is due to the random shocks.

The coefficients of the production function are interpreted as elasticity. The highest coefficient of output to fertilizer (0.63) following seed (0.092) in cluster farming whereas its 0.39 for land in individual farming suggesting that fertilizer, seed and land are the main determinants of maize production in the study area. If there is a one percent increase in the amount of fertilizer would increase maize production by 0.63%, in cluster farming whereas if there is one percent increase in the size of the land maize production would increase by 0.39 in individual farming. The increase of these inputs were increase output of maize production significantly which similar to the returns to scale analysis can serve as a measure of total factor productivity and indicated that there is increasing returns to scale. This implied that there was a potential for maize producer to continue to expand their production. In other words, a percent increase in all inputs proportionally would increase the total production by 0.767 in cluster farming whereas its 0.689 in individual farming.

The sum of the partial elasticity of all inputs for cluster and individual farming equals to 0.767 and 0.689% respectively. This means an increase in all inputs at the sample mean by one percent will increase maize output by 0.767 % in cluster farming whereas it's by 0.689 % in individual farming in the study area. This result was in line with Beyene, 2004 and Hussein, 2007, they argue that larger farmer is more likely to employ improved agricultural technologies, used as a capital base and enhances the risk bearing ability of farmers and hence could be more efficient than small farms due to its advantage of the economic scale and scope associated with larger sizes.

Table 14: Estimated Maize stochastic production function for cluster and individual farming

Variables	Cluster farming frontier		Variables	Individual farming frontier	
	ML estimate			ML estimate	
	Coefficient	Std.Err		Coefficient	Std.Err
Intercept	4.0782***	0.23229	**Intercept**	3.9189***	0.00016
Ln (land)	0.23414	0.21227	***Ln (land)***	0.3902***	0.00005
Ln (seed)	-0.09269**	0.04139	***Ln (seed)***	-1.13e-08	0.00005
Ln (fertilizer)	0.6341***	0.00936	***Ln (fertilizer)***	0.2999003	7.11e-06
	∑*β*= 0.767			**∑*β*= 0.689**	
γ (gamma)	0.99***				0.97***
Log likelihood	-15.20919				-28.8072
					8.83***
LR test	18.14***				

Source: Survey result of 2020/21

Estimation of Teff technical efficiencies of Cluster and individual farming smallholder farmers

The results of the efficiency scores indicate that there were wide ranges of differences in TE among teff and maize producer households. The result indicated that farmers in the study were relatively good TE in cluster farming than individual farming as presented in table below.

The study indicated that 70.32% and 58.22% were the mean levels of Technical Efficiency of cluster and individual farming respectively. This in turn implies that farmers can increase their cluster and individual farming productivity on average by 29.68% and 41.78% respectively at the existing level of inputs and current technology by operating at full technical efficient level. This result was in line with Beyene, 2004 and Hussein, 2007, they argue that larger farmer is more likely to employ improved agricultural technologies, used as a capital base and enhances the risk bearing ability of farmers and hence could be more efficient than small farms due to its advantage of the economic scale and scope associated with larger sizes.

Table 15: Estimation of Teff technical efficiencies of Cluster and individual farming smallholder farmers

Types of farming	Efficiency	Mean	St.dev.	Minimum	Maximum
Cluster	Technical Efficiency	0.7032	0.10388	0.3948	0.87514
Individual	Technical Efficiency	0.5822	0.18772	0.1800	0.860477

Source: Survey data, 2021

Estimation of Maize technical efficiencies of Cluster and individual farming smallholder farmers

The study indicated that 64.64% and 53.58% were the mean levels of Technical Efficiency of cluster and individual farming respectively. This in turn implies that farmers can increase their cluster and individual farming productivity on average by 35.36% and 46.42% respectively at the existing level of inputs and current technology by operating at full technical efficient level. There is huge gap among farmers in sample study which ranges 43.59% to 92.49% for cluster farming and 24.30% to 94.79% individual farming. This result needs to extension intervention by arrange experience sharing between farmers to reduce the efficiency gap. This result was in line with Beyene, 2004 and Hussein, 2007, they argue that larger farmer is more likely to employ improved agricultural technologies, used as a capital base and enhances the risk bearing ability of farmers and hence could be more efficient than small farms due to its advantage of the economic scale and scope associated with larger sizes.

Table 16: Estimation of Maize technical efficiencies of Cluster and individual farming smallholder farmers

Types of farming	Efficiency	Mean	St.dev.	Minimum	Maximum
Cluster	Technical Efficiency	0.64637	0.23327	0.139036	0.9999
Individual	Technical Efficiency	0.5358	0.2389	0.1324	0.9999

Source: Survey data, 2021

Analysis of maize and teff yield gap of cluster and individual farming

In the table 17 and 18, it was observed that the mean cluster and individual yield difference between sample farmer due to technical efficiency variation was 16.43 qt per ha and 12.056 qt per ha respectively for maize, whereas its 4.77 and 4.626 qt per ha for teff.

Table 17: Maize yield gap due to technical inefficiency of cluster and individual farming

Type of farming	Variable	Mean
Cluster	Actual qt per hectare	46.42
	TE (%)	0.646
	Potential qt per ha	62.85
	Yield gap (qt per ha)	16.43
Individual	Actual qt per hectare	25.982
	TE (%)	0.536
	Potential qt per ha	38.036
	Yield gap (qt per ha)	12.056

Survey Result, 2021

Table 18: Teff yield gap due to technical inefficiency of cluster and individual farming

Type of farming	Variable	Mean
Cluster	Actual qt per hectare	16.076
	TE (%)	0.703
	Potential qt per ha	20.85
	Yield gap (qt per ha)	4.77
Individual	Actual qt per hectare	11.043
	TE (%)	0.582
	Potential qt per ha	15.659
	Yield gap (qt per ha)	4.626

Source: Survey result of 2020/21

Perception of farmers regarding to compatibility of cluster farming in line with socio-economics circumstances and its advantage

Positive attitude towards compatibility of cluster farming is one of the factors that can speed up the change process. Positive attitude formation is also a prerequisite for behavioral change to occur. Therefore, it was hypothesized that favorable attitude towards compatibility of cluster farming positively influences the likelihood of farmers to practice cluster farming. This was measured using a summated rating (Likert) scale.

(Düvel, 1991) associates perceptions with the way the attributes of innovations are perceived and he distinguishes between (a) awareness of relative advantages, (b) awareness or concern of disadvantages, (c) the overall prominence or relative advantage of innovation (practice), and (d) the compatibility with situational circumstances. In this study, weighted average of individual positive (advantages) was calculated. As the result of research analysis indicate that, the cumulative sum of farmers perception towards the compatibility of cluster farming with the socio-economic situational circumstances was 4.093 suggesting farmers perceive farmers in cluster approach uses improved verities, working tougher, that result in productivity improvement and skill and knowledge improvement.

Table 19: Perception of farmers regarding to compatibility of cluster farming in line with socio-economics circumstances

Compatibility with your socio-economic circumstances	Freq.	Percent	Remark
Less compatible	6	2.79	The cumulative sum is 4.093 suggesting positive perception of cluster farming
Undecided	6	2.79	
Compatible	165	76.74	
Highly compatible	38	17.67	
Total	**215**	**100.00**	

Result of econometric model (Factors affecting farmers participation in cluster farming practice in East Shewa zone)

The VIF results for access to agricultural credit (Appendix Table 2) indicate that, there is no serious multicolinearity problem among the explanatory variables included in the model. In the model estimation, a robust estimation technique was used to correct for minor heteroscedasticity problems.

The probit regression model was used to analyze the smallholder farmers' cluster farming practices. The model chi square test indicates that the overall goodness-of-fit of the probit model was statistically significant at 1% probability level which in turn indicates the usefulness of the model to explain the relationship between the dependent and at least one independent variable. The result of probit model estimation shows that the factors affecting farmers cluster farming practices significantly influenced by cultivated land, access to extension, participation in field visit, and farmer's perception.

Table 20: Result of econometric model (Factors affecting farmers participation in cluster farming practice in East Shewa zone)

		Number of observation	= 215	
		LR $chi^2(13)$	= 52.45	
		Prob > chi2	= 0.0000	
Log likelihood = -122.78		Pseudo R2	= 0.1760	
Variables	**Coefficient**	**Std. Err.**	**P>z**	**Marginal effect**
Farm experience	0.0115	0.01246	0.358	0.0046
TLU	0.0419	0.03116	0.179	0.0167
Sex of HH	-0.4161	0.46967	0.376	-0.1659
Age of HH	0.0037	0.01237	0.765	0.00148
Cultivated land	0.8074**	0.35746	0.024	0.32186
Total land owned	-0.3023	0.27366	0.269	-0.12051
FTC distance	-0.0391	0.06579	0.553	-0.01557
Access to credit	0.10715	0.28212	0.704	0.04272
Access to extension	0.48819**	0.23553	0.038	0.19120
Market information	-0.0479	0.21176	0.821	-0.01908
cellphone	-0.1774	0.3100	0.567	-0.0707
participation on field visit	0.3495*	0.2137	0.100	0.1387
Perception of farmers	1.27625***	0.4241	0.003	0.4151
Constant	-1.7595	0.8431	0.037	

***, **,*: implies statistical significance at 1%, 5%, and 10% levels, Log pseudo likelihood = -122.781, Pseudo R^2 = 0.1760, Wald chi^2 (13) =52.45, Prob> chi^2 = 0.0000, Predicted probability = 0.485, N = 215.

Land cultivated: Consistent with *priori* expectation, the model result showed a positive and significant relationship between land cultivated and decision to practice cluster farming at less than 5% level of probability. This result implies that as the respondent's cultivated land increase by one hectare, their likelihood of practicing cluster farming would increase by 32.19%, keeping other factors constant. This result implies that as farmers focus more on crop production, s/he gives more attention for cluster farming than individual farming. The result would tell us status of cluster farming practicing among different sizes of land cultivated for crop production. It implies that larger farmers practice cluster farming more than small farmers land cultivated households. The result enhances the validity of an argument which states that larger area cultivated farmers are commercialized producers indicating cluster farming practice are more market demanded than individual farmers while small are subsistent producer. A possible explanation might be an increased commercial behavior of farmers' with an increase area of land cultivated. This is in line with the findings of (Mignouna *et al.*, 2011).

Access to extension service: Access to extension service was found to have a positive and significant influenced on farmers cluster farming practice at 5% level. This significance indicates that those farmers who have access to extension service practice cluster farming than individual farming producer. The result implies that access to extension service would increase farmers' cluster farming practice by 19.12% than others, keeping all other factors constant. They farmers who got the chance to more frequently visit by extension professionals are more efficient than their counter parts. Because it improves the technical knowhow and skill of the farmers thereby exchange of experience will improve the efficiency. This is in line with the findings of Abdulkadir (2015).

Participation in Field visit: As the model result revealed that, participation in different field visit had a positive impact on household's cluster farming practices at 10% level of statistical significance. This implies that the respondent's participation in field visit would increase the probability of household's cluster farming practices by about 13.87%, keeping other factors constant. The probable reason was that the respondent participation in field visit increase their awareness about technologies and create good network which increase practices of cluster farming. Participation in field visit assumes that farmers who have participated in different field visit are more likely to be aware of new practices as they are easily exposed to information. This implies those only participant farmers in different field visit exposure were more likely to practices cluster farming than non-participant farmers.

Perception of farmers: Perception of farmers on compatibility/advantage of cluster farming has positive and spastically significant at 1% level on probability of farmers cluster farming practice. Those farmers who have positive perception on compatibility of cluster farming practice practice cluster farming by 41.51% than others. (Düvel, 1991) associates perceptions with the way the attributes of innovations are perceived and he distinguishes between (a) awareness of relative advantages, (b) awareness or concern of disadvantages, (c) the overall prominence or relative advantage of innovation (practice), and (d) the compatibility with situational circumstances. In this study, weighted average of individual positive (advantages) and negative (disadvantages) were calculated and total advantage and disadvantage were calculated.

Summary, Conclusions and Recommendations

This chapter summarizes the whole findings of the study and makes conclusions based on the results of the descriptive and econometric model. It also highlights some important policy recommendations to enhance farmers' productivity and efficiency in cluster and individual farming practice.

Summary and Conclusions

The overall objective of this study was to compare the productivity and efficiency of clustered and individual farming and to identify factors affecting clusters farming practice in West Arsi and East Shoa zones. In the meantime knowing the view/perception of farmers for clustered farming approach in the study area was also the objective of this study. To conduct the study, primary data was collected from 367 randomly selected household heads through semi-structured questionnaire. Secondary data were also collected from different sources including CSA, ZOANR, DOANR, and from published and unpublished sources to supplement primary data. In this study both descriptive statistics and econometric analysis were employed. The primary data was analyzed using descriptive statistics and stochastic efficiency decomposition method to decompose TE. Stochastic Frontier approach (SFA) was used for its ability to distinguish inefficiency from deviations that are caused by factors beyond the control of farmers.

The descriptive analysis frequency and mean was used to analysis demographic characteristics of sample households.

The productivity of wheat per hectare was 47.17 and 39.042 quintal for cluster and individual farming respectively which is statically significant at 1% level. The productivity of Maize per hectare was 46.42 and 25.982 quintal for cluster and individual farming respectively which is statically significant at 1% level. The productivity of Teff per hectare was 16.076 and 11.043 quintal for cluster and individual farming respectively which is statically significant at 5% level.

The study result revealed that the mean of TE was about 78.46%, 70.22% and 64.64% of for wheat, teff and maize production respectively for cluster farming and 69.25%, 58.22% and 53.58% for wheat, teff and maize production respectively for individual farming. The mean technical efficiency scores were quite high for Cluster farmers for all three commodities than individual farming, however, the results Show that there is still some considerable level of inefficiencies in the use of inputs for the corresponding output levels. The relatively high levels of technical efficiencies among the small scale farmers/individual defies the notion that wheat, maize and teff production in the zone can only be efficiently produced by the Cluster/large scale farmers. The relationship between farm size and efficiency is one of the more persistent puzzles in development economics, even more so as many potential determinants have been put forward and tested without being able to provide a fully satisfying explanation.

In general the findings from this study suggest that gains from improving technical efficiency exist in all farm categories but they appear to be much higher on large/cluster than on small farms/individual.

The relatively high levels of technical efficiencies among the small scale farmers/individual defies the notion that wheat, maize and teff production in the zone can only be efficiently produced by the Cluster/large scale farmers.

The relationship between farm size and efficiency is one of the more persistent puzzles in development economics, even more so as many potential determinants have been put forward and tested without being able to provide a fully satisfying explanation. In general the findings from this study suggest that gains from improving technical efficiency exist in all farm categories but they appear to be much higher on large/cluster than on small farms/individual.

The result of probit model revealed that, out of total 12 and 13 explanatory variables included in the model for West Arsi and East Shewa zones 6 (Sex of HH, age of HH, nearest market center, distance to FTC, participation on field visit and participation in social organization) and 4 (cultivated land, access to extension, participation on field visit and perception of farmers) variables was statically significant that influence the likelihood of farmers to practice cluster farming positively.

Recommendations

The findings of this study point to the need for implementing differential policies that separately target each factor which affect the two zones, in order to address the specific determinants of farmers' decision to practice cluster farming. Therefore, to promote and improve farmers' participation in cluster farming, the following policy options are suggested to be addressed by various stakeholders including governments at all levels, research centers, executive bodies of cooperatives and concerned NGOs.

Productivity and efficiency of wheat, maize and teff greater when produced by cluster, so shifting farmers from individual/small scale to large scale/cluster farming is the only option to boost the production.

Cultivated land affects significantly and positively participation decision of farmers in cluster farming. Therefore, the result could reinforce the reason suggested for increaseing land for cultivation through the use of rent-in and share-in where the situation of economies of scale could operate. On the other hand, creating opportunities of providing access to credit used to rent in and shared in land is also another better option to increase household's land cultivated for crops, which has been discovered to be one of the contributing factors to low level of participation in cluster farming.

Age of the household head has positive and significant impact of level of participation decision in cluster farming. The result entails that age is important variables in enhancing farmers' level of participation in cluster farming. Older farmers are assumed to have gained knowledge and experience over time and are better able to evaluate technology information than younger farmers. Therefore older farmers tend to intensify the adoption of new technologies in their farming business as a result of more years of farming experience, and knowledge. Thus, it is important for research, extension organization and NGOs to target order farmers during on farm research and cluster farming promotion as they can easily understand about the cluster farming which, in turn helps for convincing the other to participate in the cluster farming.

Distance from farm/home to nearest market center has significantly influence participation of farmers in cluster farming. This is due to the fact that farmers who use new varieties of crop need to transport crop seed from market or distribution center of cooperatives and WoARD which involves high transaction cost. In this connection investment in the development of infrastructure, such as construction of new rural roads or improving the existing one and reorientation of the seed system will need the attention of the government in order to increase the level of farmers' participation in cluster farming decision. Also it could be that farmers located far away could face deprived access to technological information and to involvement in on-station trials are less likely to participate in cluster farming and could continue with the existing individual small scale farming practices. While the present effort of the government to extend the construction of whether road in rural areas is encouraging, improving the existing market center in the locality (which is informal and poor developed) should be given proper attention to enhance participation of farmers in cluster farming. In the meantime as farmers far from market access to information, access to extension service also low. Therefore, improving the existing market centers in the locality should be given proper attention to enhance participation of farmers in cluster farming.

Respondent's participation in social organization has significant and positive impact on participation of farmers in cluster farming. The probable reason was that the respondent participation in any social organization increase their awareness about technologies and create good network which increase access to input used for crop production. Hence, we need to encourage establishment and strengthening of participation in any kinds of social organization to enhance farmer's participation in cluster farming through providing different kinds of incentive to farmers and use other suitable mechanism which increase producer farmer in participating of any community/social organization.

In general the following policy implication was recommended to increase participation of farmers in cluster farming in both zones;

- Improve farmers access to extension service
- Improve farmers participation in field visit
- Improve farmers perception on advantage of cluster farming
- Strengthening social network of farmers
- Development of human capital and
- Development of physical capital

Appendices

Appendix Table 1: VIF for West Arsi Zone

Variables	VIF	1/VIF
Sex of HH	1.43	
Age of HH	1.78	0.563202
Family size	1.72	0.582046
Education level of HH	1.66	0.601981
Nearest market center	1.49	0.673306
Distance to FTC	1.40	0.713104
Access to credit	1.40	0.713216
Access to extension	1.36	0.735136
Access to market information	1.32	0.758071
Participation on field visit	1.28	0.781955
Participation in off-farm income	1.19	0.842648
Participation in social	1.11	0.904296
Mean VIF	**1.43**	

Appendix Table 2: VIF for East Shewa Zone

Variable	VIF	1/VIF
Farm experience	8.95	0.111682
TLU	8.92	0.112152
Sex of HH	2.71	0.368696
Age of HH	2.68	0.373273
Cultivated land	1.39	0.718380
Total land owned	1.38	0.725702
FTC distance	1.34	0.744915
Access to credit	1.32	0.758604
Access to extension	1.20	0.834139
Market information	1.19	0.839634
Cellphone	1.17	0.851780
Participation on field visit	1.15	0.868310
Perception of farmers	1.14	0.880405
Mean VIF	**2.66**	

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Economic Efficiency of Potato and head cabbage Production by smallholder Farmers in West Arsi zone, Oromia Region Ethiopia

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Abstract

This study investigated Economic Efficiency of Potato and head cabbage Production in West Arsi Zone, Oromia Region, Ethiopia. Structured questionnaires were used to collect data from 117 respondents randomly selected from designated locations in West Arsi Zone. A stochastic production frontier function was fitted to the sample households. The result revealed that the mean TE, AE and EE was about 75.60%, 91.41% and 69.07% of for potato production and 77.10%,89.99% and 69.47% for head cabbage respectively. The sum of the partial elasticity of all inputs were 1.17 and 1.513 for Potato and head cabbage indicate an increase in all inputs at the sample mean by one percent increase by 1.17% and 1.513% potato and head cabbage respectively. This indicates that the production function is characterized by increasing returns to scale for both productions. The result of Tobit model estimation indicated that the technical efficiency of Potato production in West Arsi Zone is significantly influenced by the variables potato farming experience ,education level, social participation and Extension contact affect efficiency positively while, distance to FTC affect technical efficiency negatively. The technical and economic efficiency of Head cabbage production was significantly influenced by head cabbage farming experience, education level and market information affect positively while Distance to all-weather road affect negatively. Extension contact affects technical efficiency of head cabbage production. The mean potato and head cabbage yield difference between sample farmer due to technical efficiency variation was 31.04 qt per ha and 76.56 qt per ha respectively. District office of Agriculture, stockholders and concerned bodies should focus on farmers experience sharing, providing technical support and farmers practice different social participation to improve his/her income could jointly contribute to the improvement in efficiency of Potato and Head cabbage farmers in West Arsi Zone.

Keywords: Efficiency, West Arsi, Frontier model, and Tobit model

Introduction

Back ground of the study

Ethiopia is one of the fastest growing economies in Africa. In the last decade, the Ethiopian economy registered a growth of 11 percent per annum on average in Gross Domestic Product (GDP) (MoFED, 2014) compared to 3.8 percent in the previous decades (World Bank, 2015). This growth has largely been supported by a relatively high growth in the agricultural sector. The importance of agriculture in Ethiopia is evidenced by its share in GDP (43%), its employment generation (80%), share of export (70%) and providing about 70% raw material for the industries in the country in 2012/13 (UNDP, 2013). Thus, it is not surprising that policy action in Ethiopia is largely based on influencing the dynamism of the agricultural sector.

Agricultural productivity in general and horticultural production in particular has been given heavy emphasis over the last two decades in almost all development policies and strategies of the country. The Agricultural Development Led Industrialization (ADLI) places very high priority on accelerating agricultural growth in order to achieve food security of the nation (Byerlee *et al.*, 2007). Agriculture was also the main focus of the 2002 Sustainable Development and Poverty Reduction Plan (SDPRP), and the 2004 Food Security Strategy, and also the 2006 Plan for Accelerated and Sustainable Development to End Poverty (PASDEP) (MoFED, 2006). More recently, the first Growth and Transformation Plan (GTP) of Ethiopia also gave special emphasis to agricultural growth to achieve food security and poverty alleviation (2010-2015). One of the core goals of GTP is agricultural growth program which aims at increasing productivity to bring agricultural growth at the national level and maintain agriculture as a source of economic growth (MoFED, 2010).

Despite such policies focus on the sector over the last two decades, its productivity is constrained by lack of appropriate and affordable agricultural technologies, inefficiency in production, poor infrastructure, inefficient marketing systems, land degradation, rapidly expanding population, and inaccessibility to agricultural inputs such as improved/hybrid seeds, fertilizers and agro-chemicals (Yu and Nin-Pratt, 2014). As a result, the growth in agricultural output has failed to provide food for the fast growing population and thus aggravated the food insecurity situation in the country (Rehima *et al*., 2013). Thus, the goal of self-sufficiency in food production remains a long-term target and the question of making Ethiopia food self-sufficient continues to be a policy concern. Improvement of agricultural productivity provides an important solution in addressing the problems of food insecurity and poverty, and enhancing the development of agriculture in Ethiopia.

Vegetables are integral part of the farming system in Ethiopia. They are grown as sole or intercropped, rainfed or irrigated and plays crucial role in the economy of the country. Its demand is also growing, implying the need for concerted effort to improve productivity through sustainable supply of high yielding vegetable varieties (Bazabih *et al.*, 2014). Among several root and tuber crops, potato plays significant dietary role for human beings provided that good quality and high yield is guaranteed. It is not by chance that precisely the potato has to come to play on important port in more and better food supply (Solomon, 1985).

Irish potato is the first root crops produced in Ethiopia next to Taro/*Godere* and sweet potato that accounts 70,132 ha in 2015/16 *meher* cropping season (CSA, 2016a). The estimated producers of potatoes in both *belg* and *meher* season was accounted 3,705,879 holders in the country (CSA, 2016b). Oromia is the major potato producing region that constitutes 51% of the national potato production (CSA, 2015). According to the Bezabih and Mengistu (2011) West Arsi is a major potato producing zone in Oromia National Regional state that smallholder farming has diversified from staple food subsistence production into more market oriented and high value commodities.

As other leafy vegetables, cabbage is highly nutritious vegetable and has so many health benefits. It is rich in phyto-nutrient anti-oxidants that are powerful oxidants and known to help protect against breast, colon, and prostate cancers and help reduce LDL or "bad cholesterol" levels in the blood. Moreover, fresh cabbage is an excellent source of natural antioxidant,

vitamin C that helps the body develop resistance against infectious agents and scavenge harmful, pro-inflammatory free radicals (Umesh Rudrappa, 2014).

Vegetable production is becoming an increasingly important activity in the agricultural sector of the country mainly due to increased emphasis of the government on the commercialization of smallholder farmers (Hailegiorgis and Hagos, 2016). Integrating vegetable production into a farming system has contributes substantially to the Ethiopia's economy in terms of food and nutrition security as the vegetables complement stable foods for a balanced diet by providing vitamins and minerals (Bezabih *et al*., 2015). Chicken is one of economically important vegetables in the country which grows best under cool conditions. According to CSA (2014), annual chicken production (in quintal) and area under production (in hectare) has increased by about 16 and 30 percent, respectively, from 2012/13 to 2013/14. For instance, the total area covered with potato and head cabbage were about 29.21% and 2.58% respectively of the land allocated for root and vegetables crops production. From the total annual production of vegetable chicken shared 4.76% of production and potato shared 19.90% of root crop production (CSA, 2017). According to CSA, (2017) Productivity of potato and head cabbage are 13.678 and 6.25 ton/ha, respectively. Despite the production potentials and importance of potato and head cabbage crops for the country and study area their productivity is low. West Arsi zone potato yield was very low (10 ton/ha) even though the zone are suitable for quality potato production (Hirpa *et al*., 2010).

There is, however, little knowledge about the level of efficiency of both potato and head cabbage farmers who have been producing, and the underlying factors affecting them in West Arsi Zone. Also the knowledge on the source of inefficiency for these commodities is scanty. Therefore, a thorough study on these issues may help to identify the production constraints at farm level and thereby develop policy recommendations to increase potato and head cabbage production and productivity so that it will contribute to food security and poverty reduction efforts. Therefore, a thorough study on these issues may help to identify the production constraints at farm level and thereby develop policy recommendations to increase potato and head cabbage production and productivity so that it will contribute to food security and poverty reduction efforts.

Statement of the problem

Potato (*Solanum tuberosum L*.) is the world's third most important food crop in overall production after rice and wheat, and is a food security crop in some countries, including Ethiopia (Devaux *et al*., 2014). As other leafy vegetables, cabbage is highly nutritious vegetable and has so many health benefits. It is rich in phyto-nutrient anti-oxidants that are powerful oxidants and known to help protect against breast, colon, and prostate cancers and help reduce LDL or "bad cholesterol" levels in the blood. Moreover, fresh cabbage is an excellent source of natural antioxidant, vitamin C that helps the body develop resistance against infectious agents and scavenge harmful, pro-inflammatory free radicals (Umesh Rudrappa, 2014).

Vegetables and root crops took up about 1.69% and 1.82% of the area under all crops at national level respectively which is very low in area coverage when compared to grain crops that cover 81.27% at national level. Potato and head cabbage shares 0.53% and 0.049% from all crops at national level as well as 29.21% and 2.58% area coverage out of vegetable and root crops respectively. Potato and head cabbage also production in quintals contribute 19.90% and 4.76%

to total vegetable and root crop production at national level. The productivity of potato and head cabbage is 137.68 and 62.5 quintals per hectare respectively. From root crops and vegetable area coverage in the region, potatoes and chicken cover 43.97% and 3.62% respectively. West Arsi zone produce 4.5% of vegetables and 21% of root crops out of area coverage at regional level. From total area coverage by vegetables and root crops potatoes cover about 86.86% and chicken about 2.2%. The average productivity of potatoes is 97.74 quintals per hectares which is less than the average productivity at national level is 137.68 quintal per hectare (CSA, 2017).

Evidence of low productivity in vegetable production was observed because of inefficiency in resource use (Abang *et al.*, 2004). Farm efficiency no doubt is an important subject in developing countries agriculture (Parikh *et al.*, 1995). Farrell 1975 provided the impetus for developing the literature on empirical estimation of technical, allocative and economic efficiency. Among the approaches used in measuring efficiency stochastic frontier approach has been used extensively in measuring the level of inefficiency/efficiency.
The fruit and vegetable sector compares favorably with cereals and other food crop sectors in terms of employment and income generation. The production of vegetables has a comparative advantage particularly under conditions where arable land is scarce and labor is abundant. The traditional small scale fruit and vegetable production and marketing sector is an important sector in terms of employment, income and scale of production (Frank *et al*., 2015).

There are no previous studies conducted in the area of potato and head cabbage efficiency dealing exclusively with technical, allocative and economic efficiency of farmers and the factors considered to be important in determining their efficiency farming. Therefore, the analysis of technical, allocative and economic efficiency of potato and head cabbage farming is important. Understanding the levels of these efficiencies and their determinants will contribute a lot to the identification of production constraints at farm level and thereby improve the food security and income of farm households. This study, therefore, aims at estimating technical, allocative and economic efficiencies of potato and head cabbage and assessing their determinants of production efficiency, with a view to filling the existing knowledge gap

Research Questions

- ☑ Are potato and head cabbage production technically, allocative and economically efficient in the study area?
- ☑ What are the factors that cause efficiencies in potato and head cabbage production in the study area?

Objectives of the study

General Objective

The general objective of this study was to examine producers' technical, allocative and economic efficiencies in potato and head cabbage production in West Arsi zone, Oromia National Regional State, Ethiopia.

Specific objectives of the study were:

1. To estimate technical, allocative and economic efficiencies among potato and head cabbage producing smallholder farmers
2. To identify the factors affecting allocative and economic efficiency of potato and head cabbage producing smallholder farmers.

Literature Review

Vegetable production in Ethiopia

Ethiopia has a variety of vegetable crops growing in different agro ecological zones produced through commercial as well as small farmers both as a source of income and food (Almaz, *et al*, 2014). However, the type is limited to few crops and production is concentrated to some pocket areas. The production of vegetables varies from cultivating a few plants in the backyards for home consumption up to a large-scale production for domestic and export markets (Dawit *et al*., 2004). Exports of vegetable products from Ethiopia have increased from 25,300 tons in 2002/03 budget year and it's doubled in 2009/10 (EHDA, 2011).

Basic concepts of production efficiency

Agriculture sector plays a major role in the economy of many developing countries including Ethiopia, as it contributes significantly to economic growth, export earnings, employment generation, sources of nourishment for citizens and a means of livelihood for the most vulnerable members of these countries. As a consequence, raising production level through raising the efficiency of production is one of an important policy goal taken by researchers and development practitioners in most of these countries. This is mainly due to the limited available resources and opportunities for developing and adopting improved agricultural technologies are decreasing overtime in most developing countries (Jema, 2006). Given the level and quality of production inputs available and existing technology, how well farmers are able to utilize existing inputs or resources without substantial addition of intermediate input increases output is the notion of efficiency improvement.

Following the pioneer work by Farrell (1957), efficiency of a firm consists of two components: Technical Efficiency (TE) and Price efficiency (later renamed as Allocative Efficiency (AE)). TE is defined by comparing between observed and optimal values of output and inputs of a production unit (Coelli, 1995; Coelli *et al.*, 2005). It refers to the ability of a producing unit (firm) to obtain maximum (optimal) output from a given set of inputs and technology. Formally, the level of TE is measured by the distance of firm production from the optimal production frontier, a firm that sits on the production frontier is said to be technically efficient. Stated differently, technical inefficiencies reflect the failure of attaining the highest possible level of output given inputs and technology, it is using more inputs than is necessary (Coelli, 1995; Coelli *et al.*, 2005). AE refers to the ability of a firm to use inputs in optimal proportions for a given factor prices. For AE to hold, farmers must equalize their marginal returns with true factor market prices (Arega, 2003). In other words, a productive entity is allocatively inefficient when it is not using the combination of inputs that would minimize the cost of producing a given level of output (Walter and Hezron, 2003). Thus, technical inefficiency is related to deviations from

the frontier isoquant while allocative inefficiency reflects deviations from the minimum cost input ratios.

In addition to technical and allocative efficiency, Farrell (1957) also defined the concept of overall efficiency (later renamed as economic efficiency), which can be obtained from the product of the technical and allocative efficiency and shows the overall performance of enterprises and all the three measures are bounded between zero and one. He defined the Economic Efficiency (EE) or overall efficiency as "the capacity of a firm to produce a predetermined quantity of output at minimum cost for a given level of technology".

Theoretical framework for efficiency of production

The microeconomics theory of production function that transforms input into output is a base for measurement of efficiency of production. Production function describes production performance of a firm using productivity. Productivity defined as "the ratio of the value of total farm outputs to the value of total inputs used in farm production" (Coelli *et al.,* 2005).

The concepts of efficiency and productivity are quite closely related since both of them used as the measure of performance of smallholder farmers, but they are not precisely the same things. Productivity of farmer is producing a given level of output per unit of input (it may not be maximum possible output). Efficiency of production represents the optimal input mix to produce any given level of output that minimizes the cost of production. To illustrate the distinction between the two concepts, Coelli (1995) and Coelli *et al.* (2005) used a production frontier which defines the current state of technology in an industry. Firms in that industry would presently be operated either on that frontier, if they are perfectly efficient or beneath the frontier if they are not fully efficient. Changes in agricultural productivity are depicted by a shift of production frontier.
According to Farrell (1957), efficiency can be measured using either input-orientated or output orientated approaches. The input- oriented approach addresses the question "by how much can input quantities be proportionally reduced without changing the output quantities produced". The output-oriented approach addresses the question "by how much can output be increased without increasing the amount of input use by utilizing the given input more efficiently. Brief descriptions of these methods using graphs are shown subsequently based on Coelli *et al. (*2005):

I. Input-oriented method

To illustrate this method of measuring efficiency, Farrell (1957) used a simple example involving firms which use two inputs (X1 and X2) to produce a single output (Y), under the assumption of constant returns to scale. Knowledge of the unit iso-quant of fully efficient firm, represented by UU' in Figure 2.1, permits the measurement of TE. If a given firm uses quantities of inputs, defined by the point P to produce a unit of output, the TE of that firm is defined to be the ratio of $\frac{OQ}{QP}$ which is the proportional reduction in output. Farrell (1957) has also demonstrated that the unit iso-cost is a set of standards for measuring AE. The iso-cost line AA′ gives the minimum cost of producing one unit of output given relative input prices. The AE of the firm is defined to be the ratio of $\frac{OR}{OQ}$ the total EE is defined to be the ratio of $\frac{OR}{OP}$ which is the product of TE and AE. All efficiencies will take a value between zero and one, and hence provides an

indicator of the degree of technical inefficiency of the firm. The value of one indicates the firm is fully technically efficient. For example, the point Q is technically efficient because it lies on the efficient isoquant.

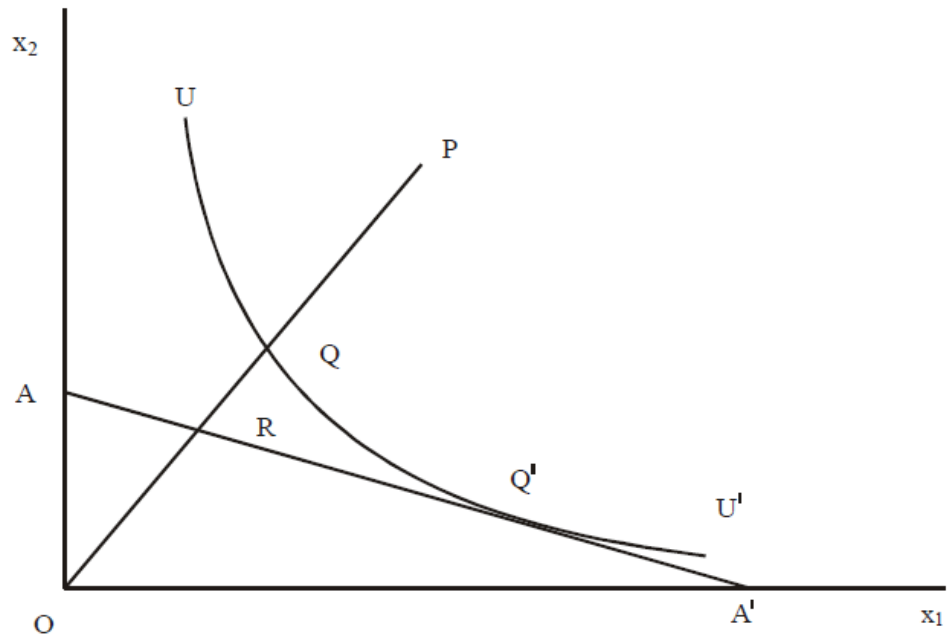

Figure 2.1: Input-oriented measures for technical, allocative and economic efficiencies
Source: Coelli *et al.* (2005)

II. Output-oriented method

According to Farrell's (1957), output-oriented measures address the question "By how much can output quantities be proportionally expanded without altering the input quantities used". In order to illustrate this method of measuring efficiency, he considered the case where production involves two outputs (Y1 and Y2) and a single input (X). Assuming a constant return to scale, we can represent the technology by a unit production possibility curve in two dimensions. The curve DD' in Figure 2.2, is the unit production possibility curve and point A corresponds to an inefficient firm. Note that an inefficient firm operating at point A lies below the curve, because DD' represents the upper bound of the production possibilities.

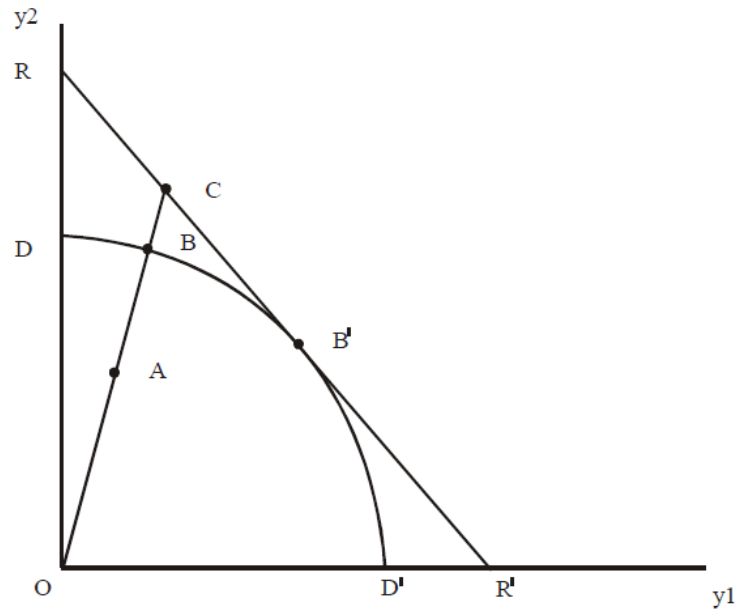

Figure 2.2: Output-oriented measures of technical, allocative and economic efficiencies
Source: Coelli *et al.* (2005)

The distance AB represents technical inefficiency, which is the amount by which outputs could be increased without requiring extra input. Hence, a measure of output-orientated technical efficiency is the ratio of $\frac{OA}{OB}$. If we have price information then we can draw iso-revenue line, RR‟, and define the allocative and technical efficiency measures as below. AE is the ratio between of $\frac{OB}{OC}$and TE is the ratio of $\frac{OA}{OB}$. Furthermore, the EE or overall efficiency can be obtained as the product of these two measurers (i.e.$\frac{OA}{OC}$).
Therefore, it is possible to measure the efficiencies of production using output oriented and/or input oriented methods. In this study, output-oriented analysis will be applied and it indicates the magnitude of output of the ith farmer relative to the output that can be produced by fully efficient potato and head cabbage producer farmer using the existing level of inputs.

Analytical framework for production efficiency

There are two analytical approaches that can be used to measure efficiency in production: non-parametric and parametric frontier approaches. A parametric approach is exemplified by stochastic frontier, while Data Envelopment Analysis (DEA) for non-parametric approach. There are strengths and weaknesses to each approach, which may influence the choice of approaches in a particular application. Parametric approaches assume that the functional form of the production function is known ahead and uses either DF (Distance Function) or SFA (Stochastic Frontier Analysis) and apply econometric method in estimating the parameters of the function. Parametric approach estimated by DF assumes that all the deviations from the frontier are a result of firms‟ inefficiency and hence it is deterministic, while SFA assume that part of the deviation from the frontier is due to random errors and part is due to firm specific inefficiency (Coelli, 1995; Coelli *et al.*, 2005). The principal advantage of SFA is the introduction of stochastic random noises that are beyond the control of the farmers. A second advantage of the approach is that it allows

statistical test of hypothesis pertaining the goodness of fit of the model and test the degree of inefficiency. However, the major disadvantage of this approach is that it imposes explicit restriction on functional form and it requires specification of the technology, which may be restricted in most cases (Coelli and Battese, 1996; Coelli *et al*., 2005).

However, the major advantage of the non-parametric approach to efficiency measurement is that it does not require the specification of a particular functional relationship between inputs and outputs. The production frontier is primary estimated using field data and measure efficiency relative to the constructed frontier using linear programming approaches. However, the main disadvantage is that it is deterministic rather than stochastic, meaning that all deviations from the frontier is attributed to inefficiency only so it takes no account of the possible influence such as random shocks like measurement errors and other noises in the data and hence the approach is sensitive to outliers (extreme observations) and data measurement errors. A second disadvantage of the approach is that it is not possible to estimate parameters of the model and hence impossible to test hypothesis concerning the performance of the model. A third disadvantage of the approach is that the estimated function has no statistical properties, and hence the estimated production frontier has no statistical properties to be evaluated upon (i.e. Mathematical programming procedure produces estimates without standard error, t-ratio, and so forth) (Coelli and Battese, 1996).

The previous studies used either parametric or non-parametric analytical approaches to estimate efficiencies of production such as Jema (2006), Ephraim (2007), Elibariki *et al.* (2008) and Endrias *et al*. (2010). However, other studies such as Arega and Rashid (2005), Ajibefun (2008), Headey *et al*. (2010), and Aye and Mungatana (2011) applied both approaches and compared the prediction capacity of the two methods. Their studies found that although there is a variation in the distributional patterns of the estimated efficiencies, they agreed that application of either approach proposed as the preferred set of efficiency measurement for policy decision making. On the contrary, Coelli and Battese (1996) argued that estimating the efficiency analysis using the parametric approach in the field of agriculture provides better results as compared with the non-parametric approaches. They justified their reasoning based on the fact that the parametric approach accounts exogenous factors in addition to accounting measurement errors, which is inherent in agriculture production. As a result of the above argument, this study employed a parametric stochastic frontier approach introduced by Aigner *et al.* (1977).

The parametric stochastic frontier approach requires a prior specification of the most widely used functional forms like Linear, Normalized Quadratic, Generalized Leontief, Constant Elasticity of Substitution, Cobb-Douglas and Translog production functions. The two popular functional forms are Cobb-Douglas and Translog production function, which have been most commonly used in the empirical estimation of frontier models by agricultural economists. Its most attractive features are simple, its logarithmic transformation provides a model which is linear in the logs of the inputs and hence easily lends itself to econometric estimation methods. Cobb-Douglas production function is a special form of the Translog production function where the coefficients of the squared and interaction terms of input variables are assumed to be zero. Besides, it imposes a severe prior restriction on the farm's technology by restricting the production elasticity to be constant (assumes constant return to scale) and the elasticity of input substitution to unity (Coelli, 1995; Coelli *et al.*, 2005). While, Translog production function, unlike Cobb-

Douglas production function is suitable for the estimation of second order functional form, which helps to account the effect of input interaction on output. However, as oppose to Cobb-Douglas, Translog production function is susceptible to the problem of serious multi collinearity (Headey *et al*., 2010).

A parametric stochastic frontier approach in agriculture field employed either Cobb–Douglas or/and Translog stochastic frontier model in measuring productivity and technical efficiency of a given farm. The selection of specific production functions primarily depends on the objectives of the research. For instance, Ephraim (2007) estimates a Cobb-Douglas stochastic frontier model in the analysis of technical efficiency of smallholder maize producer farmers in Malawi. Others such as Elibariki *et al*. (2008) estimated Translog stochastic frontier model on maize producing farmers in Tanzania and Shumet (2011) on selected crop among smallholder farmers in northern Ethiopia. On the other hand, Hassan and Ahmad (2005) applied both Cobb–Douglas and Translog production function using stochastic frontier model for wheat producer farmers in Pakistan. Moreover, empirical application of the techniques of efficiency analysis (technical, allocative and economic) using stochastic Cobb-Douglas frontier method have been reported those in Aye and Mungatana (2011) on maize farmers in Nigerian and Arega (2003) on maize farmers in Ethiopia. In their studies, Cobb-Douglas production function is selected due to it is advantage of computing self-dual cost function, which is a basis for estimating allocative and economic efficiencies. Hence, in this study Cobb-Douglas production function was estimated and computed the self-dual cost function using parametric approach among potato and head cabbage producing smallholder farmers of West Arsi zone.

The literature suggests two analytical approaches for analyzing the determinants of efficiencies of crop production. The first approach advocates a one stage simultaneous estimation approach in which the inefficiency effects are expressed as an explicit function of a vector of various independent variables. This approach is best suited to estimate only determinants of technical inefficiency as in Coelli (1995) but, the procedure has been criticized due to inability of estimating determinants of allocative and economic inefficiencies (Bravo-Ureta and Rieger, 1991). Various studies such as Wambui, (2005), Ephraim (2007), Elibariki *et al.* (2008), and Shumet (2011) employed this approach to identify the determinants of technical inefficiency of crop production. The second approach is two-stage estimation procedure in which first efficiency scores are derived employing either parametric and/or non-parametric approaches. In the next step the derived efficiency score is taken as dependent variable and is then regressed on explanatory variables using either OLS or two-limit Tobit models. Following the latter approaches, studies by Endrias *et al*. (2010) and Aye and Mungatana (2010) used two-limit Tobit model, whereas Arega (2003), Arega and Reshid (2005) applied OLS method to identify determinants of efficacies of maize production. The use of OLS model in such types of dependent variable (efficiency scores), which takes values between 0 and 1 leads to the problem of heteroscedasticity so that parameter estimates obtained are inefficient, thus classical hypothesis tests, such as t-ratios are inappropriate (Gujarati, 1995). On the other hand, two-limit Tobit model is best suited for such types of dependent variable (efficiency scores) and yield the consistent estimates for unknown parameter vector (Maddala, 1999). In this study, therefore, two-stage estimation approach using two-limit Tobit model was applied to identify determinants of technical, allocative and economic efficiencies of potato and head cabbage farmers.

Empirical studies on production efficiency

In general, there are three categories of factors that affect the level of efficiency in producing certain agricultural crops. They could be categorized into: positive, negative, and ambiguous impacts. Factors such as having the male household head, educational attainment levels, family literacy, frequency of contact with extension agents, membership of farmer's association or cooperative societies, participation in irrigation, access to credit, agro-ecological zones, family size, market access, farmers who practice mono-cropping, oxen holding, size of livestock holding, farm machinery (such as tractor) and access to improved agricultural technologies (such as use of improved seed, chemical fertilizer and agro-chemicals) are reported as having a positive effect on efficiency of crop production (Arega and Reshid, 2005; Ephraim, 2007; Elibariki *et al.*, 2008; Endrias *et al*., 2010; Aye and Mungatana, 2011; Shumet, 2011). While factors such as high cost of inputs including chemical fertilizers and herbicides, the size of farms negatively affected levels of efficiency of smallholders' farmers in crop production (Akinola and Adeyemo, 2008).

Factors such as age, years of farming, and farm size that have found both positive and negative impact on efficiency depending on the specific socioeconomic circumstances. For instance, studies such as Idiong *et al*. (2009) and Otitoju and Arene (2010) found that the relationship between land holding, age, and years of farming experience with efficiency of crop production have found positive, while other studies such as Idiong *et al*. (2009), Otitoju and Arene (2010) and Endrias *et al*. (2010) have found a negative impact on efficiency and hence there is no clear-cut relationship between these variables and hence they have an ambiguous impact on efficiency of crop production.

Most of the factors earlier identified as determining the level of efficiency of farmers are also identified in the literature as important predictors of productivity, regardless of the measure of productivity in use (Shehu *et al.*, 2010). Consequently, there is also a very strong emphasis in the literature on the quantity and quality of inputs used. The amounts of land available, availabilities of seeds, and labor (both family and hired) have strong impact on the productivity of a given land. The quantity of and the amount spent on fertilizer and agro-chemicals like pesticides and herbicides, and mechanization (the use of a tractor) are all important predictors of productivity (Otitoju and Arene, 2010). Uses of oxen, labor, chemical fertilizer in maize production has a positive effect on productivity of maize production (Endrias *et al*., 2010). However, sub-optimal utilization of any of these inputs has a negative effect on productivity. In addition, the availability of good quality, affordable inputs is a major constraint for smallholder farmers. Labor is the most easily available input, so farmers tend to overuse it (Idiong *et al*., 2009), while fertilizers and agro-chemicals, seeds, and high tech implements are often underused because of high costs in most developing countries (Shehu *et al.*, 2010). In a nutshell, from the reviewed literatures above, it is possible to conclude that household demographic, socioeconomic, farm and farmer specific attributes, marketing and institutional factors are among the most important determinants of efficiency of potato and head cabbage production and would be the focus of this study.

Conceptual Framework of the Study

Agricultural productivity in general may be increased in different ways. First, agricultural productivity may be increased through increased use of inputs, usually referred as horizontal expansion. Increasing agricultural productivity using this method requires raising the quantity of inputs used in the production. Though such activities have the potential for productivity enhancement, the method has little application in Ethiopia and other developing countries because of limited resources and restricted access to credit to increase the quantity of inputs. The second method of increasing agricultural productivity is through improving efficiency of resource utilization. Such technique increases productivity by improving the overall efficiency of farmers using the current levels, quality of inputs and existing technology. In this method, efficiency of production could be obtained through the utilization of better farm management practices and removing some existing production constraints and improvement of farm technology. Such technique is termed as transformation method, which is characterized by a shift of production frontier upward (Arega, 2003; Jema, 2006; Walter and Hezron, 2003; Headey *et al*., 2010). Efficiency in production is assumed to be affected by a wide range of factors. From the extensive reviews, the various factors can be grouped into the following six broad categories: (1) demographic characteristic (2) socioeconomic characteristics (3) farm characteristics and (4) institutional factors (5) factors related to marketing characteristics. The factors related to demographic characteristics include age, sex, family size and household size. The factors related to the socioeconomic characteristics include livestock holding, off/non-farm income, education level and family education. The factors related to farm characteristics include the size of farm, number of plots, and experience of farming. The institutional factors include use of credit, extension service, and membership of cooperatives, accessibility of development centers. The factors related to the marketing characteristics include accessibility of markets and availability of market information, etc.

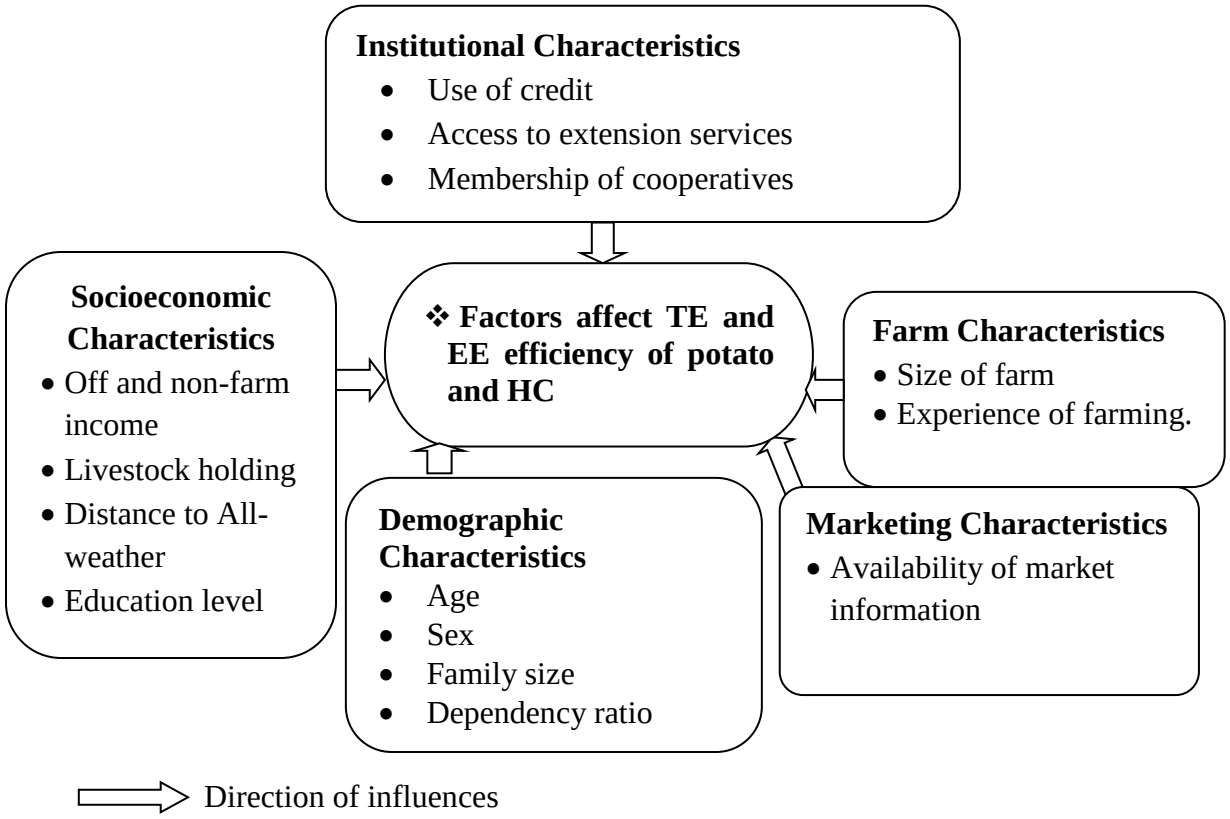

Figure 2.3. Conceptual framework
Source: Own design from literature reviewed, 2018.

Research Methodology

Description of the study area

This study was conducted in selected districts of West Arsi zone, Oromia region. West Arsi zone is one of the major potato growing zones of Oromia administrative region, Southern Ethiopia. The research was conducted in West Arsi Zone. West Arsi Zone lies between 60 00' N to 70 35'N and 380 00'E to 400 00'E and demarcated by Bale Zone in west direction, Arsi Zone in East direction, Southern Nation Nationality and People Regional State in South direction, and East Shewa Zone in north direction. The Zone has 12 districts. Shashemane city is the capital city of West Arsi Zone and located at 250 km from Finfinnee towards South direction on Finfinnee- Hawassa main asphalt road (ZOA, 2019).

West Arsi Zone encompasses different agro-ecologies namely high land, midland and lowland. In the Zone the high land agro-ecology (47.92%) took more coverage followed by midland (42.50%) and lowland (9.82%) agro-ecologies. The Zone lies within altitude of 1500-3800 meter above sea level (ZOA, 2019).

The total population in the Zone was 2,290,280 of which 45.50% are male and 50.50% are female. The Zone has a total of 1,286,277.50 hectare of land. From the total land, 0.36% is arable land, 29.27% cultivated land, 19.50% forest land, 17.05% grazing land, 4.58% used for construction and 29.26% used for other purposes (ZOA, 2019).

From total households about 98,431 participate in potato in potato production in west Arsi Zone (CSA, 2021).

Data types, sources and methods of data collection

Both primary and secondary data source were used for this study. This research was primarily based on primary data generated through cross-sectional survey during 2020 production season. The primary data was collected using structured questionnaire, key informant interviews, and focus-group discussions. Semi-structured questionnaire: semi-structured questionnaire was used to collect primary data on efficiency of production related information. Both closed and open-ended semi-structured questionnaire prepared to generate the required information. Prior to the actual data collection, semi-structured questionnaire was pre-tested to ensure clarity, validity, and sequence of the question. The questionnaire was pre-tested in each selected *district* and revised according to the feedback obtained. Then, the final semi-structured questionnaire was employed to collect data from the sample potato and head cabbage producing farmers. Key informant interview: This will be used to collect more information from some key informants on pertinent issues. This helps to understand better the issue that was raised and to triangulate the answers provided by the respondents. To obtain the views of key informant interviewees, checklists will be prepared and information was collected through unstructured interview. Key informant interview will be conducted with government officials and development agents in each sample *districts* of West Arsi zone. Focus-Group Discussions (FGD): This was made on the issues related to efficiency of potato and head cabbage production among potato and head cabbage-dominated smallholder farmers operating in the potato and head cabbage -dominated farming system. This helps to take into account different points of views and helps to strengthen or argue against some answers of farmers based on the results obtained. Accordingly, with the help of checklists/unstructured question discussions was held with selected potato and head cabbage producing farmers to get some general information about efficiency of potato and head cabbage production in the selected *districts* of West Arsi zone.
To complement the primary data, secondary data was collected from both government and Non-Government Organizations (NGOs). The major sources of secondary data were from both published materials and online resources such as Central Statistics Agency (CSA) and West Arsi zone agriculture office.

Sampling procedure and sample size

The study was based on the data that was obtained through a farm household survey administered to sample farm households drawn through multi-stage sampling techniques. The three-stages that involve the selection of (1) Sample *districts*, (2) *Peasant Association (PA)* and (3) Smallholder farmers are as follows:

Stage 1: In the first stage two ***districts*** was purposively selected based on potential of potato and head cabbage volume of production from West Arsi zone with the collaboration of West Arsi zone agricultural office expert.

Stage 2: In the second stage, three potato and head cabbage growing *PA was selected* from each of the two selected *districts* using simple random sampling method and proportional size.
Stage 3: In the third stage, 117 Potato and head cabbage producer households were randomly selected.

Methods of Data Analysis

In this study, descriptive and inferential statistics and econometric models were used to analyze data.

Descriptive analysis

Descriptive statistical tools such as average, ratios, percentages, frequencies, etc. were applied to describe household and farm characteristics of the study areas while inferential statistical methods such as χ^2 and t test were used to compare households in the two *district* in terms of household and farm characteristics.

Econometrics model

The purpose of this section is to describe the analytical models for estimation of efficiencies of production and its determinants. This begins with a brief description of analytical procedure of parametric approach of estimating production functions, dual-cost function and efficiency decomposition techniques. The analytical models for estimating production function, dual cost function and efficiency decomposition techniques of potato and head cabbage producing smallholder farmers. Finally, an analytical model for estimating the determinants of efficiencies in potato and head cabbage production is described as follows;

This study will employ stochastic efficiency decomposition method of Bravo-Ureta and Rieger (1991) to decompose TE, EE and AE. Stochastic Frontier approach (SFA) will be used for its ability to distinguish inefficiency from deviations that are caused by factors beyond the control of farmers. Farmers possess the potential to achieve both technical efficiency (TE) and allocative efficiency (AE) in farm enterprises, but inefficiency may arise due to a variety of factors, some of which are beyond the control of the farmers (Ogunniyi, 2008). The assumption that all deviations from the frontier are associated with inefficiency, as assumed in DEA, is difficult to accept, given the inherent variability of agricultural production due to many factors like climatic hazards, plant pathology and insect (Coelli, 1995). The stochastic frontier model can be expressed in the following form.

$$Yi = \mathrm{F}\,(\mathrm{Xi};\beta)\exp(\mathrm{Vi} - \mathrm{Ui}) \quad \mathrm{i}=1, 2, 3,.... \mathrm{n} \qquad (1)$$

Where Yi is the production of the ith farmer, Xi is a vector of inputs used by the ith farmer, β is a vector of unknown parameters, Vi is a random variable which is assumed to be N$\sim$ $(0, \delta 2)$ and independent of the Ui which is nonnegative random variable assumed to account for technical inefficiency in production. The variance parameters for Maximum Likelihood Estimates are expressed in terms of the parameterization

$\delta s^2 = \delta v^2 + \delta^2$ and

$$\gamma = \frac{\delta^2}{\delta s^2} = \frac{\delta^2}{\delta v^2 + \delta^2} \quad (2)$$

Where,
σ^2 is the variance parameter that denotes deviation from the frontier due to inefficiency
$\sigma^2 v$ is the variance parameter that denotes deviation from the frontier due to noise
σs^2 is the variance parameter that denotes the total deviation from the frontier

Cobb–Douglas stochastic production frontier function will be used to estimate the production function and the determinants of economic efficiencies among potato and head cabbage producers in the selected districts of West Arsi zone. The nature of the Cobb-Douglas production and cost functions provides the computational advantage in obtaining the estimates of TA and EE. According to Arega and Rashid (2005), inadequate farm level price data together with little or no input price variation across farms in Ethiopia precludes any econometric estimation of a cost function. Sharma et al. (1999), indicated that the corresponding dual cost frontier of the Cobb Douglas production function could be rewritten as:

$$Ci = C(Wi, Yi*;\ \alpha) \quad (3)$$

Where i refers to the ith sample household; Ci is the minimum cost of production; Wi denotes input prices; Yi* refers to farm output which is adjusted for noise vi and α's are parameters to be estimated. To estimate the minimum cost frontier analytically from the production function, the solution for the minimization problem given in Equation 4 is essential Arega and Rashid (2005).

$$\text{MinCx} = \sum \omega_n X_n$$
$$\text{Subject to } Y^i_k{}^* = \hat{A} \prod_{n} X_n^{\beta_n} \quad (4)$$

Where;
$\hat{A} = \exp(ß_o)$
ω_n =input price
β_n = parameter estimates of the stochastic production function
Y_{ki}*= input oriented adjusted output level from Equation 1.

The economically efficient input vector for the ith firmer derived by applying Shepard's Lemma and substituting the firms input price and adjusted output level into the resulting system of input demand equations.

$$\frac{\alpha Ci}{\alpha \omega n} = Xi(\omega i, Yi*; \theta) \quad (5)$$

Where θ is the vector of parameters and n=1,2,3,...N inputs
The observed, technically and economically efficient cost of production of the ith farm are equal to, $\omega i Xi$ and $\omega i' Xi^t$. Those cost measures are used to compute technically and economically efficient indices of the ith farmer as follows:

$$TE_i = \frac{\omega i' Xit}{\omega i' Xi} \quad (6)$$

$$EE_i = \frac{\omega i' Xit}{\omega i' Xi} \quad (7)$$

Following Farrell (1957), allocative efficiency index of the ith farmer can be derived from Equations 7 and 8 as follows;

$$AEi = EEi/TEi = \frac{\omega i' Xit}{\omega i' Xit} \quad (8)$$

Determinants of efficiency scores

To determine the relationship between socioeconomic and institutional factors and indices of efficiencies will be computed, a two-limit Tobit model was used. The model is adopted because the efficiency scores are double truncated at 0 and 1 as the scores lie within the range of 0 to 1 Greene (1991). The following relationship expresses the stochastic model underlying Tobit Tobin (1958):

$$Yi = \beta o + \sum \beta_m Z_{jm} + Ui \quad (9)$$

Where yi* = latent variable representing the efficiency scores of farm j, β = a vector of unknown parameters, Z_{jm} = a vector of explanatory variables m (m = 1, 2, ..., k) for farm j and μ_j= an error term that is independently and normally distributed with mean zero and variance σ^2.

$$Yi = \begin{cases} 1 \text{ if } yi * \geq 1 \\ yi * \text{ if } 0 < yi * < 1 \\ 0 \text{ if } yi * < 0 \end{cases} \quad (10)$$

Definition of variables for production and cost frontier analyses

Potato and head cabbage productivity depends mainly on the levels of production inputs. Therefore, the yield response of potato and head cabbage to the levels of these inputs will be evaluated under smallholder production system. In this study, the inputs used in the stochastic frontier Cobb-Douglas production function are land, labor, fertilizer, seed, pesticide and herbicide. The definition of these production inputs hypothesized to influence Potato and head cabbage productivity and their expected effects are presented as follows.

Production inputs: The amount of land available, labor (both family, hired and exchange or gift), seed, fertilizer, pesticide and herbicide have a positive impact on the output in the production function (Otitoju and Arene, 2010; Shehu *et al*., 2010). Land is the total land area allotted by the household for Potato and head cabbage production, including that owned, rented in, contracted and obtained through gift measured in hectares. Labor is family labor force and external labor supply, measured in person-days/hectare. Fertilizer is the quantity of chemical fertilizers (UREA and DAP) applied to Potato and head cabbage farming, measured in kilograms (Kg). Quantity of seed is either improved and/or local seed varieties used for potato and head cabbage farming, measured in kilograms. Pesticides and herbicides used for controlling plant diseases for Potato and head cabbage production, both measured in liters. However, suboptimal utilization of any of these inputs has a negative effect on Potato and head cabbage productivity.

The list of the variables used in the parametric stochastic Cobb-Douglas production and dual cost frontier and their expected signs are summarized in Table 1.

Table 1: Description of the variables used in parametric stochastic production and cost frontier analysis

Variables	Variable description and measurement	Unit	Expected signs
Ln(output)	***Natural log of the quantity of potato and HC cultivated***	***Kilogram***	
Ln (labor)	Natural log of family, exchange and hired labor used in production	Man days	+/-
Ln (land)	Natural log of farm land under potato and HC cultivation	Hectares	+/-
Ln (fertilizer)	Natural log of the quantity of fertilizer used in production	Kilogram	+/-
Ln(others)	Natural log of the quantity of seed, pesticides and herbicides used in production	Kilogram and liters	+/-
Ln (Ci)	***Log of the cost of potato and HC production for the ith farmers***	***Birr***	
Ln (Clabour)	Natural log of the total price of labor during farming (Size of laborers * hrs/day * Number of days* price/ day)	Birr	+/-
Ln (Cland)	Natural log of total rental price of land per hectare (Size of land * Price/hectare)	Birr	+/-
Ln(CFertilizer)	Natural log of the total price of fertilizer per hectare (Kilogram * Price/kg)	Birr	+/-
Ln (Cothers)	Natural log of the total price of seed(Kilograms * price/kg) and Natural log of total price of pesticides and herbicides (Liter * price/liter)	Birr	+/-

Definition of variables for efficiency of production analyses

Technical, allocative and economic efficiencies of smallholder potato and head cabbage producers depend on demographic, socioeconomic, farm attributes, marketing and institutional factors. These factors include sex, age, family size, education level, livestock holding, potato and head cabbage farming experience, farm size, ownership of mobile phone, market center distance, extension services, development center distance, and membership of cooperatives and use of cash credit for potato and head cabbage production. The expected effect of each of this variable are discussed as follows. The list of explanatory variables will be used in two-limit Tobit model and their expected signs are summarized in Table 3.2. The hypothesis to be tested will be the levels of technical, allocative and economic efficiencies of smallholder Potato and head cabbage producers are influenced by the combined effect of demographic, socioeconomic, farm attributes, institutional services and market access factors. The expected effect of each of the variable hypothesized to explain technical, allocative and economic efficiency are discussed below:

Sex of the household head: This refers to sex of the household head. It assumes a value of 1 for female headed household head and 0 otherwise. Male-headed households have more access to

resources and information related to better production technologies than female-headed households due to their social position. It was therefore hypothesized that sex has a negative influence on technical, allocative and economic efficiencies of Potato and head cabbage production.

Age of the household head: The age of the household is expected to have a positive effect on technical, allocative and economic efficiencies of Potato and head cabbage production. That is, older farmers are expected to have greater access to productive resources such as land, labor and relevant tacit knowledge on productivity enhancing technologies than younger farmers.

Household size: The number of members of the household possibly affects efficiencies of Potato and head cabbage producing farmers through its direct effect on availabilities of labor supply to undertake farm operation on time (Hussein, 2007). Therefore, a household with large family size was hypothesized to be more technically, allocativelly and economically efficient than household with small family size.

Education of the household head: Education enables farmers to have access to new information, ideas, knowledge and skill to use resources in more efficient ways. It was hypothesized that the education level of the household head (years of schooling) will have a positive effect on efficiencies of Potato and head cabbage production. Household who are illitirate assingned with 0 value.

Livestock holding: Total livestock holding of the household is measured as a continuous variable in terms of the TLU. Farmers who have more livestock size are expected to be more efficient in potato and head cabbage production than those who have no or few livestock size. This is because livestock provides a working power (oxen for draught power), manure fertilizer and is a source of income that can be used to purchase the necessary improved agricultural technologies. It was, therefore, hypothesized that livestock holding is positively related to technical, allocative and economic efficiencies of Potato and head cabbage production.

Experience of potato and head cabbage farming: Experience of the household head in potato and head cabbage farming is measured as a continuous variable and is expected to enhance efficiencies of potato and head cabbage production. That is, experienced farmers are expected to have greater access to productive resources (such as land and labor) and be able to use improved agricultural technologies than inexperienced farmers. It was, therefore, hypothesized that experience of potato and head cabbage farming is positively related to efficiencies of Potato and head cabbage production.

Landholding size: Land is one of the most important and scarce resources in agricultural production. The size of land holding hypothesized to have both positive and negative impact on the efficiencies of crop production (Idiong *et al*., 2009; Otitoju and Arene, 2010). Some studies suggested that small farm size is expected to be more efficient than large frames because of its simplicity in management and transaction costs. But some others oppose to this, they argue that larger farmer is more likely to employ improved agricultural technologies, used as a capital base and enhances the risk bearing ability of farmers and hence could be more efficient than small

farms due to its advantage of the economic scale and scope associated with larger sizes (Beyene, 2004; Hussein, 2007).

Extension service: Frequency of extension contact during the cropping period improves farmers' skill and knowledge on the uses of recommended agronomic practices in potato and head cabbage farming. A positive relationship will be, therefore, hypothesized between the variable extension contacts and efficiencies of potato and head cabbage production. Research result by Hussein (2007) and Otitoju and Arene (2010) also confirmed the hypothesis in their studies.

Distance to development center: Distance to development center is used as proxy for assessing the accessibility of extension services to farmer in Potato and head cabbage farming. Proximity to development center has advantage of obtaining technical supports form extension workers related to the utilization of technologies in Potato and head cabbage production. Hence, distance from the development center is likely to have a negative effect on efficiencies of potato and head cabbage production.

Participation of social group: social membership is used as proxy for assessing the role of association in efficiency of potato and head cabbage production. Farmer cooperative facilitates information provision related to price, profitability, availabilities of new technology and the provision of credit services to its members. A farmer who is member of farmer cooperative is more likely to adopt improved agricultural technologies and hence efficient in potato and head cabbage production than others. A positive relationship would, therefore, hypothesize between the variable cooperative membership and efficiencies of potato and head cabbage production.

Use of cash credit: Use of cash credit in potato and head cabbage production is one of the important factors that affect the efficiencies of farmers in potato and head cabbage production. It affects the ability of a farmer to obtain the necessary inputs at the right time and in suitable quantities. This, in turn, substantially affects efficiencies of potato and head cabbage production. Thus, a positive relationship was expected between the use of credit (cash) and efficiencies of potato and head cabbage production.

Ownership of mobile phone: Ownership of mobile phone by the household head is proxy to assess the presence and absence of market access. Access to market to input and output information by the household head enhance efficiencies of potato and head cabbage production. Accordingly, a positive relationship will be expected between the ownership of mobile phone and the efficiencies of potato and head cabbage production.

Distance to the nearest market center: Distance to the nearest market center is used as proxy for assessing the accessibility of the market to farmers. Proximity of farmer's house to the market is hypothesized to have a positive effect on efficiencies of potato and head cabbage production.

Table 2: Description of the variables hypothesized to influence efficiencies of potato and head cabbage production

Dependent variables			
TE (Technical Efficiency), AE (Allocative Efficiency) and EE (Economic Efficiency)			
Independent variables	Variable description and measurement	Unit	Expected signs
	Demographic characteristics		
Sex	Sex of household head (1= female, 0=male)	Dummy	-
Age	Age of household head	Years	+
Household size	Number of persons per household	Number	+
	Socioeconomic characteristics		
Education	Number of years of formal education (0 if illitirate)	Years	+
Livestock	Total number of livestock owned	TLU	+
	Farm attributes		
Experience in potato and HC farming	Experience of farmer in potato and head cabbage production	Years	+
Farm size	Total farm size of the household	Hectare	+/-
	Institutional services		
Extension contact	Frequency of extension contact during cropping period	Number	+
Distance of FTC	Distance of farmer house from FTC	Walking Hour	-
Cooperative	Membership of cooperative (1= yes, 0= no)	Dummy	+
Credit	Use of cash credit for potato and head cabbage (1= yes, 0 = no)	Dummy	+
	Market access		
Market distance	Distance of farmer house from nearby market	Walking Hour	-

Results and Discussion

This chapter presents the findings of the study and discusses in comparison with the results of earlier similar studies. It is organized under three sections. The first section presents results of descriptive characteristics of sample respondents the study area. The second section is about estimation of technical, allocative and economic efficiencies of potato and head cabbage producing smallholder farmers. The third section is about factors affecting the level of technical and economic efficiencies of potato and head cabbage producing farmers.

Descriptive Statistical Results

In this sub-section, descriptive statistical results of variables such as age, family size, dependency ratio and experience presented and discussed. The average age of the sample respondents were found to be 39 years. This result implied that the sample respondents were work age group and can increase production if they get technology and training. The dependency ratio was about 1.39. The average family size of the sample households was 9.05 persons per household, which is more than the national average of 4.6 persons per household (CSA, 2014b). The farming experience of potato and head cabbage production were about 11.96 and 8.74 years respectively. This implies that the producers can increase the efficiency as their experience increase since they were adult.

Table 3. Age, family size, Dependency ratio and farming experience of sample household heads

Commodity	**Statistics**	**Variables**			
		Age	Family size	Dependency ratio	Farming Experience
Potato (n=117)	Mean	39.50	9.05	1.39	11.96
	St.dev.	10.95	3.83	0.80	4.79
Head cabbage (n=117)	Mean	39.50	9.05	1.39	8.74
	St.dev.	10.95	3.83	0.80	5.59

Source: Survey result, 2021

Socio-economic factors

Physical factors

This sub-section presents socio-economic factors of sample respondents with regards to the farm income, cultivated land size, livestock holdings and participation in non/off-farm activities.

Cultivated land: Cultivated farmland land is land used by sample farm households to undertake agricultural production. The own average cultivated land holding size of the sample households was 1.47 hectares, which is greater than national average of 0.95 hectares (CSA, 2015). The average areas covered by Potato and head cabbage during the year 2019 cropping season were 0.42 and 0.31 hectares respectively (Table 4).

Table 4. Land use and allocation system of sample households

Commodity		Land allocation and use in hectares		
	Statistics	Cultivated land	Area under Potato production	Area under Head cabbage production
Potato (n=117)	Mean	1.47	0.42	
	St.dev.	1.04	0.20	
Head cabbage (n=117)	Mean	1.47		0.31
	St.dev.	1.04		0.10

Source: Survey result, 2021

Livestock holdings: Livestock is one of the major assets for the farmers and also indicates their level of wealth in the study area. Types of livestock owned by households are oxen, cows, heifers, calves, horses, donkey, sheep, goat and poultry. Livestock provides traction power, manure, and is a source of cash that can be used to purchase goods for household consumption and production inputs. The average livestock holdings measured in terms of tropical livestock unit (TLU) were found to be 6.03 (Appendix Table 1). This is relatively a large number in the crop-livestock mixed farming system (Table 5).

Table 5. Livestock owned of households

Commodity		Variables
	Statistics	TLU
Potato (n=117	Mean	6.03
	St.dev.	4.12
Head cabbage (n=117)	Mean	6.03
	St.dev.	4.12

Source: Survey result, 2021

Participation in non/off-farm activities: Off/non-farm activities refers to both self-employment in non-farm sectors such as petty trade, craft work/carpentry, blacksmith, and off-farm employment such as cash/food for work (safety net), daily labor, and guard. Out of the total households interviewed only 3.42% participated in non/off-farm activities. The result implies that participation of non/off-farm activity is low (Table 6).

Table 6. Participation in non/off-farm activities of sample households

Commodity		**Participation in non/off-farm**		
	Percent	No	Yes	Total
Potato	No.	113	4	117
	%	96.58	3.42	100
Head cabbage	No.	113	4	117
	%	96.58	3.42	100

Source: Own survey result, 2021

Human capital factors

This sub-section presents human capital factors of sample respondents with regards to the education and farming experience.

Educational status: Out of the total sample household heads, about 87.18% were literate and 12.82% illiterate. This shows that farmers can easily understand agricultural instructions and advice provided by the extension workers (Table 7). The average education level of literate sample household heads during survey period was about 6.4 years with the minimum of zero years (illiterate) and maximum of 12 years.

Table 7. Educational status of sample households

Commodity		**Education status**		
	Statistics	Illiterate (0)	Literate (>0)	Total
Potato	No.	15	102	117
	%	12.82	87.18	100
Head cabbage	No.	15	102	117
	%	12.82	87.18	100

Source: Survey result, 2021

Institutional factors

Tis sub-section presents institutional factors of sample respondents with regard to variables including access to credit, access to extension service, participation in social organization and access to market information

Participation in social organizations: Participation in social organization is believed to enhance information exchange and experience sharing among farm households on production. As shown in Table 10 about 79.49 % of the sample farmers participated in social organizations (Table 10).

Table 10. Participation in social organization of sample households

Commodity	Percent	Participation in social organization		
		No	Yes	Total
Potato (n=117)	No.	24	93	117
	%	20.51	79.49	100
Head cabbage (n=117)	No.	24	93	117
	%	20.51	79.49	100

Source: Survey result, 2021

Access to credit: Credit service is an important institutional service which was required by the respondents in the study area. During the reference cropping season, 12.77% of the sample farmers had access to credit either in the form of cash or kind. However, the majority of sample respondents (about 87.18 % of them) had not used credit because of high interest rate, shortage of credit service, amount of credit low and inappropriate payback period of received loan (Table 11).

Table 11. Access to credit services of sample households

Commodity	Percent	Access to credit service		
		No	Yes	Total
Potato (N=117)	No.	102	15	117
	%	87.18	12.82	100
Head cabbage (N=117)	No.	102	15	117
	%	87.18	12.82	100

Source: Survey result, 2021

Access to market information: Households with better information access are more likely to participate in crop production efficient way. In this study, ownership of communication equipment such as telephone, radio and television are used as a proxy to access to information. From total sample respondents interviewed, 65.81 % of sample respondents had access to market information (Table 12).

Table 12. Access to market information of sample households

Commodity	Percent	Access to market information		
		No	Yes	Total
Potato (n=117)	No.	40	77	117
	%	34.19	65.81	100
Head cabbage (n=117)	No.	40	77	117
	%	34.19	65.81	100

Source: Survey result, 2021

Distance to Farmer training center (FTC): Distance to development center is used as proxy for assessing the accessibility of extension services to farmer in onion and tomato farming. Proximity to development center has advantage of obtaining technical supports form extension workers related to the utilization of technologies in onion and tomato production. The average distances to travel from farm to the market center by sample farmers in the study area was 2.35 km (Table 13).

Distance to market center: Distance to market center included to capture the role of travel costs in influencing efficiency of production. The average distances to travel from farm to the market center by sample farmers in the study area was 10.75 km (Table 13).

Distance to all weather roads: Distance to all weather road also included to capture the role of travel costs in influencing cost. It is expected that longer distance to increase travel time and travel costs, which will have negative influence on economic efficiency. The average distance all-weather road from the study area was 1.48 km. The sample households in study area are sale their product at farm gate, as a result there is a problem of road directly connects from farm site to all-weather road (Table 13).

Table 13. Distance all-weather roads and market of sample households

Commodity	Statistics	Variables		
		Distance to FTC	Distance to Market center	Distance farm from all-weather road
Potato (n=117)	Mean	2.35	10.75	1.48
	St.dev.	2.01	7.52	1.45
Head cabbage (n=117)	Mean	2.35	10.75	1.48
	St.dev.	2.01	7.52	1.45

Source: Survey result, 2021

Model testing for appropriateness

Hypotheses stated in the model specification part and validity of the model which is used for analysis has to be tested before estimating the parameters of the model.

The appropriateness of the stochastic frontier model over the convectional production function can be tested using the statistical significance of the Stochastic Production Frontier Ordinary Least Square parameter gamma, Ý. The estimated value of gamma is equal to 99.86 for production Tomato which is statistically significant at 1% level of significance. The estimated value of gamma signifies that 99.86 % of the variation in output is due to the variation in technical inefficiency among the farmers. This indicates that there is wider room to increase productivity of farmers in the study area through identification of principal factors affecting technical efficiency. Hence, the production function estimation using SPF analysis is more appropriate than convectional production function.

The other hypothesis testing is the test for returns to scale. The results of the estimation made under model specifications, constant and variable return to scale, show that the value of log-likelihood functions equal to -88.24 and -85.60 for Potato production. Thus, the log likelihood ratio test is calculated to be 5.28 and when this value is compared to the critical value of $\chi 2$ at 4 degrees of freedom with 1% level of significance equals to 12.483(given by kodde and palm, 1986). Therefore the null hypothesis of no technical inefficiency was accepted. The sum of the partial elasticity of all inputs equals to 1.17 for Potato. This means an increase in all inputs at the sample mean by one percent will increase Potato by 1.17% in the study area. This reveals that the production function is characterized by increasing returns to scale for Potato production. This shows that the elasticity of mean value of output is estimated to be an increasing function of inputs for Potato production. The gamma (γ) of the MLEs of stochastic frontier production is 0.9986. This value is statistically significant implying that 99.86% of variability output from potato production is attributed to the technical efficiency of Potato production technic where as 0.14% due to random shocks in production.

The results of the estimated parameters revealed that all the coefficients of the physical variables conform to a priori expectation of a positive signs. The positive coefficient of land, labor, seed, Fertilizer and agro chemical implies that as each of these variables is increased, ceteris paribus, Potato output increased. The coefficients of the variables; land, seed, and fertilizer are significant even at 1% level of significance. Therefore these are factors explaining Potato production in study the area.

The appropriateness of the stochastic frontier model over the convectional production function can be tested using the statistical significance of the Stochastic Production Frontier Ordinary Least Square parameter gamma, Ý. The estimated value of gamma is equal to 0.9976 for Potato cost of production. The estimated value of gamma signifies that 99.76% of the variation in output is due to the variation in allocative inefficiency among the farmers and remaining 0.24% of output variation is due to due to variation output. Hence, the production function estimation using SPF analysis is more appropriate than convectional production function (Table, 14).

Table 14. Estimated Potato stochastic production and cost frontier function

Variables	Production frontier		Variables	Cost frontier	
	ML estimate			ML estimate	
	Coefficient	Std.Err		Coefficient	Std.Err
Intercept	1.836 ***	0.6093114	**Intercept**	2.380***	0.2882335
LnLand	0.601 ***	0.1158212	***LnLandcost***	0.290***	0.0268099
LnLabor	0.104	0.0723129	***LnLaborcost***	0.163***	0.0257309
LnSeed	0.196 ***	0.0662501	***LnSeedcost***	0.248 ***	0.0231876
LnFertilizer	0.230 ***	0.065234	***LnFertilizercost***	0.163***	0.0249031
LnChemical	0.037	0.0865632	***LnChemicalcost***	0.063***	0.0217149
	∑β= 1.167				
$\sigma^2=\sigma^2_u+\sigma^2_v$	124.612			12.014	
$\lambda=\sigma_u/\sigma_v$	27.062	22.708		20.420***	8.239
γ (gamma)	0.9986 ***			0.9976	
Log likelihood	-85.6014			25.5278	
LR test	5.29			9.35	

***, Significant at 1% significance level, Source: Own computation, 2021

The appropriateness of the stochastic frontier model over the convectional production function can be tested using the statistical significance of the Stochastic Production Frontier Ordinary Least Square parameter gamma, Ý. The estimated value of gamma is equal to 0.9987 for production of Head cabbage which is statistically significant at 1% level of significance. The estimated value of gamma signifies that 99.87% of the variation in output is due to the variation in technical inefficiency among the farmers while the remaining 0.13% of output variation is due to due to variation in random shocks. This indicates that there is wider room to increase productivity of farmers in the study area through identification of principal factors affecting technical efficiency. Hence, the production function estimation using SPF analysis is more appropriate than convectional production function.

The other hypothesis testing is the test for returns to scale. The results of the estimation made under both model specifications, constant and variable return to scale, show that the value of log-likelihood functions equal to -74.78 and -76.24 respectively for head cabbage production. Thus, the log likelihood ratio test is calculated to be 2.93 for production. When this value is compared to the critical value of $\chi 2$ at 4 degrees of freedom with 1% level of significance equals to 12.483, the null hypothesis that the Cobb-Douglas production function is characterized by constant return to scale is accepted for head cabbage production function. The null hypothesis of production in efficiency was accepted. The sum of the partial elasticity of all inputs equals to 1.513 for head cabbage. This means an increase in all inputs at the sample mean by one percent will increase head cabbage by 1.513% in the study area. This reveals that the production function is characterized by increasing returns to scale for head cabbage production. This shows that the elasticity of mean value of output is estimated to be increasing function of inputs for head cabbage production.

The gamma (γ) of the MLEs of stochastic frontier production is 0.9987. This value is statistically significant implying that 99.87% of variability of production efficiency from head cabbage production is attributed to output.

The results of the estimated parameters revealed that all the coefficients of the physical variables conform to a priori expectation of a positive signs except agro chemical. The coefficients of the three physical variables, land, labor and seed are significant even at 1% and fertilizer is significant at 10% level of significance. The positive coefficient of land, labor, seed and fertilizer implies that as each of these variables is increased, ceteris paribus, head cabbage output increased. The coefficient of the variable associated, agro chemical although positive, is statistically not significant even at 10% level of significance. Therefore these are the less factors explaining head cabbage production in study the area. The finding agrees with Abdulkadir (2015).

The appropriateness of the stochastic frontier model over the convectional production function can be tested using the statistical significance of the Stochastic Production Frontier Ordinary Least Square parameter gamma, Ý. The estimated value of gamma is equal to 0.9982 for head cabbage cost of production. The estimated value of gamma signifies that 99.82% of the variation in output is due to the variation in allocative inefficiency among the farmers. Hence, the production function estimation using SPF analysis is more appropriate than convectional production function. The gamma (γ) of the MLEs of stochastic frontier production is 0.9982. This value is statistically not significant implying that 99.82 % of variability of cost efficiency from cost where 0.18% variability of cost efficiency were attributed from head cabbage output (Table 15)

Table 15. Estimated Head Cabbage stochastic production and cost frontier function

	Production frontier			**Cost frontier**	
	ML estimate			ML estimate	
Variables	Coefficient	Std.Err	**Variables**	Coefficient	Std.Err
Intercept	3.703***	0.491	**Intercept**	2.740***	0.329
LnLand	0.703***	0.170	***LnLandcost***	0.336***	0.030
LnLabor	0.394***	0.072	***LnLaborcost***	0.108***	0.027
LnSeed	0.169***	0.056	***LnSeedcost***	0.227***	0.021
LnFertilizer	0.125*	0.073	***LnFertilizercost***	0.113***	0.029
LnChemical	0.123	0.085	***LnChemicalcost***	0.087***	0.028
	∑β= 1.513				
$\sigma^2=\sigma^2_u+\sigma^2_v$	106.63***			16.60	
$\lambda=\sigma_u/\sigma_v$	27.605	38.962		23.425***	6.831
γ (gamma)	0.9987***			0.9982	
Log likelihood	-74.777			19.488	
LR test	2.93			7.49	

*and ***, Significant at 10% and 1% significance level respectively. Source: Own computation, 2021

Estimation of technical, allocative and economic efficiencies of Potato and head cabbage producing smallholder farmers

The study indicated that 75.60% and 77.10% were the mean levels of Technical Efficiency of Potato and head cabbage respectively. This in turn implies that farmers can increase their Potato and head cabbage production on average by 24.4% and 22.9% respectively at the existing level of inputs and current technology by operating at full technical efficient level. There is huge gap among farmers in sample study which range 15.16% to 91.11% for Potato production and 26.53% to 91.60% head cabbage production. This result needs to extension intervention by arrange experience sharing between farmers to reduce the efficiency gap. On the other hand The Allocative efficiency and Economic efficiency of potato were about 91.40% and 69.07% respectively. This result indicates that there was a room to improve economic efficiency. The Allocative and Economic efficiency of head cabbage production were 90% and 69.5% respectively in West Arsi Zone (Table, 16)

Table16. Efficiency estimation by stochastic production frontier model

Types of commodity	Efficiency	Mean	St.dev.	Minimum	Maximum
Potato	Technical Efficiency	0.756	0.116	0.152	0.911
	Allocative Efficiency	0.914	0.054	0.394	0.976
	Economic Efficiency	0.691	0.114	0.135	0.846
Head cabbage	Technical Efficiency	0.771	0.113	0.265	0.916
	Allocative Efficiency	0.900	0.061	0.396	0.972
	Economic Efficiency	0.695	0.113	0.243	0.865

Source: Survey data, 2021

Returns to scale Potato and head cabbage production

The return to scale (RTS) analysis, which serves as a measure of total resource productivity, is given table 5. The maximum likelihood estimates (MLE) of the Cobb-Douglas based stochastic production function parameter of 1.167 and 1.513 is obtained from the summation of the coefficients of the estimated inputs (elasticities) of Potato and head cabbage respectively. It indicates that Potato and head cabbage production in study area is stage I of increasing returns to scale where resources and production were believed to be efficient. This means an increase in all inputs at the sample mean by one percent will increase Potato and head cabbage by 1.167 % and 1.513 % respectively in the study area (Table, 17).

Table 17. Elasticities and returns to scale of the parameters of stochastic frontier

	Production	
	Potato	**Head cabbage**
Variables	**Elasticities**	**Elasticities**
LnLand	0.601	0.703
LnLabor	0.104	0.394
LnSeed	0.196	0.169
LnFertilizer	0.230	0.125
LnChemical	0.037	0.123
Returns to scale	**1.167**	**1.513**

Source: Survey data, 2021

Efficiency among Potato and head cabbage producers by sample districts

For both Shashemene and Kofale districts the Technical, Allocative and Economic efficiency was tested for both commodities. The result showed that only Potato technical efficiency and economic efficiency significance difference among potato producers sample districts. The mean technical efficiency and economic efficiency were about 78.5% and 72.2% for Shashemene district and about 73.3% and 66.66% for Kofale district respectively. Even though different efficiency between districts in head cabbage production statistically insignificant.

Table 18.Technical, Allocative and Economic efficiency among Potato producers by districts

			Districts		
Commodity	**Efficiency**	**Mean**	**Shashamane**	**Kofale**	**t-Value**
Potato	TE	Mean	0.785	0.733	2.477***
		Std.Dev.	0.077	0.135	
	AE	Mean	0.919	0.910	0.898
		Std.Dev.	0.026	0.069	
	EE	Mean	0.722	0.666	2.697***
		Std.Dev.	0.072	0.134	
Head cabbage	TE	Mean	0.782	0.762	0.912
		Std.Dev.	0.085	0.131	
	AE	Mean	0.904	0.896	0.690
		Std.Dev.	0.041	0.073	
	EE	Mean	0.708	0.684	1.148
		Std.Dev.	0.085	0.130	

*** Significant at 5% level. Source: Own survey result, 2021

Determinants of technical and economic efficiencies in Potato production

Variance inflation factors (VIF) was computed for all explanatory variables that are used in the Tobit model and the result shows VIF values of less than 10 indicating multicollinearity was not a problem (Table Appendex2). Robust method was also employed to correct the possible problem of heteroscedasticity. Outliers were checked using the box plot graph so that there were no serious problems of outliers and no data get lost due to outliers.

The model chi-square test indicates that the overall goodness-of-fit of the Tobit model was statistically significant at 1% probability level which in turn indicates the usefulness of the model to explain the relationship between the dependent and at least one independent variable. The result of Tobit model estimation indicated that the technical efficiency of Potato production in West Arsi Zone is significantly influenced by the variables potato farming experience ,education level, social participation and Extension contact affect efficiency positively while, distance to FTC affect technical efficiency negatively (Table, 19).

Experience of Tomato farming: Experience of the household head in tomato farming had positive relationship with Technical and Economic efficiency as prior expectation significantly at 1% significance level. This implies that experienced farmers are expected were more technical efficient because they use improved variety and agricultural technology than other farmers.

Tomato farming experience increase by one year the Tomato technical and economic efficiency increase by 0.99% and 1% respectively keeping all other factors constant. This result is in conformity with the finding of (Leake.*et al*., 2018).

Education level: The coefficient for the education level had a statistically significant and positive relationship with technical and economic efficiency at 1% significant level. This is consistent with the prior expectation that those farmers that had got more education. The result implies that an additional unit of education would increase farmers' technical and economic efficiency by 1.5% and 1.7% respectively than others, keeping all other factors constant. Education enables farmers to have access to new information, ideas, knowledge and skill to use resources in more efficient ways. Positive coefficient of education means the higher the years of schooling, the higher the incidence of efficiency. Education is not only escalating agricultural productivity by increasing their understanding of modern farming techniques but also opening the mind of farmers (Schreinemachers *et al*., 2016).

Social participation: Membership of social participation was found to have a positive and significant influenced on technical and economic efficiency of sample Tomato producers at 1% and 10% level of significance respectively. Farmer who had participate in social organization were 6.1% and 4.1% more probability of technical and economic efficiency than others respectively, keeping all other factors constant. This implies that farmer participate in social organization access information provision related to price, profitability, availabilities of new technology and the provision of credit services to its members. A farmer who is member of farmer cooperative is more likely to adopt improved agricultural technologies and hence efficient in potato production than others.

Distance to FTC: Distance to farmers from Farmers Training Center of farmers had negative relationship with Technical and Economic efficiency as prior expectation significantly at 1% significance level. This implies the farmers nearby Farmers training Centers (FTC) get more information on know how to use new technologies and better management to improve their technical efficiency and economic efficiency. Farm distance to FTC increase by one kilometer the Tomato technical and economic efficiency would decrease by 1.3% and 1.25% respectively keeping all other factors constant. This is in line with the findings of Desale (2017).

Frequency of extension contact: Frequency of extension contact was found to have a positive and significant influenced on Technical efficiency of sample Tomato producers at 5% level of significance. This significance indicates that for each additional extension contact Tomato producer farmers are more likely to produce Tomato efficiently than others. The result implies that an additional unit of extension contact would increase farmers' technical by 0.44% than others, keeping all other factors constant. They farmers who got the chance to more frequently visit by extension professionals are more efficient than their counter parts. Because it improves the technical knowhow and skill of the farmers thereby exchange of experience will improve the efficiency. This is in line with the findings of Abdulkadir (2015).

Dependency ratio: Dependency ratio is computed as the ratio of the number of household members aged below 15 years and those aged above 64 years to the number of household members aged from 15 to 64 years. Dependency ratio had negative relationship with Economic efficiency as prior expectation significantly at 10% significance level. The result indicates that when dependency ratio increases by unit economic efficiency would decrease by 1.7%, keeping all other factors constant. This is implied that farmers' with relatively high dependency ratio less participated in crop management that expose to high cost of production

Table 19. Tobit results of determinants of technical and economic efficiencies in Potato production

	TE				**EE**			
Variables	Coefficient	Robust Std.Err	p>|t|	Marginal effect	Coefficient	Robust Std.Err	p>|t|	Marginal effect
Constant	0.528***	0.059	0.000		0.536***	0.059		
Sex	0.018	0.037	0.620	0.0184363	-0.044	0.043	0.305	-0.044
Potato Farming experience	0.010***	0.001	0.000	0.009913	0.010***	0.0015	0.000	0.010
Dependency Ratio	-0.012	0.010	0.231	-0.012	-0.017*	0.010	0.081	-0.017
Total livestock unit	-0.0003	0.002	0.825	-0.00034	-0.001	0.0015	0.513	-0.0010
Education level	0.015***	0.003	0.000	0.015	0.017***	0.0033	0.000	0.017
Land for Potato production	-0.004	0.034	0.905	-0.0041	0.024	0.034	0.474	0 .024
Participation of social group	0.061***	0.020	0.003	0 .061	0.041*	0.021	0.053	0.041
Distance to FTC	-0.013***	0.005	0.010	-0.013	-0.013***	0.0045	0.007	-0.0125
Distance to market center	0.0006	0.0011	0.598	0.00057	0.0006	0.0012	0.607	0.0006
Access to credit	0.00034	0 .018	0.985	0.00034	0.022	0.020	0.274	0.022
Extension contact	0.0044**	0.002	0.033	0.0044	0.001	0.0027	0.695	.0011
Non off-farm	-0.032	0.026	0.232	-0.032	-0.0078	0.0274	0.776	-0.0078
Log pseudolikelihood	143.07975				139.39554			
F(12, 105)	10.86				9.63			
Prob > F	0.0000				0.0000			
Pseudo R2	-0.6485				-0.5770			

***, **, *: implies statistical significance at 1%, 5% and 10% level respectively. Survey Result, 2021

Determinants of technical and economic efficiencies in Head cabbage production

The result of Tobit model estimation indicated that the technical and economic efficiency of Head cabbage production in West Arsi Zone is significantly influenced by the variables Head cabbage farming experience, education level and market information affect positively while Distance to all-weather road affect negatively. Extension contact affect technical efficiency of head cabbage production (Table, 20).

Experience of Head cabbage farming: Experience of the household head in head cabbage farming had positive relationship with Technical and Economic efficiency as prior expectation significantly at 1% significance level. This implies that experienced farmers are expected were more technical efficient because they use improved variety and agricultural technology than other farmers. Experience of farmers in onion production increase by one year, would Technical and Economic efficiency would increase by 0.5% keeping all other factors constant. This result is in conformity with the finding of Abdulkadir (2015).

Education level: The coefficient for the education level had a statistically significant and positive relationship with technical and economic efficiency at 5% and 1% significant level respectively. This is consistent with the prior expectation that those farmers that had got more education. The result implies that an additional unit of education would increase farmers' technical and economic efficiency by 0.61% and 0.88% respectively than others, keeping all other factors constant. Education enables farmers to have access to new information, ideas, knowledge and skill to use resources in more efficient ways. Positive coefficient of education means the higher the years of schooling, the higher the incidence of efficiency. Education is not only escalating agricultural productivity by increasing their understanding of modern farming techniques but also opening the mind of farmers (Schreinemachers *et al*., 2016).

Access to market information: Access to market information was found to have a positive and significant influenced on head cabbage technical and economic efficiency at 1% level of significance. Access to market to input and output information by the household head enhance efficiencies of cabbage production by using available input technology. Access to market information increase the probability of head cabbage technical and econonic effeciency by 8% and 6.12% than those who had not, keeping all other factors constant.

Distance to all weather roads: Distance to all weather roads was found to influence farmers head cabbage technical and economic efficiency negatively and significantly at 5% significance level. The result depicts that as distance to all weather roads increase by one kilometer, the probability of farmers' technical and economic efficiency head cabbage would decrease by 2.23% and 1.6% respectively, keeping all other factors constant suggesting that more distances to all weather roads increase travel time and travel costs as well as accessibility of available.

Frequency of extension contact: Frequency of extension contact was found to have a positive and significant influenced on Technical efficiency of sample head cabbage producers at 10% level of significance. This significance indicates that for each additional extension contact head cabbage producer farmers are more likely to produce head cabbage efficiently than others. The result implies that an additional unit of extension contact would increase farmers' technical efficiency by 0.42% than others, keeping all other factors constant. They farmers who got the chance to more frequently visit by extension professionals are more efficient than their counter parts. Because it improves the technical knowhow and skill of the farmers thereby exchange of experience will improve the efficiency. This is in line with the findings of Abdulkadir (2015).

Table 20. Tobit results of determinants of technical and economic efficiencies in head cabbage production

	TE				EE			
Variables	Coefficient	Robust Std.Err	p>|t|	Marginal effect	Coefficient	Robust Std.Err	p>|t|	Marginal effect
Constant	0.683***	0.083	0.000		0 .617***	0.075	0.000	
Sex	-0.031	0.055	0.571	-0.031	-0.065	0.054	0.232	-0.065
Head cabbage Farming experience	0.005***	0.0016	0.003	0.005	0.005***	0.0016	0.002	0.005
Dependancy Ratio	0.0037**	0.0104	0.720	0.0037	0.0035	0.010	0.714	0.0035
Total livestock unit	0.0015	0.0017	0.387	0.0015	0.0002	0.002	0.905	0.0002
Education level	0.006**	0.0027	0.024	0.006	0.0088**	0.003	0.002	0.0088
Land for HC production	0.025	0.073	0.731	0.025	0.100	0.067	0.136	0.100
Participation of social group	-0.0038	0.021	0.857	-0.0038	-0.020	0.0200	0.312	-0.020
Distance to FTC	0.006	0.005	0.281	0.0052	0.0025	0.0043	0.562	0.0025
Access to market information	0.06***	0.023	0.009	0.061	0.080***	0.022	0.000	0.080
Distance to all weather road	-0.023**	0.0087	0.011	-0.023	-0.016**	0.0079	0.047	-0.016
Access to credit	-0.014	0.025	0.583	-0.014	0.004	0.0230	0.848	0.0044
Extension contact	0.0042**	0.0022	0.066	0.0042	0.0005	0.0026	0.834	0.00056
Non off-farm	-0.002	0.016	0.900	-0.002	0.026	0.019	0.175	0.026
Log pseudolikelihood	121.33648				126.29551			
F(13, 104)	4.94				5.69			
Prob > F	0.0000				0.0000			
Pseudo R2	-0.3559				-0.4034			

***, **, *: implies statistical significance at 1%, 5% and 10% level respectively. Survey Result, 2021

Analysis of yield gap of potato and head cabbage production

Productivity can change due to differences in the production technology, efficiency of the production process and environment in which production takes place. The yield gap always occurs due to TE variation among the farmers. So, analyzing of yield gap is an important system to estimate to what extent the production could be increased if all factors are controlled.

It is computed as follows:

$TE=\frac{ym}{y*m}$. Then, solving for Ym $*$, the potential yield of each sample farmer was represented as:

$*$Ym $=\frac{Ym}{TE}$ Where, TEm, the TE of the mth sample farmer in wheat production

$*$Ym- the potential output of the mth sample farmer in wheat production in qt per ha and

Ym - the actual output of the mth sample farmer in wheat production in qt per ha Therefore, yield gap (qt per ha) = $*$Ym – Ym

In the table below, it was observed that the mean potato and head cabbage yield difference between sample farmer due to technical efficiency variation was 31.04 qt per ha and 76.56 qt per ha respectively.

Table 21. Yield gap due to technical inefficiency of potato and head cabbage

Commodity	Variable	Mean	Std.Dev.	Minimum	Maximum
Potato	Actual qt per hectare	115.89	70.502	12	538.461
	TE (%)	0.756	0.116	0.152	0 .911
	Potential qt per ha	146.929	73.209	56.338	598.291
	Yield gap (qt per ha)	31.039	2.707	44.338	59.83
Head cabbage	Actual qt per hectare	312.410	230.531	28	1200
	TE (%)	0.771	0.113	0.265	0.916
	Potential qt per ha	388.970	261.976	97.959	1463.415
	Yield gap (qt / ha)	**76.56**	**31.445**	**69.959**	**263.415**

Survey Result, 2021

Summary, Conclusions And Recommendations

This chapter summarizes the whole findings of the study and makes conclusions based on the results of the descriptive and econometric model. It also highlights some important policy recommendations to enhance farmers' efficiency in potato and head cabbage production.

Summary and Conclusions

Improvement of agricultural productivity provides an important solution in addressing the problems of food insecurity and poverty, and enhancing the development of agriculture in Ethiopia. Potato and head cabbage also contributed for food security. Therefore the analysis of technical, allocative and economic efficiency of potato and head cabbage farming is important. The overall objective of this study was to examine producers' technical, allocative and economic efficiencies of potato and head cabbage production in West Arsi of Oromia region, Ethiopia.

To conduct the study, primary data was collected from 117 randomly selected household heads through semi-structured questionnaire. Secondary data were also collected from different sources including ZOANR, DOANR, and from published and unpublished sources to supplement primary data. In this study both descriptive statistics and econometric analysis were employed. The primary data was analyzed using descriptive statistics and stochastic efficiency decomposition method to decompose TE, EE and AE. Stochastic Frontier approach (SFA) was used for its ability to distinguish inefficiency from deviations that are caused by factors beyond the control of farmers.

The descriptive analysis frequency and mean was used to analysis demographic characteristics of sample households. The result revealed that the mean TE, AE and EE was about 75.60%, 91.41% and 69.07% of for potato production and 77.10%,89.99% and 69.47% for head cabbage respectively. The sum of the partial elasticity of all inputs were 1.17 and 1.513 for Potato and head cabbage indicate an increase in all inputs at the sample mean by one percent increase by 1.17% and 1.513% potato and head cabbage respectively. This indicate that the production function is characterized by increasing returns to scale for both production.

The result of Tobit model revealed that, out of total 12 and 13 explanatory variables included in the model for potato and head cabbage respectively. Total of five variables found significantly determined TE and EE of potato production. To this effect, potato farming experience, education level, social participation and Extension contact affect positively while, distance to FTC affect technical efficiency negatively. Total of five variables found significantly determined TE and EE of head cabbage production. Those variables were head cabbage farming experience, education level and market information affect positively while Distance to all-weather road affect negatively. Extension contact significantly affect technical efficiency of head cabbage production not significance for economic efficiency. The mean potato and head cabbage yield difference between sample farmer due to technical efficiency variation was 31.04 qt per ha and 76.56 qt per ha respectively.

Recommendations

Based on the findings of this study, the following recommendations are made.

Potato farming experience and frequency of extension contact positively influenced households Technical and Economic efficiency. Therefore District office of Agriculture should be organize field days to conduct farmers experience sharing as well as frequently contact to farmers by providing technical support.

Head cabbage technical and economic efficiency were affected head cabbage farming experience and extension contact positively. Therefore District office of Agriculture should be organize field days to conduct farmers experience sharing, provide training as well as frequently contact to farmers by providing technical support.

Distance to FTC negatively affected sample households Technical and economic efficiency of head cabbage production. Therefore farmers should frequently follow the demonstration practice at FTC and ask information to development agent to improve the efficiency of head cabbage production.

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Appendices

Appendix Table 1. Conversion factors used to compute tropical livestock units (TLU)

Livestock Categories	Conversion factor
Cow/Ox	1
Bull	0.75
Heifer	0.75
Calf	0.2
Horse/Mule	1.1
Camel	1.25
Sheep/Goat	0.13
Donkey	0.7
Poultry	0.013

Source: Stork *et al*., 1991

Pre-extension demonstration of chemical risk reducing strategies through establishing and certifying chemical spryer groups in Dugda and Lume district of East Shewa zone of Oromia

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Abstract

Participatory on-farm demonstration of chemical risk reducing strategies were carried out with the objectives of Enhance the awareness of farmers on chemical risk reducing strategies, demonstrate chemical risk reducing strategies through establishing and certifying chemical spryer groups, promote certified chemical sprayers Group, create additional income for youth and collect farmers feedback *to build farmers' knowledge and skill of chemical risk reducing strategies in Lume and Dugda district of East Shewa Zone in 2020/21 production season. A total of eight (8) participant farmers were selected from two vegetable growing potential Kebeles of Lume and Dugda district to carry out the demonstration activity. Four FRG/FREG having 15 member per each farmers was established at eight Kebele four kebele from Lume and four kebele from Dugda district . Eight chemical risk reducing strategies with full package were demonstrated on the area where farmers used to experience chemical spraying in unsafe way All recommended chemical reducing strategy were purchase and distributed and equally applied to all the fields were closely supervised. Participatory training was given for a total of 104 participants on important chemical reducing strategy and disease control measures with collaboration of protection research team. At starting stage , the strategy were jointly evaluated with a team composed of researchers, farmers, development agents and experts. overall performance were the selection criteria identified by the participants for selecting the best performing chemical reducing strategy. Income earned data and farmers' perception data were collected and analyzed using descriptive statistics in order to evaluate the performance of the technology. With regard to income earned per week per person is ranges from 1000 ETB to 600 ETB were obtained from Dugda and Lume district. Besides; chemical reducing strategy were recommended to scale up/out in others district to minimize chemical risk.*

Key words: Farmers Research Extension Group (FREG),

Background and justification

Reducing pesticide exposures and health risks for workers in low- and middle-income countries (LMIC) is a low prioritized public health concern. As surveillance systems are poor in most LMIC, the assumption is that pesticide poisonings, chronic effects and fatalities are limited (London and Bailie, 2001). However, Balbus et al. (2013) highlight that nearly two-thirds of global deaths is attributed to non-communicable diseases (NCD), with pesticides playing a significant risk factor. Africa accounts for only 2–4% of the global pesticide market (Williamson et al., 2008), yet studies indicate that health risks from exposures and poisonings are higher in

Africa due to weak pesticide risk management, such as low use of Personal Protective Equipment (PPE) (Matthews, 2008), unlabeled containers (Ngowi et al., 2007), lack of understanding of exposure risks, and poor risk communication strategies (Naidoo et al., 2010; Rother, 2008).

Promoting sustainability in agricultural production requires critical consideration of agricultural technologies and identification of best practices. Pesticides are agricultural technologies that enable farmers to control pests and weeds and constitute an important input when producing a crop (Kateregga 2012; Skevas et al. 2013; Jansen and Dubois 2014). Even today, despite the advances in agricultural sciences, losses due to pests and diseases range from 10 to 90 %, with an average of 35–40 %, for all potential food and fibre crops (IUPAC 2010; Abang et al. 2014). Agro-pesticide technologies, including insecticides, fungicides and herbicides, formed one of the driving forces behind the Green Revolution. Coupled with high-yielding crop varieties and increased land for crop production, significant yield improvements were achieved. However, this was realized at the expense of the natural environment and the health of farmers (UNU 2003; Pimentel 2005; Panuwet et al. 2012; Hoi et al. 2009, 2013; Ahouangninou et al. 2012).

Recent agricultural growth in Ethiopia resulted in higher demand for pesticides. More shops are selling pesticides, and farmers have easy access to them. However, there is no proper record of the actual volume of pesticides used in vegetable production in Ethiopia (Mengistie et al. 2014; under review). According to a survey by the Irrigation Development Authority Office of Ziway and Meki districts in the Central Rift Valley (CRV) during the 2013/14 crop seasons, about 53,044 l of insecticide and 50,957 kg of fungicide were applied by 13,889 smallholder vegetable farmers. These farmers grew tomato, onion, green pepper, cabbage, horticultural crop , among others, throughout the year under rain-fed and irrigated conditions. As farmers have little tolerance for pest infestation, they rely heavily on the use of pesticides. Also, government extension programs encourage the use of pesticides arguing that farmers have no alternative (MoA 2013; Mengistie et al. 2014; Damte and Tabor 2015). Pesticide use patterns of smallholder farmers are more complicated compared with large-scale farmers, as they are usually resource-poor as well as risk-averse. In addition, due to high exposure and unsafe application techniques, smallholders experience more pesticides health risks than larger-scale farmers (Ngowi et al. 2007; Williamson et al. 2008). Among the known chemical risk areas in the East Shewa Dugda and Lume district was very risk area which needs intervention of chemical reducing strategy. This increased in chemical risk is due to growing urban populations, rising incomes, diversification of diets and the substantial time required to produce vegetable for consumption Despite the production potentials and importance of vegetable , there has been limited knowledge of farmers in chemical risk minimization strategies This study tries to fill the gap by providing location-specific and timely information on chemical risk reducing strategy and improving knowledge of producers and others stakeholders.

Statement of the Problem

Vegetable is one of the most important sources of on-farm income for the farmers in Duda and Lume district of East shewa Zone of Oromia. In areas where there is relatively good market infrastructure, vegetable has become the leading cash crop and one of the most important food security crops to farmers with high and unsafe way of chemicals application.

East Shewa Zone is one of a major vegetable producing Zone in Oromia Region having high chemical risk. Duda and Lume districts are among a major vegetable producing district with chemical risk in East Shewa zone.

The major problems in chemical utilization:- No chemical safety material utilization, which is risk for the spraying person, environment and consumers, High utilization of chemicals, lack of keeping chemical withdrawal period vegetable products results in weak market demand and exposing consumers to chemical risk and Less promotion of climate smart strategies

There is no studies on chemical risk pointed out that there is a greater need to minimize chemical risk by improving and applying chemical risk minimization strategy to contribute to the health of environment and economic growth of the country. Therefore, demonstrate chemical risk reducing strategies through establishing and certifying chemical spryer groups as well as set opportunities for income generation. Hence, this study will propose to fill the gaps by establish and promote certified chemical sprayers Group, create additional jobs opportunity to youth and promote climate smart strategies and improve vegetable producers markets

Objectives of the Study

Specific objectives:

- To Enhance the awareness of farmers on chemical risk reducing strategies
- To demonstrate chemical risk reducing strategies through establishing and certifying chemical spryer groups
- Promote certified chemical sprayers Group
- To create additional income for youth
- To collect farmers feedback.

Methodology

This study was conducted in Lume and Dugda district, East Shewa Zone, Oromia Region. At the beginning of the pre extension demonstration of chemical risk reducing techniques ; two wored as namely Lume and Dugda woreda were selected. For the commodity according to its, target (beneficiary) farmers selected and training were delivered about on the nature of the chemical risk reducing techniques. All necessary input was delivered to the farmers from Adami Tulu Agricultural research centers (over all safety cloths, spryer, shoes, apron, eye google, mask and hand glove etc). Experimental Farmers equipped and started provision of spraying service through charging faire price and follow-ups and essential advices from relevant researchers has been taken place. Finally the data were analyzed using ranking and descriptive statics

This study was conducted in one of the central part of rift valley areas of Ethiopia, East Showa Zone of Oromia Regional State, and Dugda district. It is located approximately between 70 58' latitude in the north and 380 43' longitudes in the east at an altitude of 1600 to 2300 m.a.s.l. Its annual rainfall is between 700mm to 800mm while the annual temperature is between 220C and 280C. The district's administrative seat, Meki is found 134 Km away from Addis Ababa to the Southeast and 88 Km west of Adama along the main asphalt road. The total surface area of the district is 1468 square kilometer of which 962.47 square kilometer The district, which is composed of 36 peasant associations and three urban kebeles, shares border line with Bora

woreda in the North and Northwest, Arsi in the East, ATJK district in the South and Soddo woreda of SNNPR in the West. In addition, the district is fallen in the Lake Basin of rift valley floor dominated by quaternary sediments which is conducive for farming activities.

Sampling Design

A two stage sampling procedure were used In the first stage, four horticultural crop producing sample kebeles were selected from a list of the horticultural crop producer kebeles in the district with experts from Zonal and district office of agriculture and development agents, namely Shumi Gemo, Bekele Girisa, Welda Kelina and Welda Mekdela from Dugda district and Koka Negawo, Dungugi Bekele ,Ejersa Joro and Derara Dembela from Lume district. In the second stage, 15 horticultural crop producer households or youth were be purposely selected from a list of horticultural crop producer's households of each kebele and grouped under one FRG. And vegetable producer households were randomly selected from a list of potato producer's households of each kebele and equipped with chemical safety materials. Based on the result, the mini workshop were prepared and given for stakeholder participants that involved in vegetable production and marketing to aware about the concepts and objectives of the chemical risk minimization strategy. A total of eight farmers' research group (FRG) that contain ten to fifteen (15) member farmers were stablished in each four selected kebeles based on vegetable production potentials, willingness to work together and apply chemical reducing technique. The training were given for FRGs to aware the concepts and objectives of the activity. One chairman and secretary were selected from the group and all safety materials were purchased and distributed to one members of the group four from dugda and four for Lume districts.

The joint action plan/memorandum of understanding were made between FRGs and concerned stakeholders involved in chemical risk reducing strategy. The memorandum of understanding made between PSFGs and concerned stakeholders facilitated by responsible researchers from ATARC and concerned experts from district bureau of agriculture.

Data collection method

Both primary and secondary data were used in this study.
Primary data were collected by preparing close and open ended as well as checklist.

- Source of chemical used
- Service charged per hector by spraying groups
- farmers feed back
- Volumes and how many time they give the service per week
- Constraint and opportunities available while they are providing service.
- Land size sprayed by the group
- Amount of income generated by the group from the given service

Secondary data regarding vegetable area coverage, vegetable production and marketing, and different stakeholder involved in vegetable marketing were gathered from East Shewa zonal office of Agriculture, Dugda and Lume district office of agriculture, from published and unpublished sources

Data analysis

Descriptive statistics and economic analysis were used to analyze the data collected. Descriptive and economic analysis these methods of data analysis will refer to the use of percentages, means, and standard deviations, income earned from spraying service describing chemical risk minimization strategy, facilities, services, and household characteristics.

Results and Discussion

Enhance the awareness of farmers on chemical risk reducing strategies

Before implementing the demonstration of chemical risk reducing strategies technology, training for the participant farmers and different stakeholders was provided. One hundred and four participant farmers from both woreda were selected by collaboration with woreda agriculture and natural resource office. Beneficiary farmers, Kebeles development Agents and woredas experts were selected for the training. The training was provided on chemical risk reducing strategies technology pre extension demonstration of disease identification practices from chemical preparation to spraying with collaboration of protection and socio-economics research teams. The main aims of training is to create awareness of farmers, development agents(DAs) and wored as expert on chemical risk reducing strategies technology and to compare the result finally obtained from the demonstration.

Capacity Development Number of Farmers and Stakeholders Attend the Training

Training

Training (both theoretical and practical) is very important for awareness creation and to bring improvement on the job after filling the gap on knowledge, skill and attitude of chemical risk reducing technical. Hence, stakeholders such as zone and district level Agriculture and natural Resource Office, private service providers, zone and district level agricultural inputs regulations and crop protection experts were invited and participated during min workshop meeting and training a total of 104 participant were addressed by this activities.

Table 1. Number of farmers and stakeholders attend the training

No	Training topic	Total attendant							
		Farmers		DA's		SMS		Others	
		M	F	M	F	M	F	M	F
1	Chemical risk reducing strategies	64		8	1	2		28	1
Total		64		8	1	2		2 8	1

Demonstrate chemical risk reducing strategies through establishing and certifying chemical spryer groups

Selecting participant farmers

Resident in kebele to implement the demonstration activity, willingness to contribute the experience , vicinity to roads so as to facilitate the chance of being visited by many farmers, initiatives to implement this activity in high-quality, good in using safety materials and willingness to explain the technologies to others were criteria used to select the hosting farmers. Then, four representative hosting farmers from each FRG/FREG were selected at each kebele with the help of group members and DAs. Thus, a total of eight (8) hosting farmers and one hundred two (102) followers were selected for this purpose. Farmers (FRG/FREG members and other follower farmers) were encouraged to participate in the chemical risk reducing activities from the beginning up to the end of the demonstration activity. Establish and promote certified chemical sprayers Group FRGs/FREGs for the demonstration activity is vary curtail to expand the technologies. A total of eight FRG groups were established from dugda and lume districts at which four from each to demonstrate chemical risk reducing strategies

Before implementing of pre-extension and demonstration of chemical risk reducing strategies farmers were organized under farmers research group (FRG) a total of eight groups having one hundred twenty members were established in Dugda and Lume district. The groups were assign the leaders and secretary and they could work in close relation with the researchers. They were capacitated with different training, experience sharing and min workshops to build their capacity to solve chemical risk related problems by themselves.

Monitoring and evaluation and field visit

Field visit was arranged for both district to create awareness and farmers shared experience and knowledge regular joint monitoring and evaluation and provision of technical advice were undertaken at different crop stages based on necessary emerging knowledge/skill and technical advice needs on chemical risk reducing strategies.

Table 2 Established and promoted certified chemical sprayers Group at Dugda district

		Members by Gender					
FRGs/FREGs	District and Kebeles	Adult (Male)	Adult (Female)	Youth (Male)	Youth (Female)	Total	Remark
1	Dugda district Bekele Grisa kebele			15		15	
1	Dugda district Shumi Gemo kebele			15		15	All youth male because of chemical risk
1	Dugda district Welda Kelina kebele			15		15	
1	Dugda district Welda Mekdela kebele			15		15	
	Total	0	0	60	0	60	

Table 3 Established and promoted certified chemical sprayers Group at Lume district

		Members by Gender					
FRGs/FREGs	District and Kebeles	Adult (Male)	Adult (Female)	Youth (Male)	Youth (Female)	Total	Remark
1	Lume district Koka Negawo kebele			15		15	
1	Lume district Dungugi Bekele kebele			15		15	All youth male because of chemical risk
1	Lume district Ejersa Joro kebele			15		15	
1	Lume district Derara Dembela kebele			15		15	
	Total	0	0	60	0	60	

Promoting certified chemical sprayers Group

Promoting certified chemical sprayers group is one of the means to polarize chemical risk reducing strategies. A total of eight experimental farmers four from Lume and four from Dugda district were equipped with chemical risk reducing safety materials, knowledge and certified with the collaboration of Adami Tulu Agricultural Research center socio-economics, crop protection research team and East Shewa Zone Agricultural office so as to serve the surrounding society in the future through faire price for the service they provide.

Min workshop were arranged and different stakeholders were participate from the district and zone levels which was used as strategy to Promoting certified chemical sprayers group.

Figure 1 Picture of certificate awarded for group representatives

Pair wise ranking matrix result to rank safety materials in order of importance

All participant farmers were very interested with the stands of the demonstrated chemical risk reducing strategies and good awareness was created among stakeholders about chemical risk reducing strategies. Based on farmers' assessment and evaluation, Income generating capacity ranked first followed by Chemical reducing capacity, Durability of the materials and Stand of farmers toward safety materials. farmer-to-farmers safety material exchange mechanisms and presenting at union input supply shop for purchase by the farmers themselves were designed to access safety material for FRG/FREG members and other interested farmers in the study area.

Table 4 Pair wise ranking matrix result to rank safety materials

Parameters	Chemical reducing capacity	Income generating capacity	Durability of the materials	Stand of farmers toward safety materials	Over all importance of strategy	Rank
1. Chemical reducing capacity		4	2	3	2	2
2. Income generating capacity			4	4	3	1
3. Durability of the materials				3	3	3
4. Stand of farmers toward safety materials					4	4
5 Over all importance of strategy						

Create additional income for youth

Income generated from spraying service

The study rivals that the average income earned as additional income source from chemical spraying service ranges from 600 ETB to 1000 ETB per week per person which is motivating for the youth to provide this service in sustainable manner**.** The activity is sustainable as it is environmentally friendly (reducing chemical risk), provide job opportunity for the local resident youth and it is also profitable**.**

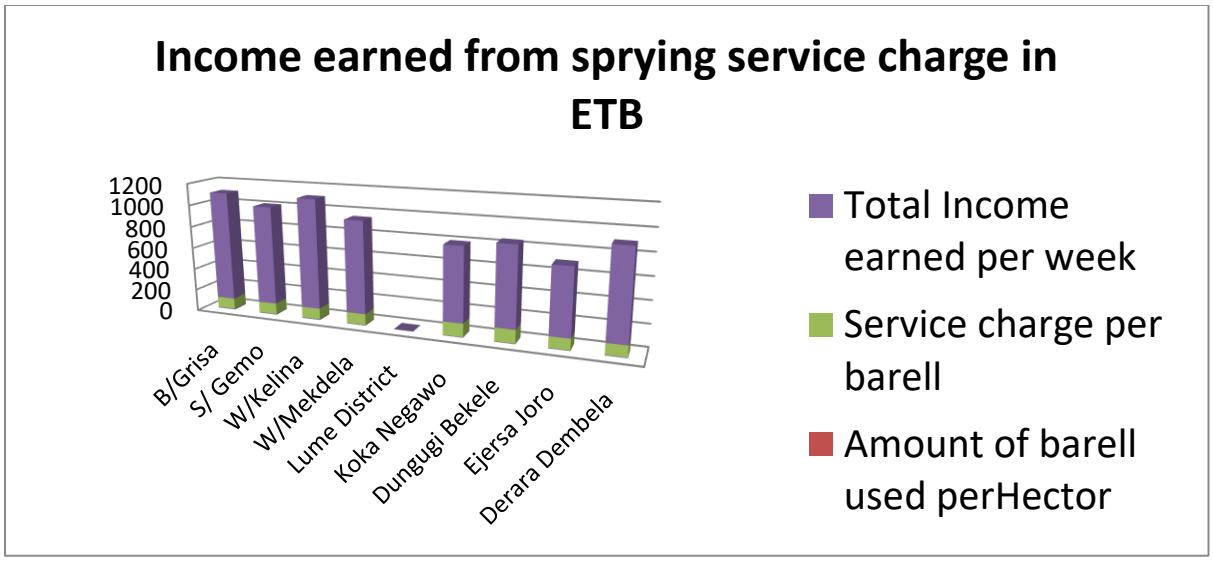

Figure 2 Mean Income generated from spraying service per week per person

Farmers Feedback

Strength

- Provision of full protection as wells spraying materials.
- Good acceptance of technology as chemical reducing strategy.
- It is good income earning source for youth.
- It is good opportunity for some group members to be promoted to tomato selectors which rewards better income.

Weakness

- Absence of safety material on the local market.
- The overall safety textiles are a hot during dry season as result we put a direction to use early in the morning and late afternoon strategic time of spring.
- Series challenge in using chemical spryer group especially by investors as they use grads for both safeguarding and chemical spryer.

Sometimes the owners are forcing the group to mix-up chemical before springs which are not well-suited

Lessons Learned

- On-farm demonstration is two-way process where farmers and researchers learn from each other.

- During the study, farmers had first hand observation on the actual performance of new demonstrated chemical reducing strategy. Farmers got familiar access to improved technologies demonstrated to them, had better knowledge and/or skill on chemical reducing and management, each FRG/FREG.

Some farmers also resisting the overall wearing with comparing to the high local temperature

Conclusions and recommendations

Based on the evaluators, Chemical reducing capacity, Income earning capacity, Durability of the materials, and good Stand of farmers toward safety materials, were the common identified election criteria across all locations for selecting the best performing chemical reducing strategy. In spite of the variability in income generating capacity between the locations, chemical reducing performance of the technology was still promising.

Promoting sustainability in agricultural production requires critical consideration of agricultural technologies and identification of best practices that will reduce chemical risk and technical advice and support to smallholder farmers is highly required to improve food quality and safety and bring the required impact. Now days, farmers' group are seen as the smallest unit of the farmers Hence. establishing and strengthening FRGs/FREGs is one of the extension approaches, which make the farmer to be central to agricultural research, technology promotion and dissemination. Chemical reducing strategy was selected and recommended for pre-scaling up activity on wider for popularization. Strengthening the linkage among stakeholders is paramount to achieve the desired reduction of chemical risk.

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Assessment of Donkey Cart Technology Impact on Households' Income Generation in the Case of Bako Tibe District

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Abstract

Ethiopian farmers have been using donkey pack for transportation for thousands of years. However, Bako agricultural engineering research center has been trying to introduce new donkey cart implements to the western area of Oromia for two decades. This study was conducted to assess the impacts of donkey-cart possession on household income in Bako Tibe district in the western Shoa Oromia National Regional State of Ethiopia. In this study, a two-stage sampling procedure was used to select 3 samples kebeles and 102 specific sample households. The result of the study indicated that out of the total, younger households (age between 18-29 years) were using cart technology for income generations than an adult. The primary major constraint for non-adopter of the cart technology, out of the total households use donkey pack for transportation 40%, 35% and 11.5% were lack of appropriate road, lack of finance and lack of cart on market was the main problem hampering cart technology respectively. The average annual household-level net return from donkey cart ownership and use in the district was 14,330 birr ETB. As policy implementations, the promotion of this technology should receive more attention to adders marginalized part of the people, particularly poor women to transport everyday chores and delivering access to the small amount of credit may be used to make the household ownerships' of technology

***Key words**:* donkey cart, households, income, technology

Back ground and Justification

Working animals play a fundamental role in human livelihoods through their direct and indirect contributions to financial, human and social capital in particular (Takele and Tadesse, 2015). Especially horses, mules and donkeys play a central role in the livelihoods of many people across the Ethiopia (Admassu and Shiferaw, 2011). According to them particularly a great deal of the energy and time of rural women is spent on the tiring and time consuming tasks of transport of domestic requirements (water, firewood, food grains, shopping) as well as of farm produce and traded goods. Much of the transport burden of women is unaided by animal or motor power. However, the donkeys have played an important role in the lives of the poor, particularly poor women (Delphine V., 2014)

Several studies highlight direct financial benefits of owning a working equine animal. In Ethiopia, Martin C. and Smith (2005) reported that donkey-owning women had a higher income

ranking and felt more secure and better off than those without a donkey. In addition, donkeys are generally inexpensive, resistant to disease (in dry zones) and low risk, easily managed and easily trained and are particularly appropriate for small-scale transport operations. According to studies conducted by Tamador E.E. et. al., 2011, in Sudan showed about 91.1% of the investigated donkeys were used for pulling carts, while 8.9% were utilized as pack animals. They showed the donkey drawn carts, the mean annual income generation reported was US$ 2,880 per annum which was more than double the minimum annual wage rate in Sudan (US$ 1,101).

Before a decade Bako Agricultural Mechanization Research Center (BAMRC) later Bako Agricultural Engineering Research Center (BAERC) demonstrated donkey cart technologies and the technology was adopted by many users in Bako Tibe district. According to annual report of Bako town administration, there are more than 250 registered cart of donkey owners around Bako town which showed created employment and income generation opportunities for many people by driving donkey cart. However, in the district, no research was conducted on the impact of the technologies on household's income. So, this activity was conducted with the objective to assess the impacts of donkey-cart possession on household income

Methodology

Description of the Study Area

The study was conducted in Bako Tibe district of West Shoa, Oromia national regional state, Ethiopia. The district is situated at a distance of 165 km away from the zonal town Ambo and 225 km from Addis Ababa. The district has 26 kebeles. There are a total of 47300 sheep, 31500 goats, 15904 cattle, 9103 donkeys, 4065 horses, and 1129 mules in use in the district. The population of the district is about 139,051 of which 49.6% are male and 50.4% are female (BTDAO, 2020). The geographical extent of the area ranges from 8^0 59' to 9^0 95'North latitudes and 37^0 04' to 37^0 29'East longitudes with the altitude ranges from 1610 – 2500m. Its area coverage is about 64469 hectares. The district has 19.63% flat slope (0-5%), 21.43 % gently sloping plain (4-8%), 38.49% strongly sloping plain (> 8%) and the rest topography was hill area considered as the slope of greater than 16% (BTDAO, 2020).

Data and Collection Methods

Both primary and secondary data were used in the study. However, the study relies dominantly on primary data whereas secondary data were used to supplement the primary data. Primary data were collected through a household survey. A multi-stage probability sampling procedures were used for sample selection. In the first stage, potential district was purposively selected. The selected district was Bako Tibe. The main reason for purposive selection was due to strong research and extension intervention programs disseminated and practiced in this district. In the first stage, three kebeles with high potential of donkey cart owner within the district has been selected. In the second stage, a sample respondent's donkey owner using their pack and this using cart were selected by a simple random sampling technique. Allocation of sample size to each kebeles was made through proportionate to the size of farm household heads population having donkeys using their pack and cart in each kebeles. In total, 102 households representing the smallholder donkey farmers were interviewed using a structured questionnaire.

Data Analysis Method

Information collected through questionnaire was extracted and summarized for analysis using SPSS statistical software computer programs (SPSS version 20). In the absence of the technology, the beneficiaries of the program or users of donkey cart did not exist on equal socio economic characteristics with those farmers who use donkey pack for transportation or in another way finding an appropriate outcome against relevant alternatives or counterfactual outcomes was the main challenge to evaluate the impact of the technology through propensity score matching methods in this study. So, descriptive statistics like percentage and mean were used to describe the advantage of donkey cart and constraints in the study area. From each of the kebeles, two categories of respondents were identified as defined below

Household use donkey pack: This category consists of households who own donkeys and use donkey pack-transport only

Household use donkey carts: This category consists of households who drive donkey carts either by buying or hiring the donkey and/or the cart to generate income or for home services only.

Results and Discussion

Distribution of Sample Household by Sex and Marital Status

The results shown in the table 1 was out of the 102 respondents, 8(7.8%)were women while 94(92.2%) were men yet there is no female riding donkey with cart in the study area. It is a highly male-dominated which require further investigation in the study area. According to Kathy Marshall and Zahra Ali (2005) women have been benefited from using donkeys, both for domestic and income generating activities. The cart pulled by donkeys in the Rift Valley (Eastern Shoa) has benefited both men and women greatly. Concerning to marital status,21 were single, 78 were married while 3 were widowed.

Table 1. Distribution of sample household by sex and marital status

No	**Categories**	**Household categories**					
		Use donkey cart		Use donkey pack		Total	
		N	%	N	%	N	%
1	Sex						
1.1	Male	49	48	45	44	94	92
1.2	Female	0	0	8	8	8	8
2	Marital status						
2.1	Single	15	14.7	6	5.8	21	21
2.2	Married	35	34	43	42	78	76
2.3	Widowed	1	0.9	2	2	3	3

Source: Own survey,2020

Age Categories of the Respondent

Young people (14-29 years) represent approximately 28 percent of the population of Ethiopia (Erulkar et al., 2010) and unemployment rates for youth are three times higher than the adult in all world regions (ILO, 2020).In this study according to table 2 below, the age of respondents was categorized into two groups, aged less than 29 years and aged greater than 29 years. Out of these interviewed 37 households were aged between 18 – 29 years while 65 were aged above 29 years. From the total values for aged groups, less than 29 years 27(73%) have used donkey cart and only 10 (27%) use their donkey for pack transportation. This showed that younger households were using cart technology for income generations than adult. This showed that it was an opportunity for youth households as a business activity to another area by scaling up of technology.

Table 2. age categories of the respondent

Household Categories	**Age less than 29 years**	**%**	**Age greater than 29 years**	**%**	**Total**
Use donkey cart	27	73	25	38	52
Use donkey pack	10	27	40	62	50
Total	37	100	65	100	102

Source: Own survey,2020

Educational Characteristics of Respondents

Many prior studies find that highly educated households tend to adopt new technologies faster than those with less education. According to Maurice M. B. (2013) people with educational backgrounds used modern technologies in farming activities whereas those without used only traditional methods in farming. To understand the role of education for using the technology and the result was indicated in table 3. Out of the respondents 14(13.7%) had no education, 26(25% had gone up to fourth class, 44(43%) had gone up to primary level, and 12(11.7%) had secondary education while 6(0.06% had gone up to different level. The table indicated the respondents who use the cart were categorized in the high grade school. So education has a positive impact on the acceptance of this technology in interviewed sample households.

Table 3. Educational characteristics of respondents

Household categories	Household education categories					Total
	illiterate	1-4	5-8	9-12	Level	
Use donkey cart	4	11	25	7	5	52
Use donkey pack	10	15	19	5	1	50
Total	14	26	44	12	6	102

Source: Own survey,2020

Household's Land Holding, livestock and Family Size

As presented in Table 4, livestock was found important asset for sample households and considered as wealth and prestige. The average TLU of the households was 4.2. The mean TLU possession of the households using donkey cart was 2.55 units and that of the households using donkey pack was 5.96 units. The difference appeared significant at 1 percent probability level between household use donkey transportation by cart and pack. The maximum number of livestock kept by sample household was 16.7

Table 4. Household's land holding, livestock and family size

Variable	use donkey cart		use donkey pack		t-test	Total		
	Mean	Std.er	Mean	Std.er		Mean	min	max
Livestock(TLU)	2.55	3.82	5.96	4.19	4.29***	4.2	0	16.7
Total land(He)	0.59	1.66	1.3	1.61	2.21**	.94	0	10.5
Family size	4.5	2.9	7	3.7	3.72***	5.74	1	20

, * represent the significant at 5%, and 1% level of probability of significance respectively

Source: Own survey,2020

The average size of land holding possessed by sample households was 0.94 ha, the minimum and the maximum being 0 and 10.5 ha respectively. But the average household's land holding at the national level was 1.34 hectares (ERSS, 2013). Farmers use donkey cart owned on average 0.59 ha of land. The corresponding figure for the farmers use of donkey pack was 1.3 ha. The mean difference of own cultivated land for the two groups was significant at 1 percent probability level of significance.

The average family size was 5.74 persons which ranged from 1 to 20 persons. This shows the average family sizes per households were slightly higher than the national level of 5.1 persons per household (ERSS, 2013). From the surveyed households, the mean total family size of the households that used cart was 4.5 and that of used donkey pack was 3.7. The mean difference was statistically significant at 1 percent probability level of significance.

History of Donkey Cart in Bako Tibe District

The importance of the donkey cart introduction was started before more than one decade in mandate area of the center including Bako Tibe district and the success was obtained especially around Bako town. Bako Tibe district has been significant experience and practice on the use of mule drawn cart. There is change from mule cart to donkey cart for most of respondents. Out of the sample interviewed 29% have used a mule cart before coming to a donkey cart (table 5). The cheapness of donkey and resistance to different harsh condition than other animals for traction was the major reasons why more farmers had access to donkey in the study area

Table 5. Households' exposure to mule cart before

Variable	Response	Frequency	Percent
Would you use mule cart before	Yes	15	29
	No	37	71
Total		52	100

Source: Own survey,2020

Constraints to Adoption of Donkey Cart

According to Bako Tibe agriculture and natural resource office, the total number of donkeys found in the district was 9103, of which only about 250 donkey cart owners registered and pay tax to the government every year. Those owners directly or indirectly serve a wide range of urban and rural people by transporting farm products, water, firewood, construction materials, transport goods to and from the market place and other essential items for the whole household. In this survey, out of 102 households, 50% of them do not use the donkey cart and use their donkey pack transportation. Those non user of donkey cart were interviewed with the question" what was the major factor hampering not to buying donkey cart?" and the respondents revealed that the primary major constraints of 40%, 35% and 11.5% were lack of appropriate roads, lack of finance and lack of cart on market respectively (table 6).

Table 6 Constraints to adoption donkey cart

No	Constraints	Frequency	Percent
1	Lack of appropriate road	20	40
2	Lack of finance	18	35
3	Lack of labor	5	9.6
4	Lack of adequate training	3	5.6
5	Lack of cart	6	11.5
	Total	50	100

Source: Own survey,2020

Ownership of Donkey Carts

According to table 9, even though the initial cost to be ownership of a cart was with average 4297 amount of birr and of donkey was 2560 amount of birr there were households using someone's (other persons) by hiring donkey and/ or cart, especially for income generation. Households using donkey cart have interviewed the ownership of the carts or the donkey he drives. Table 7 showed that only 35(67%) were owner of both cart and donkey and other 33% had access to the use of donkey cart by hiring from other person. For instance, 10(19%) household have only cart and 7(14%) have only donkey and obtain cart by hiring from these have cart

Table 7. household categories in ownership of donkey and cart

No.	Ownership of	Frequency	Percent
1	Both cart and donkey	35	67
2	Only cart	10	19
3	Only donkey	7	14
	Total	52	100

Source: Own survey,2020

Household Member In Decision Making to Hire their Donkey

This paper examines the intra-household decision-making patterns among spouses regarding decisions to rent or lent to another person in the Bako Tibe district and the result was indicated in table 8, out of the total interviewed 40% men households confirmed that it was impossible to lend to another person without consulting his spouse. It was more progress toward the equal representation of men and women in decision-making to hire their resources.

Table 8. Household member in decision making to hire their donkey

No.	Decision maker in household	Frequency	Percent
1	Did not hire/borrow by any means	36	35
2	By men only	23	23
3	By both	41	40
4	Either of them	2	2
	Total	102	100

Source: Own survey,2020

Impact of Donkey Cart on Household

There is a growing recognition and collection of evidence that working animals play a significant role in supporting the livelihoods of the families who own them and in fulfilling socio-economic functions that benefit animal owning households and the wider community (FAO, 2011). Even though there are so many impacts on a donkey, what type of impact and how much is donkey welfare worth? was the objective of this finding and discussed according to the following

Profitability Analysis of Donkey Cart

Financial profitability is arguably the most important factor determining whether or not the technology is adopted. Many other factors including status and social benefit play a part (SSATP 2001). During the interviews, households that used donkey cart emphasized the benefits of donkey's cart for income generation rather than others using donkey pack-transport. Mainly because it provided regular income, often earning money every day. The average cost and return of the technology incurred and gained by households were calculated in table 9 below. The average working day per year was 240 days. The average annual household-level net return from donkey cart ownership and use in the district was 14,330 Birr ETB. This amount of money per farmer showed that the donkey cart is one of the most important farm implements in income-generating activities.

Table 9.Sampled household profitability analysis

No.	Item	Cost in birr
1	Purchase of cart	4297
2	Annual cart depreciation	429
3	Purchase of donkey	2560
4	Annual cart maintenance	456
5	Annual feeding cost	2055
6	Veterinary cost	117
7	Tax	250
8	Total annual cost	10,164
9	Total working days in a year	240
10	Annual income	24,494
11	Net income	14,330

Source: Own survey,2020

Economic Impact

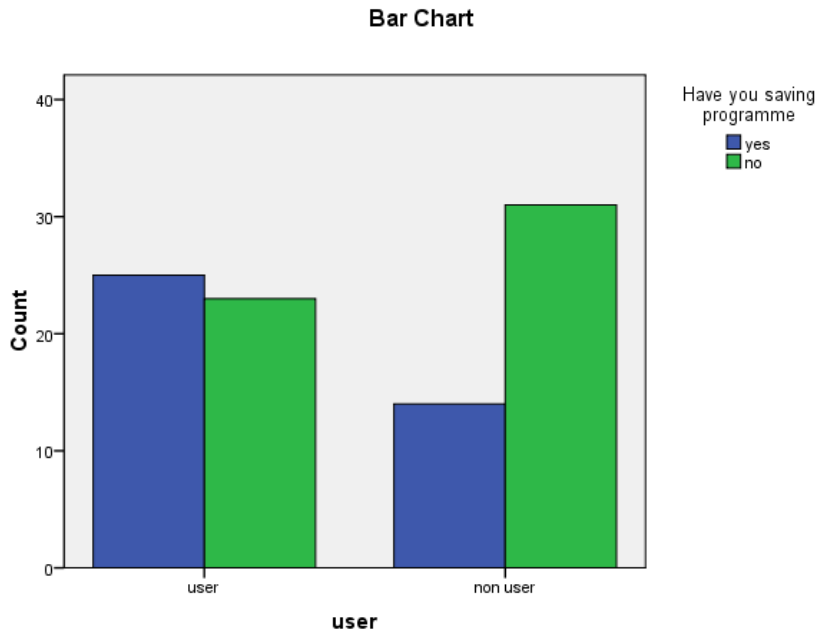
Smallholder farmers obtain most of their income from their farming activities to meet their subsistence needs. By considering data in table 4 above in column 2 and row 3, many of the households that have donkey cart survive on land which was less than 0.59 ha on average. Which require non-agricultural income have become very important to smallholder farmers for subsistence need. Donkey provided a source of income and employment to the households. Both owners and drivers of the donkey they worked with, supported significantly more people than those who were just owners/drivers. In addition, the other advantage of keeping donkeys with cart was presented in tables 10. The study involved 102 donkey cart drivers of which 32 (31%) had no land and were dependent on working donkey cart for their family living as major. This activity may be used as important as employment for no access to any land in our country.

Table 10 household categories having land

Categories	Have land	Have no land	Total
Use donkey cart	20	32(31%)	52
Use donkey pack	43	7	50
Total	63	39	102

Source: Own survey,2020

The saving status of the interviewed household was considered as one economic impact and discussed in graph 1 below. Animals assist particularly animal traction in eliminating poverty, reducing drudgery and creating wealth (Ravallion, M., 2005). In this study, households that have used donkey cart driving have more saving than these use donkey pack for transportation. These showed a significant difference in cash saving between households having donkey cart and non-having the cart.



Graph 1. household categories in saving programme

A comparison of load weight capacity in user and non-user of cart with a donkey was conducted in this study to show the productivity of interviewed household labor. As shown in Table 11, n=42 respondents reported that the average load weight for a nonuser of donkey cart was less than 1 quintal of loading per trip. While these using donkey cart, 50 respondents replied pulling more than 1 and less than 4 quintal weight of loading at a time depending on the road suitability (table 11).

Table 11. household load weight capacity at time

No.	Categories	Weight load in quintal			
		0.5-1.0	1.1-2	>2 and <4	Total
1	user	2	26	24	52
2	Non user	42	8	0	50
3	Total	44	34	24	102

Source: Own survey,2020

Social Impact

Mechanical power could be seen to reduce drudgery and increase speed of operations for both men and women. This is mainly noticed as animals enhance rural mobility and improve local marketing systems. For instance, strengthening social relationships within extended families and communities through lending donkeys at times of need which may be during marketing (FAO 2011).

They obtain transportation services with relatively low cost from farm to market. The most important function of the donkey is that it relieves the women of much of the drudgery and exhaustion associated at gathering firewood, transporting water and other everyday chores.

Conclusions

Working animals play a fundamental role in human livelihoods through their direct and indirect contributions to financial, human and social capital in particular donkeys contribute to the process of urbanization besides solving the problems of marginalizing people by providing necessary transport services. The findings provide evidence that the constraints to utilization of donkey drawn cart at farm level were lack of appropriate road and finance. The donkey cart act as a source of income mostly for low age groups like youth with low investment costs including enhancing their employability. Labor saving technologies and practices like donkey cart play a crucial role in releasing poor women form different burdens to have more time for productive work and to participate in development opportunities.

In study area, there is plenty of animal power that is not yet properly utilized. Manufacturing, demonstrating and adapting the donkey-cart is a part of the solution to solving small scale transportation problems in the rural areas

Recommendation

The constraints to utilization of donkey drawn cart at farm level were marginalized due to lack of appropriate road has to be solved in the study area for more success of technology.

Access to the technology increase to generate income and saving status even for these having small land and/or landless households. So, the promotion of this technology should receive more attention to adders marginalized part of our people, particularly poor women to transport everyday chores through scaling up

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Value Chain Analysis of Tef in Western Oromia Ethiopia

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Abstract

The study was analyzed the tef value chain in selected zones of western Oromia with the objectives: to identify major tef value chain actors, assess major constraints and opportunities of tef value chain actors, estimate market margin, identify factors affecting tef market participation decision and intensity of participation and identify factors affecting market outlet choice of tef producers'. Descriptive, inferential statistic and econometrics models (double hurdle, and multivariate models were employed for this data analysis. The margin result showed that cooperatives (86.62%) and direct wholesalers (83.92% to 83.24%) were the highest producer share. Double hurdle model result was revealed that tef market participation decision and intensity of participation were affected by the volume of tef produced, gender, education level, off/non-farm income, extension service, access to credit, livestock holding, and access to market information. Furthermore, the multivariate model result showed that market outlets choosing of tef producers were also affected by the volume of tef produced, age, gender, off/non-farm income, extension service, household size, education level, improved variety, market distance, and market information. These results suggest that to enhance the flow of product to market and choose the best outlet produces skills and knowledge through training, advising and supervision; capacitate farmers by the addition work environment and empowering women farmers by improved variety, working capital and other recommendations who enhance the tef production and marketable surplus are among need attention by the government, research centers, universities, NGOs and private sectors who participates in the commodity value chain.

Keywords: Value chain analysis, Tef, Double hurdle model, Multivariate model, Oromia

Introduction

Agriculture has a considerable contribution to Ethiopia's economy in terms of employment (80%), gross domestic product (GDP) (42.5%), and foreign exchange earnings (70%) (Teka and Lee, 2020). Smallholders farmers of Ethiopia are most cultivating cereals, legumes, vegetables, fruits, and cash crops based on rain-fed (Kassahun and Bender, 2020). Amongst the cereal crops, tef is the first cultivated crop in case of land allocated and several farmers' participation and elevated as a global crop (Lee, 2018). The wide-scale farming of crops is related to its tolerance to diverse environmental constraints and nutritious value (Bekele *et al*., 2019). It shows that tef production is the most significant source of livelihood as food security and wellbeing status for smallholder farmers in the country (Fentie and Beyene, 2019) for home consumption and market.

In western Oromia, tef is the greatest cultivated crop for food security and cash crop following coffee (Hussen and Geleta, 2021). It is the first crop amongst the cultivated crops by farmers in terms of land coverage and total production contribution in the West Shewa zone (CSA, 2019). The crop is the second importance in the East Wollega zone by land coverage and total production following maize. It is the first crop grown by farmers in terms of land coverage and second in terms of production following maize in the Horro Guduru Wollega zone (Tesema, 2021). It tells that tef is vital for all livelihood activities in case of economic, socially acceptance, technically feasible, and an environmental friend in the areas (Geleta, 2020). Urban population more voluntarily eat tef than rural population which trusting on national population consumption data, urban consumption per capita is as high as 61 kg per year and 20 kg per capita per year in rural areas (Minten *et al.,* 2016). This tells that tef is an economically superior good that is relatively more consumed by the rich than by the poor (Abate *et al.,* 2019).

Even though having this importance, the tef continues to face several of problems. The main ones are poor adoption of improved varieties, poor production management practices, poor soil fertility management, high weed infestation, limited production input, and limited market facilities resulting in low participation of the farmers in the value chain of their products (Ademe *et al*., 2020; Birhanu *et al*., 2020). Understanding these problems different research centers, NGOs, and districts extension offices had been tracking lot efforts to improving tef productivity by developing technologies and disseminating them to the agro ecological contexts of their mandate areas (Fayso, 2018). To reverse this condition and enhance tef production and productivity in areas among sounds for the development of a well-performing marketing system that satisfies consumer demands with the minimum margin between producers and consumer prices (Barretto et al., 2021). Integrated value chains offer better opportunities for transforming African agriculture because they have the potential of intensifying market opportunities and enhancing incentives for private investors to assume long-term investments in agribusiness and agro-processing (Andreoni, 2019; Jayne *et al.,* 2019).

A value chain is a set of value-adding activities through which a product passes from the initial production or design stage to final delivery to the consumer and can be local, national, regional, or international in scope (Minten *et al.,* 2016) also defined value chain as a sequence of target-oriented combinations of production factors that create a marketable product or service from its conception to the final consumer. The value chain is important in the enforcement of standards, with each player ensuring that the product originating from the previous stage and doubling tef production (Kabeta *et al.,* 2021). It exists when all of the actors in the chain operate in a way that maximizes the generation of value along the chain. There is no empirical information study on the tef value chain, tef marketing system and determinants of marketed supply of tef in the study areas. Therefore, this study was tried to addressing the research and development gaps and determinants of smallholders which affect tef marketing channels choice and supply to the marketing by smallholder tef producers with the flowing objectives:

- To map and identify the main tef value chain actors;
- To estimate marketing margins of identified channels;
- To assess major constraints and opportunities along tef value chain function;
- To identify factors affecting market participation decision and intensity of marketed surplus of tef in the study areas;
- To identify factors affecting market outlet choices of tef producers in the study areas

Research Methodology

Description of the Study Areas

Description of the Study Areas

The study was conducted in East Wollega, Horro Guduru Wollega, and West Shewa zones. The important information of seven districts like distance from Finfinne the capital city of Ethiopia and others were presented in Table 1. Three districts from Horro Guduru Wollega zone and two districts from East Wollega zone and two districts from West Shewa zones based on potential tef production.

Table 5. Study areas descriptions of tef value chain analysis

Zone	District	Distance from Finfinnee	Location	Agro-ecology	RF	T^0	Major crops
Horro Guduru Wolega	Guduru	372 km	✓ Latitude $9^0 30'$ N ✓ Longitude $37^0 35'$ E ✓ Altitude 1969 m a.s.l	✓ Highland 18% ✓ Midland 62% ✓ Lowland 20%	1450 - 2500 mm	19^0c - 22^0c	Tef, maize, wheat, nug, bean, pea, etc
	Horro	320 km	✓ Latitude $9^0 34'$ N ✓ Longitude $37^0 6'$ E ✓ Altitude 1450-2844 m a.s.l	✓ Highland 43% ✓ Midland 55% ✓ Lowland 2%	Mean 1566 mm	10^0c - 25^0c	Tef, wheat, barley, maize, bean, pea, nug, potato, etc
	Jima Rare	243 km	✓ Latitude $9^0 10'$ N ✓ Longitude $37^0 20'$ E ✓ Altitude 1540-3047 m a.s.l	✓ Highland 45% ✓ Midland 52% ✓ Lowland 3%	1450 - 2500 mm	18^0c - 25^0c	Tef, maize, wheat, barley, bean, pea, nug, potato, etc
East Wolega	Jima Arjo	372 km	✓ Latitude $9^0 30'$ N ✓ Longitude $37^0 35'$ E ✓ Altitude 1969 m a.s.l	✓ Highland 18% ✓ Midland 62% ✓ Lowland 20%	2417 mm	12^0c - 22^0c	Tef, maize, wheat, sorghum, nug, sesame, potato, barley, etc.
	Gudeya Bila	274 km	✓ Latitude $9^0$17'36 N ✓ Longitude $37^0 01' 46''$ E ✓ Altitude 1100-2400 m a.s.l	✓ Highland 18% ✓ Midland 56% ✓ Lowland 26%	1000 - 2200 mm	19^0c - 28^0c	Tef, maize, wheat, nug, potato, onion, tomato, coffee, etc.
West Shewa	Cheliya	175 km	✓ Latitude $9^0 00'$ N ✓ Longitude $37^0 29'$ E ✓ Altitude 1300-2039 m a.s.l	✓ Highland 75% ✓ Midland 20% ✓ Lowland 5%	1000 - 2000 mm	8^0c - 28^0c	Tef, barley, maize, wheat, bean, pea, potato, nug, etc
	Dano	260 km	✓ Latitude $8^0 34' – 8^0 56'$ N ✓ Longitude $37^0 8' - 37^0 29'$ E ✓ Altitude 1600-1880 m a.s.l	✓ Highland 5% ✓ Midland 75% ✓ Lowland 20%	900 - 2400 mm	18^0c - 30^0c	Maize, Tef, sorghum, wheat, nug, bean, pea, coffee, etc.

Sources: secondary data from districts and **notes:** m a.s.l = meters above sea level; T^0 = Temperature, RF = Rainfall and ha = hectare

Types and Sources Data

Both primary and secondary data sources were used for this study. Primary data was collected from both qualitative and quantitative data types were collected. The qualitative data was collected by key informant interviews and focus group discussions from DAs, experts, traders, input suppliers, and model farmers. The quantitative data on household demographic and socio-economic characteristics, inputs used and their sources, tef production management, crop product, amount of tef sold, inputs used price, institutional factors, and tef grain price were collected from prospective actors using a semi-structured questionnaire. Secondary data on the population size of the study areas, lists of kebeles administration, list of licensed tef traders', amounts of products in the district, traders (wholesaler and retailer) and retail prices of tef, number of cooperatives and NGOs engaged in tef business, Central Statistical Agency, trade and industry of the districts were collected.

Methods of Sampling

A multi-stage sampling design was used to select appropriate sample households. (i) three zones of wester Oromia included East Wollega, Horro Guduru Wollega, and West Shewa were selected purposively based on their proximity and existence of tef production and marketing access. (ii) seven districts were sampled randomly from those potential districts of tef production in selected zones. (iii) from each District, two kebeles were sampled randomly from that potential for tef production kebeles and have access to market kebeles. (iv) from those kebeles, 339 sampled households were sampled randomly based on probability proportional to size following the formula developed by Yemane (Yemane, 1967).

The formula is: $n = \frac{N}{1 + N(e)^2}$

Where: n = sample size, N = total number of households tef producing in the study area, and e = is the desired precision level take 5 to 9%. Lastly, 10-15 tef traders, hotels, restaurants, processors, and input suppliers have sampled purposively based availability of actors.

Methods of Data Analysis

For this study, two statistical approaches of data analysis were employed. Descriptive statistics like means, standard deviation, frequencies, percentages, and inferential statistics like independent *t*-test and chi-squared test were applied to define the variables used for analysis. The independent *t*-test was used to determine statistically significant differences between market participants and no-participants with regards to continuous variables of sampled tef producers. The chi-square test was applied to determine statistically significant differences between the subsamples with regards to categorical variables of sampled tef producers.

The performance of channels was estimated by the following formulas.

$TGMM = \frac{CP-FP}{CP} X100$ Where, TGMM is total gross marketing, CP is consuming price and FP is farm gate price

$GMM_p = \frac{CP-MGM}{CP} X100$ Where, GMM_p is producer margin or share in the consumer price and MGM is marketing gross margin and

Econometrics Model Specification

(i). Analysis approach elaborated to examine the market participation and the intensity of market participation double hurdle model was used. This analysis requires a situation where at each observation the event may or may not occur. This occurrence is associated with a continuous non-negative random variable, while a non-occurrence yields a variable with zero value (Cragg, 1971). Such a situation presents a limited dependent variable modeling problem where the lower bound of the variable, zero value, occurs in a considerable number of observations (Engel and Moffatt, 2014).

In the first stage probit regression model was used to examine the market participation decision as follows:

$$D_i^* = \alpha z_i + \mu_i;\ \mathrm{D}_i = 1 \text{ if } \mathrm{D}_i^* > 0 \text{ and } \mathrm{D}_i = 0 \text{ if } \mathrm{D}_i^* < 0$$

Where: D_i^* is the latent variable for binary dependent variable taking a value of one for market participation decision and zero for non-participants, z_i, α & μ_i represent vectors of explanatory variables, parameter estimates & error term for market participation decision.

In the second stage, truncated regression model was used to examine the intensity of market participation decision as follows:

$$Y_i^* = \beta X_i + \varepsilon_i;\ \mathrm{Y}_i = 1 \text{ if } \mathrm{D}_i^* > 0 \text{ and } \mathrm{Y}_i = 0 \text{ if } \mathrm{D}_i^* < 0$$

Where: Y_i^* is the latent variable reflecting the volume of tef sold, X_i, β, ε_i represent vectors of explanatory variables, parameter estimates & error term for level of market participation

(ii). Analysis approach elaborated to examines the factors affecting market outlet choices multivariate probit model was used and expressed as follows:

$$\mathrm{Y}_{\mathrm{im}}^* = \beta_m X_{im} + \varepsilon_{\mathrm{i}}\ (\mathrm{m} = Y_1, Y_2, Y_3, Y_4\ \&\ Y_5);\ \mathrm{Y}_{im} = 1 \text{ if } \mathrm{Y}_i^* > 0\ and\ \mathrm{Y}_{im} = 0 \text{ if } \mathrm{Y}_i^* < 0$$

Where: Y_i^* is dependent variables for tef market outlet choices, β_m is a vector of estimators, X_{im} is explanatory variables and ε_{i} is vector of error terms under assumption of normal distribution. Multivariate model was considering the possible inter-relationships between the various market outlets. Hence, multivariate probit model was reflects the interdependent and simultaneous choice decisions of various market outlets (Dessie et al., 2018). Therefore, for this study multivariate probit model was used with normal distribution at zero conditional mean and variance normalized to unit. The symmetric covariance matrix **Ω** is given as follows:

$$\Omega = \begin{Bmatrix} 1 & \rho_{12} & \rho_{13} & \rho_{14} & \rho_{15} \\ \rho_{21} & 1 & \rho_{23} & \rho_{24} & \rho_{25} \\ \rho_{31} & \rho_{32} & 1 & \rho_{34} & \rho_{35} \\ \rho_{41} & \rho_{42} & \rho_{43} & 1 & \rho_{45} \\ \rho_{51} & \rho_{52} & \rho_{53} & \rho_{54} & 1 \end{Bmatrix}$$

Where ρ_{ij} represent the correlation between different types of tef market outlets

Results and Discussion

Socio-demographic and Farm Characteristics

The descriptive comparison of dummy variables based on frequency counts and the chi-squared test was presented in Table 2. Statistically significant differences at 1% were shown concerning off/non-farm income earned, access to credit, access to extension service, access to market information, own transport service, and use of improved variety. The results revealed that among market participants, 34.81% received off/non-farm income as compared to 9.44% among non-market participants. If reinvested this income into tef production and marketing activities such as input purchase, labor rent for production, and harvesting, it increases tef production and marketable surplus which increases the probability of market entry and level of market participation. This result shows that there is a positive relation between tef marketing participation and off/non-farm income.

The results revealed that 61.95% of subsample market participants were exposed to access credit compared to the non-market participants (28.02%). This farm credit is vital for investment in tef production and marketing processes that promote tef production. Increased tef production increases tef marketable surplus that turns in, increases the tendency for market entry and the extent of market participation. This result suggests that there is a positive relationship between access to credit and involvement in tef marketing.

Table 6. Comparison of percentages of households between market and non-market participants

Variables (dummy)		Market participant (n = 243)		Non-market participant (n = 96)		Overall (n = 339)		Chi-square
		N	Percentage	N	Percentage	N	Percentage	
Sex of households	Male	218	64.31	87	25.66	305	89.97	0.064
	Female	25	7.37	9	2.65	34	10.03	
Off/non-farm income	Yes	118	34.81	32	9.44	150	44.25	6.467***
	No	125	36.87	64	18.88	189	55.75	
Access to credit	Yes	210	61.95	95	28.02	305	89.97	11.989***
	No	33	9.73	1	0.29	34	10.03	
Extension service	Yes	189	55.75	95	28.02	284	83.78	22.712***
	No	54	15.93	1	0.29	55	16.22	
Access market information	Yes	58	17.11	5	1.47	63	18.58	15.836***
	No	185	54.57	91	26.84	276	81.42	
Access own transport	Yes	156	46.02	35	10.32	191	56.34	21.526***
	No	87	25.66	61	17.99	148	43.66	
Improved variety	Yes	53	15.63	9	2.65	62	18.29	7.121***
	No	190	56.05	87	25.66	277	81.71	

Extension service was enhancing farm production and marketing through the mastery of skill and knowledge of the farmers in using recommended input and management, thus increasing tef marketing. The result showed that 55.75% of subsample market participants were exposed to extension services compared to the non-market participants (28.02%). Thus result suggested that a positive relationship of extension service on farmers' sales decisions.

The result further revealed that among the market participant, only 17.11% were accessed market information that is greater than non-market participants (1.47%). This result reflects a wider human resources base for decision-making of increasing marketable surplus by seeking better price information. Access to own transport service also affected market participation on tef marketing. This reflects that farmers who own transport services choose better markets received better prices. Therefore, the results suggest a positive relationship of both market information and transport own on sales decision.

The result revealed that market participants tend to use improved tef variety about 15.63% which is greater than non-market participants (2.65%). The result suggested that there is a positive relationship between improved variety and market participation even if the majority of farmers used local variety.

Table 3 presented a descriptive mean comparison of continuous variables between market participants and non-market participants. Education level of household, tef farming experience, land allocated for tef, total tef produced, and livestock holding (TLU) variables that exhibit statistically significant differences at 1% level of significance. Age of household and household size variables were statistically significant at a 5% level of significance. The result shows that education and age (as experience) enhance tef productivity and marketing through the mastery of skills and knowledge which increases tef marketing. Thus, suggested that there is a positive relationship between these variables and tef marketing.

The tef farm size variable was revealed as the key factor required for tef production and marketing activities. The results suggested that market participants have a larger tef farm size relatively as compared to non-market participants, thus indicating the positive effect of this variable on marketing decisions and intensity of market participation by increasing the tef production.

Quantity of tef produce variable was directly affected market participation due to surplus marketable tef produce. The result revealed that market participants have a larger amount of product when compared to non-market participants, so it indicates that there is a positive effect of quantity of produce on marketing decisions and intensity of market participation.

Household size variable was revealed of the availability of labor required for tef production and marketing activities. The results suggested that market participants have a larger household size compared to non-market participants, thus indicating the positive effect of this variable on marketing decisions and intensity of market participation.

Livestock holding (TLU) was positively affected market participation between participants and non-participants. This result showed that farmers who have greater livestock number were more participated in tef marketing compared to non-market participants' farmers which used as key factors tef production (purchasing inputs) and marketing activities. This increases the marketable

surplus of tef in the market, which indicates that there is a positive relationship between livestock on marketing decisions and intensity of market participation.

Table 7. Comparison mean of sample households between market and non-market participants

Variables (continuous)	Participants (n = 243)	Non-participants (n = 96)	Overall (n=339)	T-value
Age of household (year)	47.564 (10.824)	44.844 (10.682)	46.794 (10.838)	2.092**
Education level (year)	5 (3.778)	3.125 (2.758)	4.469 (3.616)	4.418***
Land allocated for tef (ha)	1.074 (0.541)	0.488 (0.239)	0.908 (0.543)	10.226***
Total tef produced (Quintal)	11.350 (6.438)	3.641 (2.192)	9.167 (6.567)	11.465***
Household size	6.947 (2.348)	6.323 (2.070)	6.770 (2.287)	2.276**
Livestock holding (TLU)	10.505 (5.550)	7.078 (4.909)	9.534 (5.587)	5.287***
Distance of tef market (min)	47.140 (38.201)	52.677 (36.076)	48.708 (37.641)	1.221

Standard deviations in parentheses

Mapping the Tef Value Chain

The main functions in the tef value chain are inputs, production, marketing, processing, and consumption. The tef market map is up of three interlinking components include value chain actors, enabling environment, and service providers. Value chain actors who are participated directly in the value chain development of tef. These actors may have participated in input suppliers, producers, traders, processors, and consumers.

Input suppliers: Input is one of the most important factors in tef farming activities used by tef producers. Among these inputs seed, fertilizer (Urea & NPS), agro-chemicals (Roundup, 2-4-D & Pallas) are the major ones that producers used for tef production. Farmers used local and improved varieties as seeds. In the study, areas improved varieties include Kena, Guduru, Dursi tef varieties used by farmers. These inputs were provided by cooperatives, district agricultural development, research centers, traders, and farmers are the major inputs sources in the study areas.

Producers: They are smallholder farmers of the study zones who produce tef for market and/or consumption. This smallholder farmer is explained as a family-owned enterprise that produces crops or livestock on two or fewer hectares (Gebre et al., 2020). Tef producers are important actors who accomplished most of the value chain functions right from farm inputs preparation from other sources to post-harvest handling and marketing. Smallholder farmers are the main actors of the chain by participating in both the product supply to the market and purchasing basic inputs from input suppliers. Among others activities land preparation, sowing, fertilizer application, weeding, harvesting, post-harvesting handling, and marketing were mainly undertaken by tef producers.

Collectors: These are actors in the tef value chain who collects tef from smallholder farmers in the village, kebele, and/or district and sell product to wholesalers and consumers in districts and zones market. Collectors were buying, assembling, transporting, packing, and selling to wholesalers and consumers.

Wholesalers: They are significant actors in the tef value chain and participated in buying a relatively large volume of tef from collectors and/or producers and selling the product to retailers and consumers. Wholesalers have relatively strong working capital, better storage house, communication access, and govern (price-setting & volume) the tef value chain in the study areas.

Retailers: They have purchased products directly from producers at districts and zones markets and wholesalers at storage. They provided it to consumers. They have limited working investment operate on a small scale related to other tef traders of the study areas.

Cooperatives: These actors play a key role in tef value chain development by promoting producers to produce more by providing input and buying tef product at a relatively better price in the kebele and resale tef product to consumers in the districts and zones.

Consumers: These actors are the end-user of the tef value chain. Tef is consumed in the form of injera in different hotels, restaurants, and individual consumers. This shows that the marketed tef reaches consumers through direct producers, collectors, wholesalers retailers, and cooperatives. Rural people who visit the markets, travelers, urban people, and institutions are the main consumers' tef product inform of injera in the villages, districts, and zones town.

Chain supporters/enablers: In the study areas zonal and district levels of different bureaus were supporting and influencing tef value chain in one or another way. The supporters and enablers were providing supportive services including improved tef varieties, training and advice, market information, chemicals, fertilizers, credit, and other agricultural inputs for tef producers and traders. These services were provided by unions, agricultural and natural resource offices (zones and districts level), primary cooperatives, research centers, universities, cooperative agency office, and micro finances and facilitate sustainable development of value chain including unions, agricultural and natural resource offices (zones and districts level), trade and market development office (zonal and district level), and microfinance (Oromia credit and saving; wasasa share companies). These supporters and enables have a big impact on the value chain understanding the trend that are affecting the entire value chain, examining the power, and interesting that are driving change and supported by business and extension services (Thome et al., 2021; Masamha et al., 2018). These are individuals or institutions that are engaged either in financing or supporting the main actors of tef value chain from other enterprises and support organizations (Kilelu et al., 2021) which shape the value chain environment and conditions (Maestre et al., 2017). They don't participate directly in the tef value chain, but indirectly facilitate the main actors in tef chain to make their task effective and practical. These supporters’/enablers services are beyond the direct control of economic actors in the value chain (Goerzen et al., 2021; Rivera & Gutierrez, 2019).

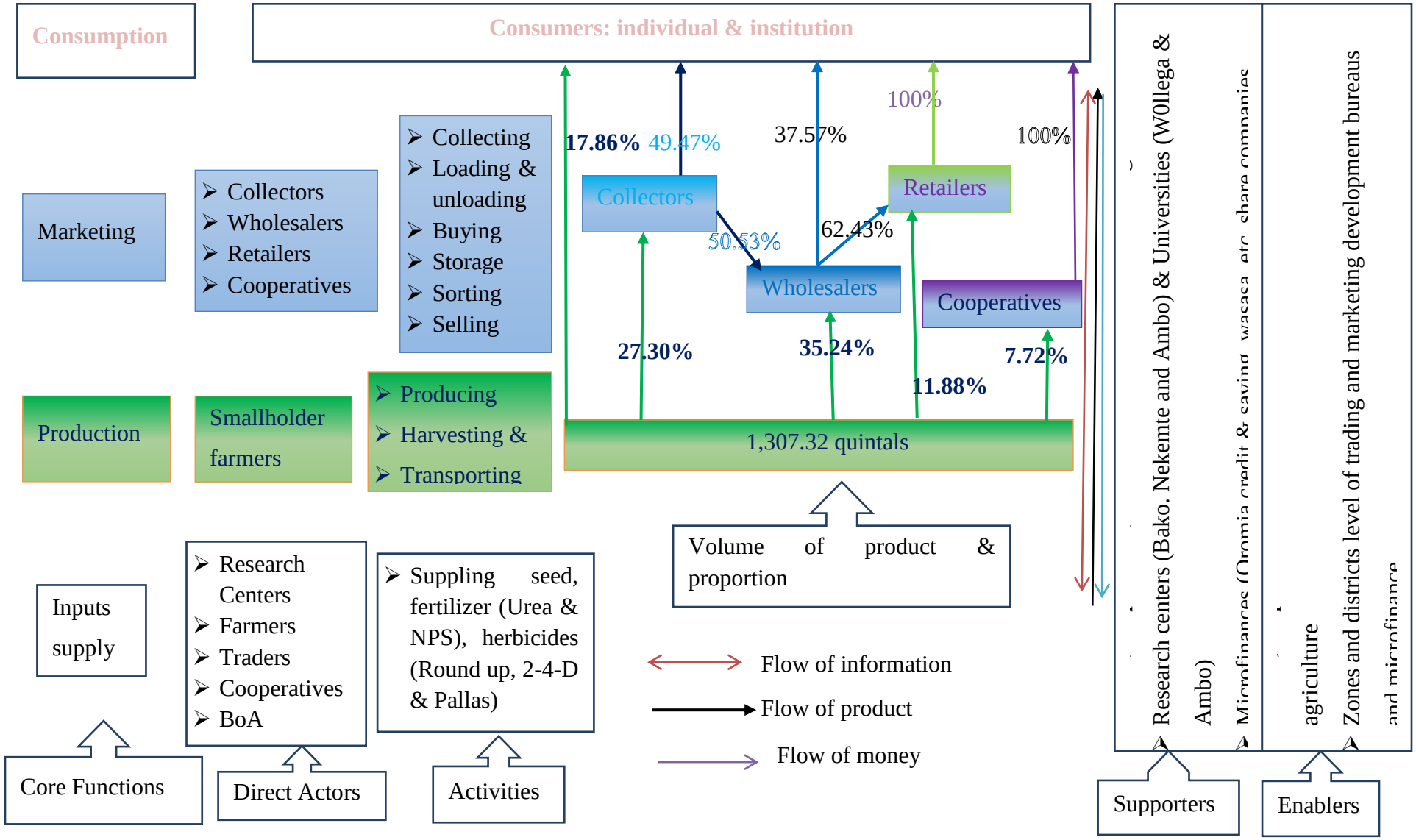

Figure 3. Tef value chain core functions, actors with activities and flow of output

Marketing Channels of Tef Value ChainIn this study tef marketing channel for this study was designed based on the volume of flow of product passing through different routes during the 2020/21 cropping season. Figure 1 shows marketing channels of tef in the study areas starting with a collection of tef moving to the end-users. The market channels performance in the study areas was evaluated by considering association costs, returns, and marketing margins of Ethiopian Birr (ETB) per quintal. Total costs (production costs and marketing costs) were used. The marketing margin of the actors was calculated using the average price of tef for each actor. To indicate the distribution of marketing costs and margins, eight (8) tef marketing channels were identified and the amount of tef transacted in these market channels was different. This analysis of tef marketing channels provides a systematic knowledge of the flow of goods or services from their production to the end-users (Kabeta et al., 2021).Channel I: Producers – Consumers: This channel was the shortest channel which is producers directly sold to the consumer at different market days. It represented 17.86% of the total tef marketed which was 233.49 quintals during the survey period. The channel was the second most important marketing channel in terms of volume supplied.

Channels II: Producers – Collectors –Consumers: In this channel rural collectors were buying tef product from tef producers and sold to consumers. It amounted, 13.51% of tef marketed through this channel at which supplied 176.56 quintals during the survey period. It was the third most important marketing channel in terms of volume supplied and the largest channel in terms of market routes.

Channel III: Producers – Collectors – Wholesalers –Consumers: In this channel, wholesalers were bought tef product from collectors and supplied to consumers which is about 5.18% (67.75 quintals) of total tef supplied to the market during the survey period. The channel was least in terms of volume supplied and the largest channel in terms of market routes.

Channel IV: Producers – Collectors – Wholesalers – Retailers – Consumers: In this channel, wholesalers were bought tef from collectors and sold it to retailers then the retailers were sold this product to consumers almost 8.61% (112.59 quintals) of total tef product marketed. The only difference in this channel from channel III was that wholesalers sold to retailers and retailers sell to consumers.

Channel V: Producers – wholesalers – consumers: The wholesalers were bought tef from producers and supplied it to consumers in this channel. It accounted, about 13.24% (173.08 quintals) of tef total marketed during the survey period and was the fourth most important channel in terms of volume supplied to the market.

Channel VI: Producers – wholesalers – retailers – consumers: In this channel wholesalers were bought tef products from tef producers and supplied them to consumers which was 22% (287.61 quintals) of total tef supplied to the market during the survey period. The channel was the first most important channel in terms of volume supplied to the market.

Channel VII: Producers – retailers — consumers: In this channel, retailers were bought tef products from producers and supplied them to consumers. It accounted, about 11.88% (155.31 quintals) of total tef supplied to the market during the survey period.

Channel VIII: Producers – cooperatives – consumers: In this channel cooperatives were bought tef product from producers and sold to consumers. It amounted, about 7.72% (100.93 quintals) of total tef supplied to the market during the survey period. The channel was the second least important channel in terms of volume supplied to the market.

Tef Marketing Costs and Margin Analysis

The average cost of tef production per quintal was 2,315 ETB which includes land rent, inputs cost, production activities cost, and transporting cost which is different depending on the market distance. The tef producers market profit was the highest in channel VIII when farmers sold their product to cooperatives which was 415 ETB while taking the lowest market profit from channel III and IV when they sold their product to collectors which was accounted 293 and 298 ETB respectively. These results showed that as market routes increased then producer market profit was decreased which is in line with Ayele et al. (2021) and Minten et al. (2016) as results which indicated as market channel largest market profit of producer fairly low. The producer shares from channel VIII was higher whereas the producer share of channel III and IV was lower than the other channels (Table 4).

Table 8. Tef marketing margin for different channels and actor (Birr/ton)

Actors		I	II	III	IV	V	VI	VII	VIII
Producers	Selling price	2,750	2,858	2,858	2,858	3,000	3,050	3,055	3,075
	Production cost	2,315	2,315	2,315	2,315	2,315	2,315	2,315	2,315
	Marketing cost	58	225	250	245	325	350	365	345
	Total cost	2,373	2,540	2,565	2,560	2,640	2,665	2,680	2,660
	Market profit	377	318	293	298	360	385	375	415
	GMMp (%)	100.00	81.66	76.70	75.71	83.92	81.33	83.24	86.62
Collectors	Selling price		3,500	3,426					
	Total cost		3,008	3,083					
	Market profit		492	343					
	GMMp (%)		18.34	15.25					
Wholesalers	Selling price			3,726	3,601	3,575	3,550		
	Total cost			3,581	3,476	3,250	3,305		
	Market profit			145	125	325	245		
	GMMp (%)			8.05	19.68	16.08	13.03		
Retailers	Selling price				3,775		3,750	3,670	
	Total cost				3,656		3,625	3,305	
	Market profit				119		125	365	
	GMMp (%)				4.61		5.63	16.76	
Cooperatives	Selling price								3,550
	Total cost								3,325
	Market profit								225
	GMMp (%)								13.38
TGMM (%)		**-**	**18.34**	**23.30**	**24.29**	**16.08**	**18.67**	**16.76**	**13.38**

Regarding traders (collectors, wholesalers, retailers, and cooperatives) were presented in Table 4. The highest market profit and share of collector have occurred in channel II following channel III which accounted, 492 and 18.34% respectively. In cases of wholesaler market profit and share were existed in channel VIII following channel VI which represented 325 and 245 ETB

respectively whereas higher collector share occurred in channel IV following channel V which accounted 19.68% and 16.08% respectively. In this result, the retailer has collected a larger market profit and share in channel VII which amounted, 365 ETB and 16.76% respectively.

Concerning cooperative, the market profit and shared presented were faired related to market profit and shared of other channels. These results in line with Lee (2018) result revealed that the number of marketing channels decrease the marketing profit and shared was increased. The Total Gross Marketing Margin (TGMM) was highest in channels VI and III which was accounted, 24.29% and 23.30% respectively while the lowest existed in channel VIII. This result supported that as the number of marketing agents increases the producers share (GMMp) decreases which implies that as producers share decreases the total marketing margin increased which is in line with Aliyi et al. (2021) and Tarekegn et al. (2020) indicated that as marketing agents increase the producers' share was decrease.

The Major Constraints and Opportunities Actors

One of the advantages of value chain analysis in this study was identifying bottlenecks of the value chain development from input supply to consumption level. Accordingly, several constraints and opportunities were explained by different actors through face-to-face interviews and focus group discussion and presented in Table 5. In the input supply shortage of input, untimely supply of input shortage of capital, and information gaps between farmers and input suppliers were identified and ranked. Regarding farm level, the main constraints faced by farmers were high price of input, shortage & untimely supply of input (seed, fertilizer, & chemical), poor soil fertility, disease, and lodging problems, weed infestation, and poor infrastructure (road) also summarized and ranked. Concerning traders' poor transport facility, computation of unlicensed traders, grain price and buyer fluctuation, capital shortage, and limited access to credit services for traders were identified and ranked as main constraints of traders. This result shows that commonly agricultural policies in the areas and strategies that create and sustain an enabling environment and support of promoting greater integration of smallholder farmers into the markets are not developed effectively. Besides, these constraints opportunities of tef value chain mentioned by actors and interventions for main constraints were presented in this Table 5.

Table 9. Summary of constraints and opportunities along tef value chain actors

	Constraints	Rank	Opportunities	Interventions
Input supply	Untimely supply of input	2	Sources seed supply	Provide inputs (seed, fertilizer, & chemicals) on time and enough amount requested input suppliers from importers
	Shortage of input	1	Chemicals and fertilizer source	
	Shortage of capital	3	Credit availability	Credit availability for input suppliers
	Information gap	4	Research source	Strengthen linkage between farmers & input suppliers
Production	Disease and lodging problem	4	Government support research and chemical availability	Awareness creation and develop tolerant/resistance varieties should give attention by researches
	Shortage & untimely supply of input	2	Enabling environment policy by government on inputs	Provide inputs (seed, fertilizer, & chemicals) on time and enough amount requested by producers
	Poor market information	6	Favorable climate condition for tef production	Strengthen linkages among input suppliers, producers and buyers on price information and price setting
	High price of input	1		
	Poor infrastructure	7	Availability daily laborer	Road construction for rural farmers and maintained the old
	Weed infestation	5	Good initiation on soil fertility for production	Used appropriate herbicide for weed and lime application/other soil management for soil improvement
	Poor soil fertility	3		
Marketing	Grain price and buyers fluctuation	3	Government investment on infrastructure	Strengthen cooperatives and establish well linkage between producers and cooperatives
	Poor transport facility	1	Establishment of cooperatives	Road construction and maintenance for the old one
	Capital shortage & limited credit service	4	High market demand of tef product	Credit availability with amount needed by traders specifically for crop trading purposes
	Presence of unlicensed traders	2	Establishments of credit providers	Control unlicensed traders and improve farmers bargaining power by supporting licensed traders

Factors Affecting Tef Market Participation Decision and Intensity of Participation

Farm size of tef had a positive and significantly affected on the decision to participate in the tef value chain at 10% significance level. This suggested that as the household increased the land size allocated for tef by one hectare, the probability of being a market participant under tef would increase by 3.57% due to its increase the production and improvement of market participation (Table 6). The result was consistent with the findings of Tarekegn et al. (2020) and Tadesse et al. (2019) stated that plot size has more important for increasing the produce and market participation.

Quantity of tef produced was positively and statistically affected on market participation decision at 1% significance level (Table 6). This indicates that a household that produces more quantity of tef had also supplied more to the market or when the production of tef in a given year was better, the higher the market supply and the amount of tef that can be sold to the market. This result is in line with the finding of Mirie and Zemedu (2018) stated that as increases the quantity production and increases market participation.

The gender of the household head was negatively and statistically affected the probability of household market participation at a 5% significance level (Table 6). This result revealed that the male household head was more market participant than the female household head. The result was in line with the finding of Gebre et al. (2021) stated that there was a gender gap in market participation.

The educational level of farmers had a positive and significantly affected farmers' decision to participate in the tef market at a 10% significance level. The marginal effect showed that an increase in the educational level of the farmers increases the probability of participating in smallholder participation of tef marketing by 0.17%, ceteris paribus (Table 6). This implied that as the educational level of the farmers' increases, their ability to get information on how to produce and sell tef produce increases which are in line with Regassa Megersa et al. (2020) and Mossie et al., (2020) stated that more educated farmers they were more likely to produce and sell more at market price.

Off/non-farm income was positively and statistically affected farmers' market participation decisions at a 5% significance level (Table 6). This implies that the more amount of off/non-farm income received by farmers, the more produce tef and more participation in the market. This was because the farmers received off/non-farm income, they could purchase much more inputs that increase the production of tef and sold in the market. If the off/non-farm income of the sampled household increased by one birr, the market participation decision would increase by 2.19%. The result was in line with the finding of Ademe et al. (2017) stated that off/non-farm income increases production and market participation.

Table 10. Probit regression estimates for determinants of tef market participation

Variables	Coefficient	Robust Std. Err	Marginal Effects
Constant	7.1413***	1.5293	-
Land allocated for tef (ha)	0.8205*	0.5010	0.0357
Total tef produced (quintal)	0.6464***	0.0849	0.0203
Age of household head (year)	0.0044	0.0136	0.0001
Gender of household heads	-0.9847**	0.4917	-0.0408
Education level of household head (year)	0.0758*	0.0472	0.0017
Variety (improved)	-0.4060	0.4050	-0.0271
Distance of nearest tef market (minute)	0.0020	0.0036	-0.0001
Total household size	0.0795	0.0676	0.0025
Off/non-farming income obtained	0.6409**	0.2750	0.0219
Access to credit service	0.5829***	0.1130	0.1825
Livestock holding (TLU)	0.0412	0.0304	0.0013
Access to extension service	0.2677***	0.1001	0.0948
Access to market information	0.1612**	0.0664	0.0562
Price of tef	0.0523	0.03742	0.0231
Access to own transport	0.0217	0.0275	0.0017

Access to credit was positively and significantly affected the farmer's decision to participate in tef marketing at a 1% significance level. This implies that a farmer who has credit access increases the probability of participating in the tef market by 18.25%, ceteris paribus (Table 6). This suggests that access to credit improves the financial capacity of farmers to buy improved inputs, thereby increasing production which is reflected in the marketed surplus of tef. The result is a consistent result finding of Abate et al. (2019).

The extension contact was positively and significantly affected farmers' participation decisions on the tef market at a 1% significance level (Table 6). This implies households with higher contact with extension agents have got better information about to make informed decisions on the production and marketing of tef outputs than other farmers which are in line with the finding of Kyaw et al. (2018) and Giziew & Admas (2020) who stated that as extension contact increases the market participation of farmers also increased.

Access to market information was found to affect smallholder farmers' decision to sell tef produce positively and significantly at a 5% significance level. The marginal effect showed that an increase in getting information on time increases the probability of farmers' participation in the marketing of tef in the output market by 5.62%, ceteris paribus (Table 6). This indicated that farmers need to be able to get their products to market and receive equitable price treatment to make the right decision. This result similar to the argument Kassahun et al. (2020) and Tarekegn et al. (2020) indicated that better access to market information significantly increased the probability of production and market participation of households.

Factors Affecting the Intensity of Tef Market Participation

The result presented in Table 7 indicated that tef quantity produced had positively and significantly influenced the extent of market participants at a 1% significance level. The result showed that the increase in tef output by one quintal increases the volume of tef supplied to the market by 0.052. This was ultimately expected since households who have greater production have more surpluses that can be sold to market. The findings of the study were in line with that of Alphonse et al. (2021) that households with a higher volume of crop produced sell a higher proportion of their produce.

Gender of the household head was positively and statistically affected the volumes of tef sold in the market at a 1% significance level (Table 7). This result revealed that the male household head was dominated in the selling tef to the market because male farmers have more contacts that were social with buyers while Female farmers lack such contacts and are in most cases omitted from direct transactional negotiations with buyers. The result was in line with the finding of Dibaba (2021) and Gebre et al. (2021) stated that the male gender of farmers positively and significantly influenced farmers' volume of sales in the market.

The household head schooling degree has a positively and statistically affected the intensity of tef market participation at a 10% significance level. This revealed that as the sample household head education level increases by a year, the quantity of tef supplied to the market increases by 0.0178 quintals (Table 7). This suggested that the educated household head highly tef suppliers to the market because educated farmers have more knowledge and experience that allow them to understand information about the market. This study is consistent with the finding of Dubale et al. (2021) who stated that the education level of the household head affects the market supply positively.

Table 11. Truncated regression estimates for determinants of intensity of tef market participation

Variables	Coefficient	Robust Std. Err
Constant	0.7706***	0.3015
Land allocated for tef (ha)	-0.0407	0.0794
Total tef produced (quintals)	0.0520***	0.0070
Age of household head (years)	-0.0006	0.0030
Gender of household heads	0.6516***	0.1696
Education level of household head (years)	0.0178*	0.0106
Variety (improved)	0.1730**	0.0850
Tef price	0.4362	0.3974
Distance of nearest tef market (minutes)	0.0001	0.0009
Total household size	-0.0010	0.0130
Off/non-farming income obtained	-0.0380	0.0668
Access to credit service	0.3859***	0.1219
Livestock holding (TLU)	0.0078*	0.0048
Access to extension service	0.4845***	0.1645
Access to market information	-0.0287	0.1465
Access to transport own	0.0468	0.0718

Improved variety was positively and statistically affected the level of tef market participation at a 5% significance level (Table 7). The result revealed that farmers who used an improved variety of tef increases the production which marketable surplus. This marketable surplus also increases the level of tef produce to marketing which is in line with the finding of Singbo et al. (2021), Achandi and Mujawamariya (2016) and Awotide et al. (2016) stated that as adopted improved varieties increased marketable surplus.

Access to credit was positively and significantly affected the farmer's level of tef volume in the marketing at a 1% significance level (Table 7). This implies that farmers with better access to credit were more interested to allocate their financial resources from the credit on tef production and marketing activities. The result shows that as credit access to the farmers the probability of increasing the intensity of tef for market by 0.3859, ceteris paribus. This suggests that access to credit improves the financial capacity of farmers to buy improved inputs, thereby increasing production which is reflected in the marketed surplus of tef. The result is in line with the finding of Bekele et al. (2020), Belay (2020), and Tadesse (2020) stated that access to credit was enhance the farmer's financial capacity to purchase inputs thereby increasing production and supply the greater marketed surplus.

Total livestock holding was powerfully linked and statistically significant to the marketing point. The result suggested that a fact in ceteris paribus as livestock unit per household increases the probability level of tef commercialization increased by 0.0078 due to produced surplus of tef by reinvested incomes from livestock in tef production and marketing activities (Table 7). The result is in line with the finding of Meleaku et al. (2020) stated that livestock holding increases the level of marketing participation.

The extension contact was given by the respective service to the household had strong and important on the level of tef marketing (Table 7). This implies that households access additional service with training/advice the probability of household increase level of tef market by 0.4845 the reason for this is extension service increase the capacity of farmers to produce and manage the tef produce and access important information on the market, production, and management of the crop which is similar with the finding of Endalew et al. (2020) stated that extension service has been correlated with the volume of tef marketing.

Factors Affecting the Market Outlet Choices of Tef Producers

The multivariate probit model was used to estimate several correlated binaries jointly predicting these five outlet choices. The Wald X2 (75) = 670.47 was statistically significant at a 1% significance level (Table 8, which indicated that the subset of coefficients of the model was jointly significant and the independent variables power of the variables included in the model was reasonable. The likelihood ratio test in the model showed that X2 (10) = 94.096 was statistically significant at a 1% significance level, which indicated the null hypothesis that choices of the five market outlets were independently rejected and there are different market outlets choices among the smallholder farmers. The results showed that the goodness of fit of the Multivariate probity model for the study.

The value of ρ (ρ_{ij}) indicated that the correlation of each market outlet's choices. The ρ_{31} (the correlation between the choice of cooperative and wholesaler outlets) was positively and significantly at a 1% significant level. The ρ_{41} (the correlation between consumer and wholesaler), ρ_{51} (the correlation between retailer and wholesaler), ρ_{32} (the correlation between cooperative and collector), ρ_{42} (the correlation between consumer and collector), and ρ_{52} (the correlation between retailer and collector) were negatively and significantly significant at 1%, 1%, 1%, 1%, and 5% significance level, respectively (Table 8).

The results presented in Table 8 indicated that the marginal success probability of each market outlet choice was different. The predicted probability estimation result showed that the likelihood of choosing a cooperative outlet was relatively high (72.6%) as compared to the probability of choosing consumer (71.9%), wholesaler (69.3%), retailer (63.7%), and collector (57.4%) which presented in Table 8. The result revealed that the collector outlet was less expected chosen to the delivered to wholesale and processor.

The result presented in Table 8 indicated that land allocated for tef, the quantity of tef produced, age of household head, education level of household head, gender of household head, household size, extension contact, the improved variety used, off/non-farm income, nearest market distance, market information, and own transport facility were statistically significantly affecting the market outlet choices performance of tef producers.

Total land allocated for tef production in hectare was found to have a negative and statistically significantly affected in choosing cooperative tef market outlet at 5% significance level. This implied that as land allocated for tef increases by a hectare the probability farmers' choice cooperative market outlet decrease by 10.7%, ceteris paribus. The result showed that those with large parcels of land were likely to participate less in cooperative markets as they have a scale advantage to reduce costs to take products to other outlets.

Table 12. Factors affecting of market outlet choices of tef producers in selected zones of western Oromia

Variables	Wholesalers		Collectors		Cooperatives		Consumers		Retailers	
	Coef.	RSE	Coef.	RSE	Coef.	RSE	Coef.	RSE	Coef.	RSE
Constant	1.251***	0.164	1.934***	0.559	3.639***	0.941	2.414***	0.591	3.614***	0.791
Land of tef	-0.058	0.324	0.219	0.279	-0.107**	0.490	-0.231	0.332	0.261	0.324
Tef product	0.245***	0.050	0.119***	0.034	0.127***	0.033	0.095***	0.032	0.130***	0.042
Age of hhh	-0.011	0.011	0.005	0.009	0.016	0.014	0.011	0.009	0.019*	0.011
Educ. lev. hhh	-0.012	0.035	-0.021	0.032	0.123**	0.052	-0.001	0.028	0.031	0.057
Sex of hhh	0.557*	0.327	0.593**	0.289	0.370	0.466	0.560*	0.337	0.495	0.471
HHsize	-0.078*	0.045	0.052	0.047	-0.066	0.056	0.016	0.041	-0.072	0.054
Credit access	0.211	0.208	0.090	0.185	0.367	0.275	-0.023	0.190	0.165	0.229
Extension	0.028	0.206	-0.199	0.200	0.416*	0.239	0.359**	0.188	0.403*	0.241
Variety used	-0.045	0.335	0.485*	0.286	-0.066	0.056	-0.155	0.284	-0.221	0.391
Off/non inco.	0.339*	0.220	-0.080	0.191	0.216	0.252	0.364*	0.200	-0.519**	0.271
Tef price	0.067	0.132	-0.097	0.089	0.435	0.395	0.038	0.047	-0.197	0.201
Market dist.	0.005**	0.002	-0.002	0.003	0.004	0.047	0.001	0.003	-0.003	0.003
Market info.	0.341**	0.136	0.105	0.256	-0.193	0.323	0.487*	0.254	0.546*	0.267
Own transport	-0.018	0.224	-0.072	0.220	-0.255	0.941	0.574***	0.193	-0.307	0.277
Predicted pro.	0.693		0.574		0.726		0.719		0.637	
Independent variables satisfactory	$Number\ of\ observation = 243$, Wald X^2 (75) = 670.47 and Prob X^2 = 0.000									
Likelihood ratio test of; $\rho_{21} = \rho_{31} = \rho_{41} = \rho_{51} = \rho_{32} = \rho_{42} = \rho_{52} = \rho_{43} = \rho_{53} = \rho_{54} = 0$ & X^2 (10) = 94.096 & $Prob > X^2 = 0.000$										
Estimated correlation matrix										
ρ_{21}	0.112 (0.122)	ρ_{31}	0.432*** (0.152)	ρ_{41}	-0.455*** (0.146)	ρ_{51}	-0.264 (0.170)	ρ_{32}	-0.483*** (0.117)	
ρ_{42}	-0.512*** (0.091)	ρ_{52}	-0.602** (0.289)	ρ_{43}	-0.088 (0.124)	ρ_{53}	0.166 (0.321)	ρ_{54}	0.195 (0.122)	

Variables marked with *, ** & *** were significant at 10%, 5% & 1% levels

The quantity of tef produced by producers was found to have a positive and significant relationship with the likelihood of choosing wholesaler, collector, cooperative, consumer, and retailer market outlet at a 1% significance level. This result indicated that the quantity of tef produced by a farmer increases by a quintal, the likelihood of choosing wholesaler, collector, cooperative, consumer, and retailer market outlet increases by 0. 245, 0.119, 0.127, 0.095, and 0.130, ceteris paribus, respectively (Table 8). This suggests that for a household that produces more tef products, farm households are more likely to choose all market outlets based on profitable gained which is in line with Nwafor et al. (2020) and Awotide et al. (2016) results who found that the quantity of product sold increases market outlets.

Age of household head was found to have a positively and significantly affected in choosing retailer tef market outlet at 10% significance level. This implied that as the age of household increases by a year, the probability of farmers to sell their product to the retailer market outlet increases by 0.019%, ceteris paribus (Table 8). This might be due to the fact that older people may take the decision to choose better market outlet which gives the higher price as compared to younger peoples which in line with Melese et al. (2018) result who found as the age of household head increases by a year better market outlet choose decision increase.

The education level of household heads was significantly affected by the likelihood of choosing cooperative at 5% of the significance level. This result suggests that as the household head's become literate, the probability of choosing a cooperative market outlet increases by 0.125 (Table 8). This can be explained by the fact that as a producer becomes literate, they had good skill and knowledge of agricultural marketing, which enables them to sell their product in a profitable market outlet. This study is consistent with Dessie et al. (2018) who found that the education level of respondents affects profitable market outlets.

Gender of household heads was significantly affected by the likelihood of choosing wholesaler, collector, and consumer at 10%, 5%, and 10% of significance level, respectively (Table 8). This suggests that male-headed households had a higher probability of selling their produce to wholesalers, collectors, and consumers as compared to female-headed households and vice versa. This result is consistent with the finding of Ahmed et al. (2017) which the sex of the household headed had a significant effect on the choice of market outlet.

Household size was negatively affected the wholesaler market outlet choice of tef producers at a 10% significance level. The result showed that as household size increases by one person, the probability of choosing a wholesaler market outlet decreased by 0.078 (Table 8). The reason might probably be due to larger produce demand for food home consumption. This result is consistent with Temesgen et al. (2017) who found that as the number of families increased, the probability to participate in the market decreased.

Extension contact was positively and statistically affected the likelihood of choosing cooperative, consumer, and retailer market outlets at a 10% significance level (Table 8). This was because farmers having high contact with development agents and other experts were more likely to know about market outlets that offered a better price for their produces. In addition, extension service increases the ability of farmers to attain significant market information as well as enable tef producers to improve production method, hence leading to more output which in turn increase producers' ability to choose the best market outlet for their product market. Thus, households that were more visited by extension agents were highly

likely to deliver tef product cooperative, consumer, and retailer market outlets than other existing market outlets. This result was in line with Wosene et al. (2018) and Tarekegn et al. (2017) who founds that extension contact has positively affected cooperative, consumer, and retailer market outlets.

The improved variety used was positively and statistically affected the likelihood of choosing collector market outlet at a 10% significance level (Table 8). This was because farmers who used improved variety was more likely to know about market outlet which offered a better price for their produces because of the farmers leading to more output which in turn increase product which increase the ability to choose the best market outlet for their product. This result was in line with Alphonse et al. (2021) and Ezeibe et al. (2020) who founds that improved variety has positively affected market outlet.

Off/non-farm income received was positively and significantly affected by the probability of choosing wholesaler and consumer market outlets at 10% significance level while negatively affected choosing of household retailer market outlet at 5% of the significance level. This implied that as the farmer involved in off/non-farm activities, the probability of choosing retailer market outlet was decreased by 0. 519 and increases the probability of choosing wholesaler and consumer market outlets by 0.339 and 0.384, respectively (Table 8). The possible justification was producers chooses wholesaler and consumer than the retailer. This result consistent with Degaga and Alamerie (2020) revealed that off/non-farm income increases the probability of choosing a better profitable market outlet than other outlets.

Distance from the nearest market was found to have a positive and significant relationship with the likelihood of choosing a wholesaler outlet at 5% of the significance level. This result revealed that for those households whose residence from the nearest market increases by a minute, the likelihood of households choosing wholesale market outlets increases by 0.005, ceteris paribus (Table 8). This implied that households located far from the nearest market were more likely in delivering tef produce to the wholesale market outlet. The reason for this was that farmers located distant from the market were focused on better profitable outlets than transportation costs spent. This result is in line with Abate et al. (2019) who found that farmers chose a better profitable market outlet than higher transaction cost.

Concerning market information, the results showed that if a farmer receives preliminary information on tef prices and buyers, the probability that farmers choose wholesalers increased. The result revealed that as market information on price and buyers, the probability of farmers choosing wholesaler market outlets increased by 0.005 at a 5% significance level (Table 8). On the other hand, households unable to obtain pricing and buying information were more likely to travel to the district and zone market center to sell their produce to wholesalers. Providing them with marketing information was gave them more bargaining power and reduced their uncertainty when making trade deals with buyers. A similar result was found by Mgale and Yunxian (2020) who argued that timely access to marketing information helps smallholder farmers to make informed decisions on market outlet choice.

Ownership of transport influenced the choice of consumer outlet positively and significantly at a 1% significance level (Table 8). This might be farmers who have transport facilities that could supply their product to the consumer directly by getting a better price. The result is in

line with Ermias (2020) and Mohammed Kassaw et al. (2019) who stated that the availability of own transport increases the probability of transporting goods to the consumer in the market.

Conclusion and Recommendations

Conclusion: In the study areas, there are various actors elaborated in the tef value chain playing different roles. The major ones are input suppliers, producers, collectors, wholesalers, cooperatives, retailers, and consumers. Concerning marketing margin and profit across the tef chain high producers share was occurred from cooperative (86.62%) and direct wholesalers (83.92%) and retailer (83.24%) buyers with different market profit. The traders also received different market profit and their shares in this value chain. This suggests that the distribution of tef value shares was inefficient in all channels except channel I (direct supply to consumers). Different tef value chain actors had different constraints which were well identified and ranked with different opportunities in the areas.

The results of the double hurdle model show that market participation decision and intensity of participation were affected positively and negatively by land allocated for tef, the volume of tef, gender, education level, off/non-farm income, credit access, livestock holding, extension service, and market information. The resulting synthesis that increased tef marketing mainly depends on farmers' skills and knowledge on tef production and marketing, strengthening the women household, facilitating additional working environment for farmers, delivering improved seed and market information.

Furthermore, the multivariate probit model result indicated that the probability to choose the wholesaler market outlet was positively and significantly affected by the quantity of produce, gender, off/non-farm income, market distance, market information while negatively and significantly affecting household size. The probability to choose the collector market outlet was positively and significantly affected by the quantity of produce, gender, and variety. Regarding cooperative market outlet quantity of produce, education level, extension service was affected positively and land allocated for tef was affected negatively. Likewise, the probability of accessing consumer market outlets was positively influenced by the quantity of produce, gender, Extension service, off/non-farm income, market distance, and transport owned. Concerning the retailer market outlet quantity of produce, age, extension service, and market information were affected positively the probability to choice. Based on the findings, the following are possible areas of interventions for different stakeholders which supporting tef value chain in the areas.

Agriculture and natural resource development office

- Strengthening the training and advice on tef production managements. The extension services and education help farmers can easily and practically recognize the difference in productivity and production possible obtained through the adoption of appropriate agronomic practices and varieties.
- Building the ability/skill of development agents on tef disease management to provide appropriate advice for farmers concerning tef disease.
- Major constraints and agriculture office interventions were identified and ranked, Therefore, these constraints need effective policies and strategies that create and sustain an enabling environment for integrating smallholder farmers into markets.

- Disseminated improved varieties and empowering women farmers need attention to enhance tef value chain activities.
- The diverse working environment for farmers and marketing communication linkages between farmers and cooperatives to b essential more boost tef production and market surplus.
- The multivariate probit model result suggests that to increase the flow of tef product through better profitable market outlets farmers' skills and knowledge on production and marketing through training, mass media, supervision and etc. and capacitate working capital through addition working environment and credit access should areas necessity more attention.

Marketing and cooperative office

- Continuous awareness creation on the linkage between farmers and cooperatives, who take over the roles of traveling unlicensed traders.
- Strengthening the cooperatives management members on business market information and working capacity (storage & transport facilities to add value and gain better market price for farmers).
- Provide extension service for traders and delivery market information for farmers on product price and bargaining power.

Research centers and Universities

- Develop high yielder varieties with disease resistance/tolerance for farmers.
- Strengthening districts' agricultural experts and development agents on disease occurrence and better crop production managements to provide appropriate advice for farmers' tef disease and production management (harvesting and post-harvesting) handling.

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Potato Value Chain Analysis in Highland of Guji Zone, Southern Oromia Regional State, Ethiopia

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Abstract

Potato plays a significant role in the national economy though the marketing channels differ for area to areas. Hence, this study was conducted to analysis potato value chain, actors, market supply and its determinants. The study used both secondary and primary sources. The primary data was collected from 141 randomly selected producer households. Additionally, 24 traders and 13 consumers were selected purposively. In data analysis, both descriptive and econometric analyses were employed. The study indicated that 89.8% of the product was supplied to the market in the study area through six marketing channels. From this supply, 38.92%, 26.13%, 11.2% and 23.75% were sold to wholesaler, retailers, collectors and consumers respectively. Result of a multiple linear regression model also indicated that age, potato production experience, amount consumed, quantity of potato produced, information access, off farm income and credit access significantly affected volume of potato supplied to market in the study area. Moreover, shortage of improved seed supply, disease, credit low price, poor market linkage and lower consumer demand were identified as constraints of potato value chain. Therefore, promoting and encouraging the production and dissemination of quality seed, strengthening experienced farmers in producing potato through provision of training on proper farm management and postharvest handling, empowering farmers to be a member of primary cooperatives and encouraging farmers to have off farm income and credit access in availing agricultural inputs can more improve potato value chain in the study area.

Key words: Actors, Constraints, Potato, Guji**,** Producer, Value Chain,

Introduction

Potato is considered to be the world's fourth important food crop after maize, wheat, and rice because of its high yield potential and nutritive value (Kumar *et al*., 2013; Pandey *et al*., 2014) and the third most important food crop after rice and wheat is being grown and consumed in all over the world (Devaux *et al.*, 2014 ; FAO, 2015).

Potato is cultivated worldwide in over one hundred countries throughout Africa, Asia, Australia, Europe, and North and South America (USDA, 2014). Potato is one of the widely grown root and tuber crops of the world being a rich source of nutrients for human nutrition. It contains about 79% water,18% starch as a good source of energy, 2% protein and 1% vitamins including vitamin C, minerals including calcium and magnesium and many trace elements (Ahmad *et al.*, 2011).The past few decades have seen a dramatic increase in potato production and demand in many developing countries (FAO, 2014).

Potato has been widely described as global food and nutritional security option particularly for the poor people (Singh and Rana, 2013). Farmers consider potato as a transitional crop that helps them survive the severe and prevailing food shortage that occur every year (Semagnet *et al*., 2007).

Potatoes are among the most widely-grown crop plants in the world giving good yield under various soil and weather conditions of requiring high altitude of about 1200 m above sea level, cool temperatures ranging between 15 and 20°C and high rainfall ranging between 1000 and 1500 mm per year and optimum soil pH ranges from 5.0 and 6.5n Arega *et al.*, (2020).

As CSA (2019) report of 2018/19 production year, Even though, Ethiopia has suitable environmental condition, the average national yield of potato productivity was 14.176 tha^{-1} which is very low as compared with world average yield of 20 tha^{-1} (FAOSTAT, 2019). On the other hand, the yield potential of the released potato variety in Gudanie ranges between 21 to 29 t tha^{-1} (MoARD, 2009). Moreover, at Bore Agricultural Research Center (2013) an unpublished research progress report clearly indicates that average yield of Gudanie 46.4 t tha^{-1} in the highlands of Guji zone. However, after four years of cultivation, the average yield of variety declined from 46.4 to 29.4 t tha^{-1} in the study area (Dembi *et al*., 2017).

Oromia is the major potato producing region in Ethiopia that constitutes 51% of the national potato production (CSA, 2015). Even though the country has suitable environmental conditions for potato production, the region (12.22 t/ha) as well as the national (13.69 t/ha) productivity of potato is very low (CSA, 2015), as compared to the world average of 17.16 t/ha (FAO, 2012). This is mainly due to shortage of improved potato varieties, lack of certified potato seed and poor agronomic practices which leads to low potato productivity in the region.

Highland parts of Guji zone is potential for potato production potato where 14,547.00 household farmers were participated on production of the crop (CSA, 2018). In the area the main objective of growing potato is for both household consumption and income generation. Potato is an interesting crop because the land used for potato is reused for other crop or vegetable production helping famers double cropping that enhances their food security and maintains their livelihood. Despite these benefits, potato producing farmers are still not benefiting from potato production due to nature of crop high perishability, Input supply

shortage, transportation problem, and low market price of output during harvesting and high cost of inputs during planting. Moreover, poor post-harvest management and low trust among actors were major constraints of potato production in the highland of Guji Zone. In doing so, the study attempted to contribute in filling the knowledge gap by assessing potato value chain and its performance, constraints and opportunities faced by potato value chain actors, marketing costs and margins across market channels and factors affecting potato marketed surplus in the study areas.

Objective

The specific objectives of the study were to:

- ✓ Identify the major value chain actors and develop potato value chain
- ✓ Analyze marketing costs and margins across market channels.
- ✓ Identify the determinants of potato quantity supplied to the market
- ✓ Identify the constraints and opportunities faced by potato value chain actors

Methodology

Description of study area

The study was conducted in a selected highland part of Guji Zone, Southern Ethiopia. The area is located at a distance of 385 km from Addis Ababa, capital city of Ethiopia. Geographically, the area is situated between 5° 57'23"-6° 26'52"-N latitudes and 38° 25'51"-38° 56'21"-E longitudes. Most of the earth surface of the study area has an undulating land surface with an elevation ranging from 1,450-2,900 meters above sea level. It has the annual rainfall of 1,250 mm and the annual temperature ranges from 15-24 ^{o}C. The study area also characterized by two agro climatic zones, namely humid which starts in early April up to October and sub humid which starts late November up to the beginning of March. The major soils of the area are Nitosols (red basaltic soils) and Orphic Acrosols. The two soils are found on the highland areas, and they are red brown and black brown in colors and on sloping topography and their utilization are good under natural vegetation. The farmers of this area produce cereals such as wheat, barley and maize, pulses such as faba bean and field pea, tubers like Irish Potato and others such as high land fruits and vegetables.

Data

The data used in this study were obtained via a cross-sectional survey of rural households. A random sampling procedure was followed to select rural households in consultation with district agricultural officers. First, districts in the highland parts of Guji Zone were selected purposely because the area was advantageous in producing and marketing potato. Secondly, since the production of the crop is evenly distributed over the selected area, simple random sampling were used to select producers. Therefore, Producers were selected from each segment of the value chain using simple random sampling due to the area is potential in producing potato and each and every household were expected to cultivate the crop. Thus, based on the CSA (2018) the total population of producing the crop of 14547 household farmers, 141 household farmers where selected using Yamane sample size determination

formula at 0.085 margin of which is in the ranges of 4-8% acceptable margin for sample size determination of normally distributed population (Yamane, 1967). Determined as:

$$n = \frac{N}{1+N(e)^2} = \frac{114547}{1+0.085^2} \approx 141 \quad (1)$$

Where: n= Sample size, N= Population size which was 4547 and e = is margin of error. Based on the above formula a total of 141 households were interviewed in the study area.

Moreover, six wholesalers, two rural collectors and 16 retailers were selected purposively.

Methods of Data analysis

Data obtained from various sources were analyzed using Descriptive and inferential statistics. The qualitative data were described by frequency tables whereas quantitative data were analyzed using summary statistics of descriptive statistics. Data gathered using direct observation; focus group discussion and key informants will be transcribed using qualitatively narrating. From inferential statistics hypothesis testing and estimating parameters using econometric model of multiple regression were employed in quantifying factors affecting potato market supply.

The value chain was visualized the chain actors, identify roles and linkage among the actors. Potato market performance of the area was examined by analyzing market cost and price margins among different potato value chain actors in order to measures the degree of potato marketing efficiency. The marketing margin is the difference between prices at different levels in marketing system whereas total marketing margin is different between what a consumer pays for potato per quintal and what producers or farmers receives for the produce. (Mendoza, 1995).

$$\text{TGMM} = \frac{\text{final consumer price} - \text{farmer price}}{\text{final consumer price}} \quad (2)$$

Where, TGMM is Total Gross Marketing Margin. It is useful to introduce here the idea of producer participation, farmer's portion or producer's gross margin (GMM) which is the portion of the price paid by the end consumer that belongs to the farmer as a producer. The producer's margin or share in the consumer price (GMMp) is calculated as:

$$\text{GMMp} = \frac{\text{consumer price} - \text{TGMM}}{\text{consumer price}} = 1 - \text{TGMM} \quad (3)$$

The consumer price share or portion of market intermediaries is calculated as:-

$$\text{MM} = \frac{\text{selling price} - \text{buying price}}{\text{consumer price}} * 100 \quad (4)$$

Where MM is Marketing Margin in percentage

Net marketing margin (NMM**)** is the percentage over the final price earned by the intermediaries as their net income after their marketing costs are deducted. Thus, the net marketing margin is calculated as:

$$\text{NMM} = \frac{\text{GMM}-\text{marketing cost}}{\text{consumer price}} * 100 \quad (5)$$

Econometric Model

Finally, **m**ultiple linear regression models were used to analyze determinants of potato supply. Multiple linear regression models are employed to estimate the determinants of continuous dependent variables and two or more continuous or categorical independent variables. This model is also selected for its simplicity and practical applicability (Woodridge, 2002). Based on literatures, Econometric model specification of supply function is defined as:

$$y_i = \alpha + x_i\beta_i + \varepsilon_i \quad (6)$$

Where is ε_i distributed as $\varepsilon_i \sim N(0, 1)$

X_i is a vector of explanatory variables hypothesized to affect farmers' potato market supply,

β_i is a vectors of parameters to be estimated which measures the effects of explanatory variables on the farmers decision of potato market supply and

ε_i is random error normally distributed with mean zero and constant variance.

Result and Discussions

Descriptive Statistics Demographics and Socioeconomics Characteristics of Households

The variables used to describe demographic characteristics of sample farmers were sex, educational level, marital status, age, and family size. The results depicts that 90.78% male whereas 9.23 % were female headed households (Table 2). The results of the study also indicated that 17.73% of the respondents were not participated neither in formal nor informal education. Whereas 46.81% of respondent household heads were attended grade one to eight (8). The result also revealed that around 96.45% of the respondents in the were married.

Age is one of the important characteristics of the community. It reflects on the productivity of the population as it has a bearing on the overall health situation within the community. In developing countries, aged members are more prone to diseases and thus are less productive (Mossie *et al*..2020)). The survey data indicates that the mean age of the respondent was 32.2 within the range of MAX and MIN which is in working force range. Moreover, the family size of the respondents ranges between Max and Min with the mean of the average of 8 family members (table 2).

Table 2 Demographic and Socio-economic characteristics of Respondents

Variable	Description	N N = 141	Percent N = 141
Sex	Male	128	90.78
	Female	13	9.23
Educational level	No –education	25	17.73
	8th grade or less	65	46.81
	9th to 10th grade	34	24.11
	11th to 12th grade	9	3.38
	Diploma and above	10	7.1
Marital status	Married	136	96.45
	Unmarried	4	2.84
	Widowed	1	0.71
Descriptive variables	Max	Min	Mean
Age		32.2 (11.6)	-
Family size		8 (4.1)	-
Distance from market center hour		33.83 (22.28)	-
Distance of from main road in hour		20.53 (20.37)	-
Potato production experience	Mean	4 (3.87)	-
Farm size in hectare	Mean	3 (2.41)	-

The average market distance ranges from Min to max with the average travelling hour is about 34 minutes in study area. The result also revealed that information collected from sample respondents of about 4 years of potato production experience with average farm size of 3 hectare land holding. Generally from this result it can be observed that age respondent is fall in active labor farce range expected to positively affect the potato production. Likewise, the distance travelled to nearest market and distance from main road is 34 and 20 minutes which initiate the producers in accessing markt information and tranisporting bulky agricultural product they produce especially horticultural crops like potato.

Access to services

The most important services that were in practices to promote production and marketing of potato in the study area include access to credit, access to extension service, and access to market information.

Access to extension services: Extension service in agriculture is indispensable to assist farmers in improvement of production and productivity. In addition, access to agricultural extension services helps to facilitate dissemination and adoption of improved technologies and ensure the local availability of these technologies for many smallholders (Gobie *et al*. 2019).

The key informant discussions pointed out that some development agents have no time to deliver technical advice to farmers sufficiently. The result indicated that only 50.4% of respondent farmers have access to agricultural extension services (Table 2).

Access to credit: The availability of financial sources for credit is crucial for farmers to purchase important input for agricultural activities. The study results show that 94% % of respondents have not access to credit in the study area (Table 3). According to information obtained from FDG, limited access and fear of interest rate are the major bottle neck to access credit services. The major source of credit local money lenders and microfinance. Particularly, Oromia Credit and Saving share company provide credit to farmers on group collateral though farmers were not happy due to fear of credit area sharing if a member fail to pay.

Access to market information: Access to agricultural markets and marketing information are essential factors in promoting competitive markets and improving agricultural sector development. A well-organized market intelligence information system helps all the producers and traders freely interact with one another in arriving at reasonable prices. From the study, friends or neighboring farmers are the major source of market information from which about 96% of the respondents access market information.

Table 3. Household's access to service for potato production and marketing

Service Type	Total (N=141)		
		N	Percentage (%)
Extension service	Yes	71	50.4
	No	70	49.6
Credit service	Yes	9	6
	No	132	94
Market information	Yes	135	96
	No	6	4

Input utilization

Inputs used by farmers of the study area are Seed, fertilizer, herbicides and pesticides. These inputs are supplied to farmers either by District Agricultural office, cooperative/unions, private traders or local markets.

The value chain map of potato in both district was similar and presented in Figure 1, the two potato value chain actors were identified namely direct actors those are input suppliers, producers, traders, consumers and indirect actors were those that provide financial or non-financial support services, such as government offices, research institutions, credit agencies, business service providers, union and cooperatives.

Use of improved seed varieties with its appropriate recommendation is believed to improve production and productivity of potato crop and its market supply in the study area. The major suppliers of seed for the study area were district agricultural office and union or cooperatives are two primary agents to supply improved seed to the area. The result revealed that 88.65% of the respondents have used improved potato seed where the available improved seeds were Guidane and Belete varieties.

The survey result indicated that around 98 of sample respondents applied fertilizers for production of potato in the study area (Table 3).

The result revealed that major respondent were not used farm chemicals especially where Gudane potato variety was highly attacked by disease like early blight and late blight and Belete is highly attacked by bacterial wilt as Kebede and Korji (2017). As it can be observed from the result, the potato production in the study area was not practiced with its full package which may due low performance of extension service (Table 4). The major problem of not using input especially farm chemicals for potato protection in the study area in controlling early blight and late blight is there are no supplies of these chemicals in the study area as raised by sample respondents. Out of the total interviewed households 98% were used inorganic fertilizer of DAP and UREA (Table 4). About 22% of farmers used chemical for controlling potato diseases in the study area indicating all most no chemical controlling is experienced (Table 4).

Table 4 Input usage of sample Respondents

Input	Measurement	Total (N=141)	
		Frequency	Percentage (%)
	Yes	125	88.65
Improved Seed	No	16	11.35
Fertilizer	Yes	138	98
	No	3	2
Chemicals	Yes	31	22
	No	110	78

Analysis of Potato Value Chain

Value chain actors

The value chain actors can be categorized as main value chain actors, directly involved in the value chain, and supporters, support the value chain. The main value chain actors include input Suppliers, Producers, Collectors, Wholesalers, Retailers and Consumers. Similarly, value chain supporters include District Agricultural Offices, Trade and Transport Office, Primary Farmers' Cooperatives, Bore research center, Private Transporters and NGOs.

Main value chain actors

Input Suppliers: Primary multipurpose farmers' cooperatives, Union, district agricultural office and local trader are major suppliers of seed, fertilizer, and other agrochemicals (Table 4). Potato farmers also participated in preparing their own inputs and to fellow farmers. In the study area, farmers use inorganic fertilizer, DAP and UREA, which has been supplied by cooperatives and agricultural office (Table 5).

Table 5 Major input Suppliers

Input	Source of inputs	Total (N = 141)	
		N	Percentage (%)
Improved Seed	Agriculture Office	40	28.4
	Local Market	15	10.6
	Research Center	10	7.1
	Cooperatives	45	31.9
	NGOs	2	1.4
	Fellow farmers	29	20.6
Fertilizer	Agriculture Office	84	59.6
	Local traders	23	16.3
	Union	29	20.6
agrochemicals (Pesticides and Herbicides)	Agriculture Office	3	2.1
	Local Market	25	17.7
	Cooperatives	2	1.4
Labor	Family labor	93	66
	Hired labor	17	12
	Labor Exchange	14	10
	Cooperation	17	12

A larger proportion of farmers were purchased seed from cooperatives (28%) or cooperatives (31%) from market (Table 5). This contradicts with the finding of Kassa that the most common seed sources were producers themselves (Kassa, 2014).

Producers: Smallholders are the major potato producers in the study area with 3 hectare average land holding. In the study area, the average production was 279 quintal per hectare Kebede and Korji (2017) which is more than double of the national average, 136.85 quintal per hectare, (CSA, 2015). In the study area, potato production is dominated by rain fed production practices.

In the study area, producers sold their produce at any available market options dominantly nearest village market. Most dominantly, collectors, wholesalers, retailers and consumers (including individual households, hotels and restaurants) are the major buyer.

Collectors: Collectors are found in village markets. During peak harvest seasons, July to - August, they assemble potato from farmers either at farm gate or from nearest market. They also retail seed potato (supply input) to farmers, April to May. These collectors communicate with wholesalers and asses the demand for the product before going to purchase. They do not store the collected potato for more than 3 days because of the fear of weight loss due to product perishability. Some collectors receive payment in advance from wholesalers and assemble the product. In the study area, it is common that the collectors negotiate with farmers to purchase potato at farmers' field and use hired daily laborers to harvest a product. They use horse/donkey carts for transporting the product from farm gate to their work place (storage house) and use human back in the area not accessible for carts and horse transportation.

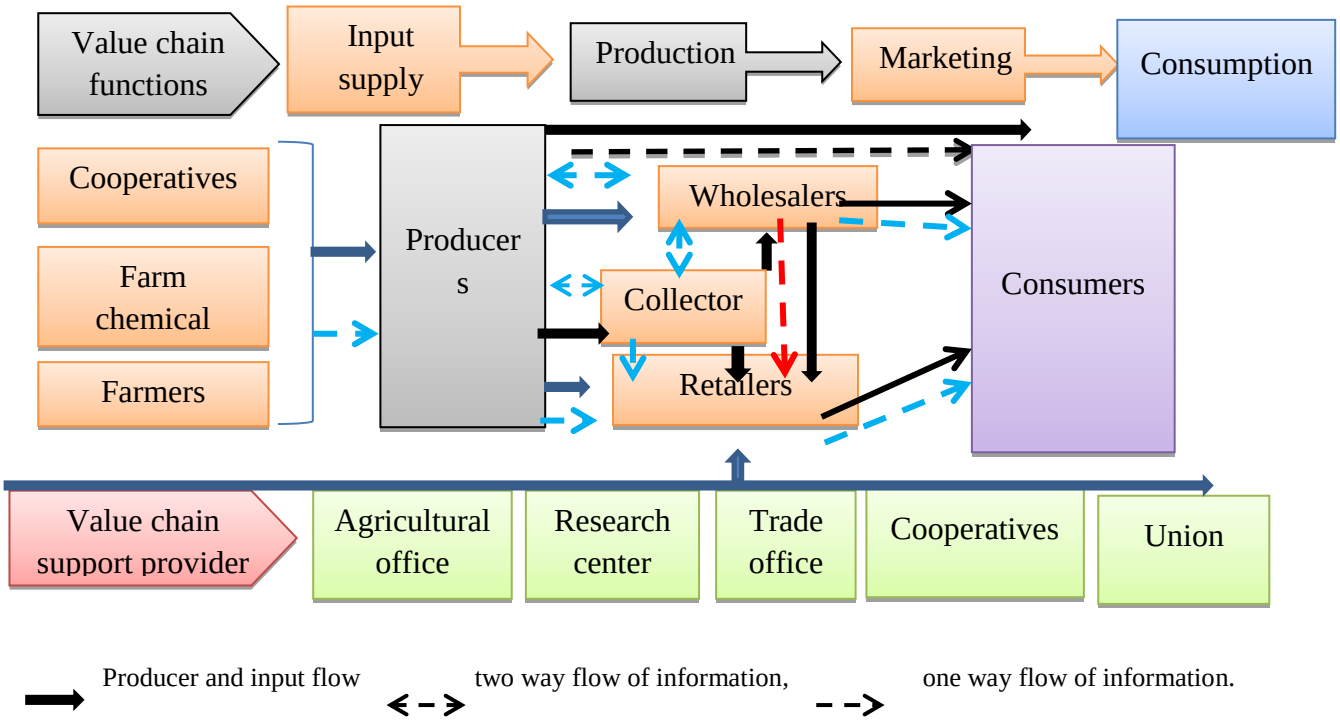
Wholesalers: They handle large volume than other value chain actors. Most dominantly, they have been purchasing from collectors and producers to resell to wholesalers, retailers and/or consumers. Wholesalers at local market were selling potato through cell phone communication with traders in different cities in the zone and Sidama regional state.

Retailers: There were considerable number of retailers who traded potato with other vegetables like onion, tomato, cabbage, green pepper, and other vegetables. Retailers purchased potato mainly from wholesalers, producers, and collectors for reselling to consumers (including individual households, hotels, cafes, restaurants, and road vendors).

Consumers: Consumers are found in both rural and urban areas include individual households, institutions, hotels, café, and restaurants. They purchased potato from retailers, farmers, and wholesalers.

Value chain support

The major value chain supporter includes different governmental and non-governmental organizations. Among the major, District Agricultural Offices, Trade and Transport Office, Primary Farmers' Cooperatives, Bore research center, Private Transporters and NGOs are value chain supporters identified in the study area. However, some service providers multiple functions along the value chain. Particularly, Agricultural offices provided agricultural extension services, field monitoring, advicers services on potato cultivation and agronomic management, organizing and providing trainings. Similarly, multi-purpose primary cooperatives have also a responsibilities and duties on supplying different agricultural inputs and purchase farmers produce. But the information from the study showed that these multi-purpose primary cooperative were only supplying fertilizers, both DAP and Urea either on cash or on credit to potato producer farmers



Analysis of Potato market Chains

Six marketing channels were identified for potato market chain in the study area through which 5897 quintal of potato flow during study season. Accordingly, a channel of Farmers → Wholesalers → Retailers→ consumers is the largest in which was about 31% of the product passed through (channel III) and followed by a channel of Farmers →Retailers → Consumers in which 26.13% of the product passed through it (channel IV) in the study area (figure 1).

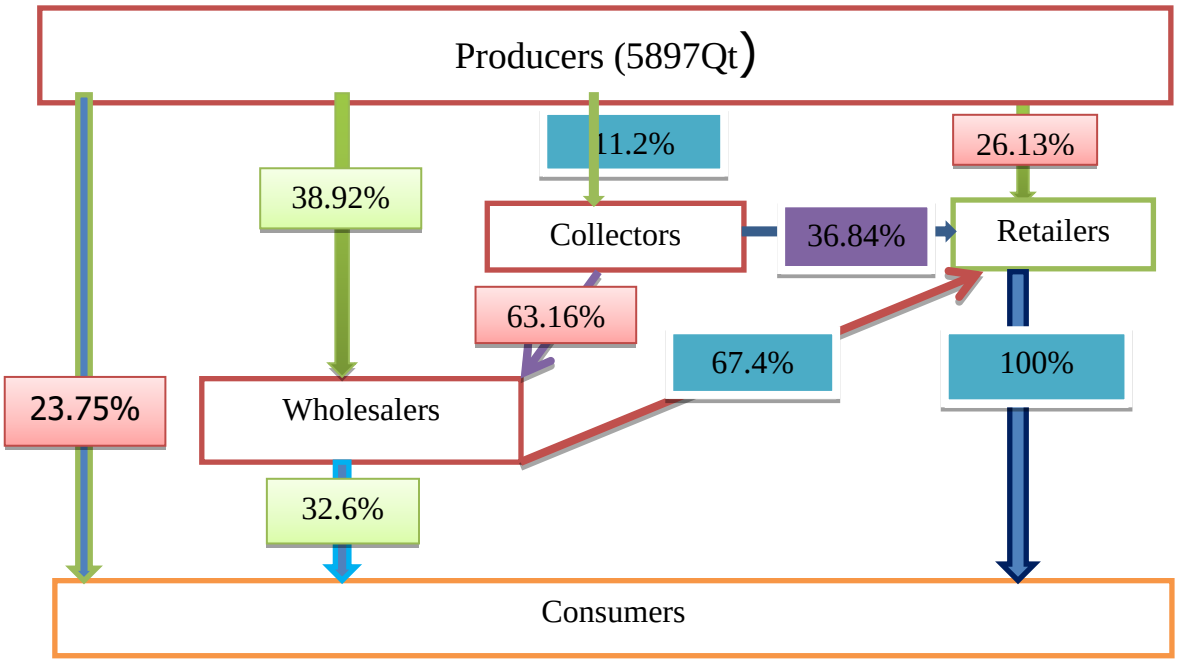


Fig 1 Potato Marketing Chanel chain map of study area

Channel I. Farmers ⟶ Consumers (23.75%)
Chanel II. Farmers ⟶Wholesalers ⟶ Consumers (14.99%)
Channel III. Farmers ⟶Wholesalers ⟶Retailers ⟶Consumers (30.99%)
C**hannel IV**. Farmers ⟶ Retailers ⟶ Consumers (26.13%)
Channel V. Farmers ⟶Collectors ⟶ Wholesalers ⟶Retailers ⟶Consumers (7.07%)
Channel VI. Farmers ⟶ Collectors ⟶Retailers ⟶Consumers (4.13%)
Farmers sold about 38.92% of their potato to wholesalers, 26.13% Retailers, 11.2% to collectors and 23.75% to consumers.

Marketing Performance

Marketing margin is one of the commonly used measures of the performance of a marketing system. It is defined as the difference between the price paid by consumers and the price rcieved by producers. . Computing the total gross marketing margin (TGMM) is always related to the final price or the price paid by the end consumer, expressed in percentage (Mendoza, 1995).
Gross marketing margin (GMM) is the gap between prices at consecutive levels in the marketing channel. Therefore for this study the marketing margins were computed based on the data collected of value chain actors.
In Table 9 Market margin of market actors
Table 6: Marketing margin (Birr/kg)

Channels	GMMP	GMMr	GMMc	GMMw	TGMM
I	100	-	-	-	0.00
II	74.2	-	-	0.258	25.8
III	67.45	0.0675	-	0.1905	32.55
IV	79.4	0.206	-	-	20.6
V	54.44	0.198	0.079	0.1786	45.56
VI	73.46	0.1984	0.067	-	26.54

Total gross marketing margin is the highest in channel V, 45.56%. Without considering channel I, which farmers sell directly to consumers, producers gross marketing margin is the highest in channel IV which is 79.4%.

Profitability of potato production in the study areas

In conducting profitability analysis of potato production, market prices for purchased inputs and output were considered. For inputs like family labor, exchange labor, own animal draft power, own land, and other inputs which the households use in potato production without paying direct cost, computed based the opportunity costs were used. Prices differ per marketing channel, per quantity sold, over the season, and even can vary during one single day. Therefore, weighted average price was used in analyzing profitability of potato production and marketing for the market chain actor.

Table 7. Profitability analysis of potato producer sample farm households

Input cost Items	Average Cost	
	Birr/Qt	Production cost (%)
Labor cost	58.70	15.5
Seed cost	137.03	36.27
Land rent	57.32	15.17
Fertilizer cost	109.81	29.1
Oxen cost	12.80	3.4
Pesticide cost	2.15	0.57
Total cost	**377.81**	
Marketing cost		
Packing material	9.60	
Loading and unloading	6.60	
Transportation	19.50	
Broker	6.20	
Sell tax	0.18	
Other cost	20.40	
Loss	0	
Total marking cost	**52.88**	
Overall total cost	**430.69**	
Selling price	850	
Net return	**419.31**	

Qt = quintal, % = percentage, other cost implies opportunity costs
Source: Own survey result, 2021

The average production cost of potato was 377.81 Birr/ Qt from which seed accounts for 36.27% of the total production cost This result coincide with others' study conducted in Tigray where the largest input cost was seed in production of potato (Bezabih and Mengistu, 2011). The average selling price was 850 Birr/Qt and net return of farmers from potato production was estimated at 419.31 Birr/Qt, which is 49.33% their selling price.. The study result was higher as compared with potato value chain analysis in Banja district of Gonder zone. The study found that the producer's net profit was 27.33% of selling price and 37.7% of total cost Melkamu *et al*. (2020). However, this variation could be arise from types of market agency where farmers were selling and land allocation affected vegetables production profitability (Masuku and Xaba, 2013).

Among market actors, retailers in general get highest net return, 17.88% of purchase,per quintal than other value chain actors followed by wholesalers. However, this does not mean that retailers are generating more income in general than other actors due to their management of small quantity in the maket. This finding is also in line other finding where retailers earn the highest marketing margin from all other vegetable traders in East Shoa, Ethiopia (Dawit and Fitsum, 2016). Generally, Wholesaler generates highest income from all other actors due to their administration of large volume of the product.

Table 8 Cost, Marketing margin and profit margin of value chain actors

Cost items	Producers	Collectors	Wholesalers	Retailers	Total
Production cost	**329.425**	-	-	-	-
Purchasing price	-	850	950	1010	2810
Labor for packing	-	0	1.25	1.5	2.75
Loading and unloading	-	10	20	18.25	48.25
Transport	-	0	40	26	66
Packing material	-	10	10.5	13.2	33.7
Sorting	-	15	0	3	18
Telephone	-	12.5	56.25	19	87.75
Storage	-	15	0	-	15
Marketing cost	123.17	62.5	128	81.2	394.87
Total cost	452.6	62.5	128	81.2	724.3
Total cost (%)	54.5	7.52	15.4	9.8	100
Sale price	850	975	1175	1260	4260
Marketing Margin	520.6	125	225	250	1120.6
Share (%)	46.46	11.15	20.08	22.31	100
Profit margin	**397.43**	**62.5**	**97**	**168.8**	944.23
Share (%)	42.09	6.62	10.27	17.88	100

Source: Own computation from survey result, 2021

Econometrics Model Results

Several variables were hypothesized to influence the volume of market supply of potato by sampled farmers. The results for all VIF values were ranges between 1.12 and 2.01. Hence, multicollinearity was not a serious problem among the variables used for constructing the model.

The regression model has also no problem of heteroscedasticity which proves that all the explanatory variables were included for the model can be used to analysis determinants of market supply of potato. Similarly, the model has no the problem of endogeneity (Appendix table 1 and 2). Generally, Moreover, the overall goodness of fit of the regression model, was measured by the coefficient of determination, R^2 . R^2Values of the model was 0.91 which shows that what proportion of the variation in the dependent variable is explained by the explanatory variable. Hence this result indicates that about 91% of the variation in marketed supply of potato was attributed to the hypothesized variables in the study area. There are 6 continuous and 15 dummy independent variables of which 9 variables significantly affect the market supply of potato (table 9).

Table 9 Results for factors influencing volume of potato supplied to market in Bore and Ana Sora districts

Volume	Coefficient	Std. Err.	Tcal	P>t
Sex	-1.192	3.720	-0.32	0.749
Age	0.162	0.075	2.16	0.034**
Education level	1.101	1.673	0.66	0.512
Marital Status	0.491	1.777	0.28	0.783
Market Distance	-0.077	0.047	-1.65	0.103
Cooperative member	6.096	2.712	2.25	0.027**
Family Size	0.131	0.205	0.64	0.525
Land owned	-0.505	0.569	-0.89	0.376
Transport facility	-1.799	2.025	-0.89	0.377
Potato production Experience	0.451	0.265	1.7	0.092*
Production amount	0.783	0.051	15.39	0.000***
Amount Consumed	-1.055	0.352	-2.99	0.004***
Information access	4.491	2.574	1.74	0.085*
Off farm income	3.524	1.713	2.06	0.043**
Credit access	10.821	4.099	2.64	0.01**
Total Livestock Unit (TLU)	0.183	0.210	0.87	0.385
Constant	-6.697	9.550	-0.7	0.485

(N = 141, F (15, 87) = 108.5, Prob >F = 0.000, R^2 =91.04, RMSE = 9.163) *, **, *** is significant at 10 %, 5% and 1% respectively

Age of household head: as expected age of household head significantly and positively affected potato market supply at 5% significance level. The result identified that one-year increase in age of households increase the quantity of the potato supplied to market by 0.162 quintal keeping all other factors constant. It implies that aged farmers (age should be within the working years) share greater experience of deciding to share land for producing the potato and supply to market. The result is in line with Mossie *et al*. (2020) that identified the direct the relationship between age of farmers and market supply.

Membership to any Cooperatives: Membership in any cooperative determines farm household's potato market supply. As hypothesized the coefficients for this variable is positively and significantly related with volume of suppliers at 5% significance level. This result indicated that those households who were members of cooperatives supply increased by 6.096 than No-members. This is mostly related to the reality that member of multipurpose cooperatives have access to better market and information than nonmembers.

Potato production experience: The potato production experience of households affect potato market supply positively and significantly at 1% significance level. The model result implied that as production experience increase by one year (within the working age), the quantity of potato supplied to the market increases by 0.451 keeping others factors constant. This means that the potato producers with more experience in potato production supplied more 45.1 quintal to market than less experienced due to their having more knowledge in potato management and marketing network. This result is in line with finding of Samuel (2014) and Bestalot (2012) who illustrated the positive relationship between beekeeping experience and volume of honey supplied to the market.

Potato Production (Output): The quantity of potato production has a positive and statistically significant relationship with quantity of potato market supplied. the result indicates that an increase in production in a one unit, the potato supply increases market supply of potato by 0.451 in the study area (Table 9). This finding is congruent with Yimer (2015) report of potato production output positively and significantly influenced the extent of market participation.

Information access: The finding also described that access to market information is positive and significantly affect the quantity of potato supplied to the market. This indicating that producers who has access to market information will increase their supply to market by 4.491 quintals than those who have no market information in bore district (Table 9). This shows that access to market information like where to sell, how to sell, when to sell and price information plays a pivotal role in deciding the amount of potato supplied to the market. This finding is similar with findings of Muhammed (2011), Abraham (2013) and Nuri (2016) declaring that access to market information increases marketed supply of agricultural products.

Access to credit: Farmers' access to credit as hypothesized significantly and positively affected the quantity of a potato supplied to market at 1% significance level. It indicates that farmers with access to credit service supply 10.821 quintal of potato than who did not access. The research finding of Jaji *et al*. (2018), Faris *et al*. (2018), Sharma (2016) and Gobie *et al*. (2019) are in line with the result of this study. Similarly, Bradbear (2003) reported that in poor societies, lack of credit is a major constraint to everyone concerned with selling and buying of honey.

Constraints and Opportunities in Potato Value Chain

Even though potato is widely grown and marketed for a long time in the study area, farmers face many constraints. In the study area, shortage of improved seed, disease, credit availability, pesticides, shortage of fertilizer, insect, pests, product perishability, low linkage with lower value chain actors,

lower price, lack of market information, low consumer demand and collective marketing were some of the Problems existing at farmers in potato value chain.

Limited access to inputs: The most important physical inputs for potato production are improved seeds, fertilizers and pesticide or herbicides. Farmers replied that limited access and supply of inputs like improved seed are among their production problem due to absence of potato seed multiplying and distributing enterprise. Most dominantly, farmers get inputs from informal seed system through private traders and otherwise they should prepare their own seeds locally. As farmers reported that supply of improved seed, fertilizer and pesticides shortage accounts 80.9% as a problem in the locality.

Diseases and pests: Even though disease and pest are not a sever problem, diseases (12.1%) and pests (0.7%) were reported as a production problem. According to key informant interview with agricultural experts, bacterial wilt, late blight diseases and insects were among the problems prevalent in the area. It is possible to control late blight disease by using chemicals but bacterial wilt is becoming a major limiting factor for potato production in all seasons. The expertise reported that the main causes of widespread of disease in the area were improper potato farm management practices and lack of crop rotation (table 10).

Table 10 Potato production and marketing constraints

Constraints	N	Percentage
Production constraints		
Lack of Improved varieties	104	73.8
Insect and pests	1	.7
Disease	17	12.1
Lack of Credit	9	6.4
poor supply of fertilizer	4	2.8
Lack Pesticides	6	4.3
Marketing Constraints		
Lack of Market information	15	10.6
Market distance	3	2.1
Low price	38	27.0
Low consumer demand	20	14.2
Transportation facility	2	1.4
Brokers	8	5.7
Poor linkage of with actors	39	27.7
Low quality of product	3	2.1
Storage	13	9.2

Source: Own survey result, 2021

Postharvest and marketing problems: The use of traditional harvesting tools, poor product handling, perishability and lack of proper storage facility are among postharvest problems. Similarly, lower price, poor linkage, absence of formal marketing information and far market distance are among the market problems occurred in potato marketing. Poor linkage among value chain actors (27.7%) and lower price (27%) were the main problem of farmers in the study area (Table 8). Potato selling and buying process is mainly undertaken at farm gate and pricing is usually estimated mostly at farm field before harvested. Storing potato is almost not practiced in the study area As a result, farmers have been hardly benefited because a majority of farmers do not wait for good price due to lack of appropriate storage.

Moreover, poor product handling absence of storage facility, lack of credit availability, price fluctuation, poor sectorial support and inadequate market information were the common problems

which have been raised by traders. Traders reported absence of proper storage facility and product perishability as the main problems in potato trading which cause price fluctuation and lower price. About 37.5 % of the traders reported that low quality of potato product as their main problem in the area..

However, suitable agro-ecology, presence of experienced and interested farmers, , the existence of non-governmental and governmental support to the kebele level, are playing great role in improving farmers livelihoods regarding potato production. On the other hand, availability of market demand throughout the year, growing number of buyers, high experience in potato production and marketing were some of the opportunities of potato. Potato also consumed by both rural and urban societies across in all income groups taken as a good opportunity.

Table 11. Potato marketing constraints of traders

Constraints	N	Percentage
Lack of Credit	6	25.0
Low Price	3	12.5
Lack of demand	1	4.2
Inadequate information	2	8.3
Quality problem	9	37.5
Absence of government support	1	4.2

Source: Own survey result, 2020

Conclusion and Recommendations

In the study area potato is the most important and widely known cash crop mainly produced for the market. This study focused on identifying potato market chain actors, channels and factors that affect the volume of potato marketed in the study area.

The primary data were collected from 141 randomly selected potato producers, 24 traders and 13 consumers. The survey result indicated that on average 6568 quintals of potato produced by sample smallholder farmers from which 89.8% was supplied to the market. The most important market actors of along potato value chain are producers, wholesalers, retailer, rural collectors and consumers. The product has been distributed through six marketing channels where channel III (Farmers-Wholesalers-Retailers-Consumers) share 31% of the product flow. Moreover, the Multiple linear regression models indicated that Age of producers, potato production experience, potato yield, amount of potato consumed, cooperative membership, access to market information, off farm income and credit access were important variables that determine amount potato supply to a market.

Recommendations

To improve the value chain of potato in the study area, it is important to work on promoting and encouraging the production and dissemination of quality seed since the area is suitable for seed and ware potato production. Furthermore, strengthening experienced farmers in producing potato through provision of training on proper farm management and postharvest handling. Additionally empowering farmers to be a member of primary cooperatives and strengthening them financially and technically that can supply inputs for increasing potato production and boast its market supply for common transport; exchange of marketing information and bargaining position of farmers. Finally encouraging farmers to have off farm income and providing credit access especiall at early production crop for availing agricultural inputs

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Appendix

Appendix table 1 multicollinearity test result

Variable	VIF	1/VIF
Sex	2.01	0.497691
Age	1.91	0.524484
Education level	1.83	0.545899
Marital status	1.56	0.642011
Market distance	1.54	0.647762
Cooperative Member	1.52	0.655953
Family size	1.46	0.684863
Land owned	1.45	0.687506
Transport facility	1.44	0.695726
Potato production experience	1.39	0.717234
Production amount	1.36	0.737217
Amount consumed	1.24	0.806029
Information acess	1.21	0.827252
Off farm income	1.20	0.831098
Credit access	1.16	0.863557
Total Livestock Unit	1.12	0.894379
Mean VIF	1.46	

Appendix table 2 test results of Heteroscedasticity and omitted variables

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
Ho: Constant variance
Variables fitted: Volume of potato market supply
Chi square (1) = 8.71
Prob > Chi square = 0.0032
Ramsey RESET test for omitted variables
Ramsey RESET test using powers of the fitted values of volume of potato market supply
Ho: model has no omitted variables
F(3, 119) = 7.48
Prob > F = 0.0001

Assessment of Poultry Production and Marketing System in Jimma Bunno Bedelle and Ilu Abba Bora Zone

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Abstract

The study was conducted to assess poultry Production and Marketing System in Jimma, Bunno Bedelle and Ilubabor Zones.A total 138 households were randomly selected for the study. There were three chicken production systems in the study area; scavenging with seasonal feed supplementation (78%), scavenging with regular feed supplementation (18%) and intensive (4%).The average chicken size per household was 17.13. The purposes of chickenproduction were; selling for cash income (44%), both consumption and income generation (38%), for hatching (14%) and home consumption (4%) accordingly. The average number of eggs laid/clutch was 12.67 for local breed 23.8 for exotic breed, and the number of total clutch periods/hen/year was 3.82. The most important constraints of poultry production in the study villages were disease outbreak and predators were the first and second main constraints that devastating chicken productivity in the study areas. Attention should be given for the disease prevention and predators to improve production and productivity poultry in study area.The chickens share the same room with the family house shows focus should be given on housing system for making separate shelter for better poultry production system. Generally, there are factors, including chicken management practices on housing, feed and feeding and market need improvement, which makes differences in chickens' production and marketing situation in the study area, which suggests that there is an opportunity to improve poultry production and marketing in the future.

Keywords: **Poultry Production, scavenging, marketing, production constraints**

Introduction

In Ethiopia, chicken production is a mainstay of animal agriculture, where human food production is comparatively fast, initial capital investment is low, and uses are often made by using available household labor. The sector shows a clear distinction between traditional, low-input systems and improved production systems using relatively advanced technology, on the other hand. In the outdated system of chick production, greater than 90% of the national poultry, egg and meat output is from local poultry (Chaimiso 2018).Poultry production, as an essential sector of agricultural production, has a significant contribution to the world, which is evident from the recent increase in demand for poultry, meat, and eggs in fast-growing urban cities and, therefore, the increasing number of economic poultry farms around urban and peri-urban areas (Nkukwana 2018).

The country also possesses about 60% of the entire chicken population of the East Africa subcontinent (Chaimiso 2018). The poultry population, on the other hand, was estimated to be 42 million based on the (Hiluf et al. 2018) census, excluding pastoral and agro-pastoral areas. Furthermore, the entire chicken population of Ethiopia is estimated at about 42 million, which comprises 0.55%, 2.84%, and 96.61% of the entire poultry were hybrid and exotic indigenous, respectively. Ethiopia is one of the few countries with a significantly large population of chickens, which is expected to be about 56.5 million chickens, out of which 99% are local chickens. In Ethiopia, chicken production is a mainstay of animal agriculture, where human food production is comparatively fast, initial capital investment is low, and uses are often made by using available household labor. The sector shows a clear distinction between

traditional, low-input systems and improved production systems using relatively advanced technology, on the other hand. In the outdated system of chick production, greater than 90% of the national poultry, egg and meat output is from local poultry (Chaimiso 2018). In Ethiopia, chicken added significant socio-economic impacts on food security, generating income, and religious and other purposes (Gulilat et al. 2021). Poultry production in Ethiopia has a significant role in the country's economy representing 98.5% and 99.2%, respectively, of chicken egg and meat production.

Poultry production is an important activity in terms of income generation, job creation, food security, and animal source protein particularly for low-income countries where most of the population do not afford to buy other sources of livestock meat. As chicken has fast proliferation and growth rate, it is a potential agri-food source to respond to the fast-growing population of developing countries like Ethiopia. Besides, chicken meat is high in protein content, rich in vitamins and minerals, and has considerable health benefits such as causing weight loss, helping the control of blood pressure, reduced cancer risk and cholesterol (Mitchell, 2016).The 68.46 % of annual meat productions are produced by poultry and the egg productions are contributed by Indigenous chicken, hybrid and exotic breed with an average annual output of 85,918,543, 16,137,806 and 34,707,761 of egg production, respectively (CSA, 2017/18).

Many researchers believe that chicken production is crucial to poverty alleviation in rural low-income societies and the demand for more chick eggs and meat in the future is clear in developing countries due to the increasing human population and the expected increase in income. This needs the supply of those products in adequate amounts to satisfy the protein needs of several populations in developing countries (Rajkumar et al. 2019). Thus, for those with capital to finance, feed, housing, and health inputs, the resulting output could be profitable. However, it is estimated that the commercial sector comprises only 1–2% of the nation's chickens in Ethiopia (Gebremariam and Girma 2019). In Ethiopia, the bulk of poultry raised is indigenous ecotypes, which display a large difference in body position, comb type, plumage color, and productivity (Belay et al. 2018).

Rural small-scale farmers use indigenous chickens under poor management practices in poultry production, and the output from this outdated production sector is low compared to the contribution of exotic and hybrid chicken populations (Hinsermu et al.2018). In the study area, the poultry population expected to be high due to the favorable ecological conditions. However Poultry production and management practice characterized by extensive poultry production system and the production and productivity of village chicken is low because of different reasons. The objective of this paper was to review poultry production, management and Marketing system so as to identify the bottlenecks of this sector in the mandate areas.

Objectives

- To determine village chicken management, production performance and marketing systems in the study area
- To assess the existing opportunities and challenges in the study area

Methodology

Types and Sources Data

This research used both primary and secondary data sources. Primary data was collected from sample respondents, focus group discussion, field observation, and key informant interviews. Secondary data were gathered from all available published and unpublished documents, records and research reports of offices and other relevant stakeholders in relation to the objectives of the study.

Methods of Sampling

Multi-stage sampling procedure (purposive & random) was applied for the study; hence, the study area was divided in to three agro-ecologies based on altitude as; highland, mid-altitude and lowland. Therefore a total of six representative districts were selected from three zones. Then representative kebele were selected from each districts, about 6-9 households were purposively selected after asking consent for participation to the survey for interview. Thus, 138 poultry producer farmers were interviewed during survey. Agro ecology representation and chicken production potential was the main criterion considered in the selection of study sites.

Method of Data Analysis

The qualitative and quantitative data sets were analyzed using appropriate statistical analysis software STATA and Excel. The data were analyzed through simple descriptive statistics like average, frequency and percentage and presented in form of tabulation.

Results and Discussions

Socio-economic and demographic characteristics

Socio-economic and demographic characteristics of the respondents were presented in Table 1. From the total interviewed village chicken owners in the study areas; (73 %) male and (27%) were females. The major management activities pertinent to poultry production are the responsibility of women. The average age of the respondents was; 44.3 years in Shabe, 43.6 years in Omo Nada, 40.2 years in Bedelle, 38.5 years in Chora, 37.7 years in Bure, and. 38.5years in Gechi districts.

Regarding education level of respondents; 23% were illiterate, 20% had basic education (reading and writing), 42% primary education and 15% secondary education & above. The high number of primary education and illiteracy might influence negatively the perception of village chicken technology transfer.

The average family size of the study area was 4.68 which is a little bit higher than the national average of average of 4.6 persons (CSA, 2011)

Table 1: Demographic characteristics of respondent and Socio-economic status of poultry producers

Parameters	Study Area(woredas)						Average
	Shabe sombo	Omo Nada	Bedele	Chora	Bure	Gechi	
Age of the respondents	44.3	43.6	40.2	38.5	37.7	41.3	41.2
Family size/HH	4.11	5.68	4	4.77	4.95	4.47	4.68
Sex							
Male	22	24	14	14	12	15	101(73%)
Female	5	1	4	8	11	8	37(27%)
Marital status of house							
married	23	25	17	17	23	18	123(89%)
single				3		2	5(4%)
divorced	1			1		1	3(2%)
widow	3		1	1		2	7(5%)
Educational background							
Illiterate	6	3	2	6	7	8	32(23%)
Read & write	10	10	2	2	1	2	27(20%)
Primary education	8	11	10	10	10	9	58(42%)
Secondary education and above	3	1	4	4	5	4	21(15%)
Average Livestock holding/in **TLU**	2.9	4.8	4.7	4.7	3.9	3.6	4.1
Average land size(in ha)	1.4	1.21	1.53	1.7	1.33	2.06	1.1

Livestock is the basic physical asset for rural households as a means of production and used for smoothing consumption during any shocks. As a result, livestock is an important component of the farming system in the study area. The result indicated that the average livestock ownership of the households was 4.1 in TLU. The land size of the respondents was on average 1.1 hectares.

Chicken Production System

Production and reproduction performance of chickens were evaluated under existing management conditions at farmer's level. The survey result indicate that chicken free range scavenging system is used by farmers with minimum/limited input; however there is a wide range of management systems.
The most dominant chicken production systems in the study area was the back yard or subsistence extensive systems (78%) that are based on the local indigenous chickens and scavenging with occasional and seasonal supplementary feeding of homegrown grains and household food refusals (Table 2**).** The findings of the present study slightly higher than with (Abera and Hussein, 2016) indicated that 70% chicken production system in the study area is a free range or extensive type.

The major management activities pertinent to poultry production are the responsibility of women. There was separate simple overnight shelter made locally available material. The back yard chicken production system in the study area also characterized by high chick mortality caused by disease, and predators. The birds find their feed by scavenging among the houses in the village, and in addition, they might get leftovers from the harvest and from the kitchen with some supplements of homegrown grains.

Table 2. Chicken production system in the study areas

No	Production System	Frequency	Percent
1	Scavenging with seasonal supplementation	107	78%
2	Semi scavenging with regular supplementation	25	18%
3	Intensive	6	4%
	Total	138	100%

The other chicken production systems identified in the districts were (18%) of the respondent farmers, practice Semi scavenging with supplementation type of chicken management using fences around their homestead. However, about 4 % of the respondents rear their chickens in intensive system of poultry production system.

Flock Size and Breed composition

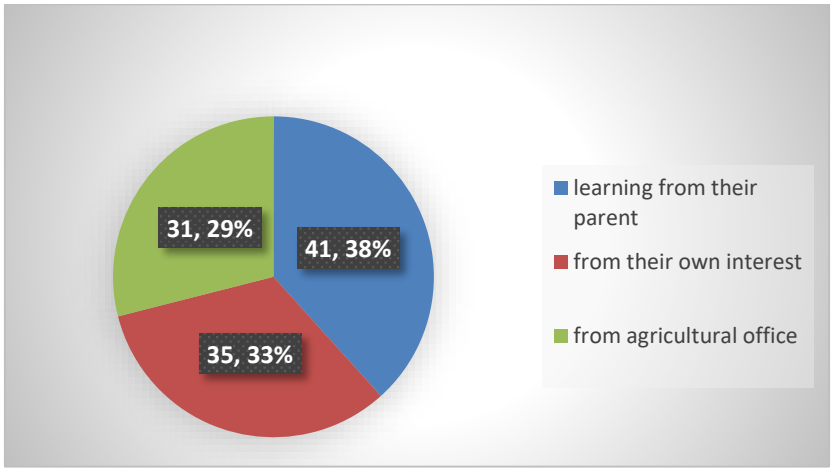
The average flock size of respondent in the study area was about 8.35chickens per household for local chicken, 7.63 exotic breed and 3.15 cross breed chickens per household respectively. Nearly similar to this study, Ahmedin (2014) was reported the mean flock size of 17.7 local chicken per household in Goro Gutu district, Eastern Hararghe, Ethiopia.

Table 3 . Breed composition and flock size

No	**Types of Breed**	**Average Number of Chicken in Each Study Areas**	**Percentage (%)**
1	Local breed	8.35	43%
2	Exotic breed	7.63	39%
3	Cross breed	3.15	18%
	Total	17.13	100%

How the farmers in the study area start of chicken production

The results of the study showed that (38%) of the respondents have start chicken production system got experience from their parents. However,(33%) of the respondent farmers practice chicken production from their own interest. In the same manner 29% of the respondents start chicken production system where get from agricultural office.



Purpose of Chicken Production in the Study Areas

The most important reasons for keeping chickens and producing eggs were primarily as source of income. According to this study about 44% of the respondents, keeping chickens and producing eggs for income generation. This indicated that the extensive backyard poultry production in the study area is mainly used to generate cash income.

Table 5. Purpose of chicken rearing and eggs production

No	Purpose	Frequency	Percent
1	For income generation	61	44%
2	For both consumption and income generation	52	38%
3	For Hatching (broodiness purpose)	19	14%
4	Only Home Consumption	6	4%

Reproduction and Productivity of Chicken

Age of cock at first mating: - indicated that the overall average age of cock at first mating. The average age at first mating of local and exotic cockerels in the study area was 5.5 months and 4.1 months, respectively.

Table 6. Reproductive performance of the poultry based on history data obtained from the study area

No	Reproductive performance of the poultry		
	Parameters	local	Exotic
		Mean ±SD	Mean ±SD
1	Age of cock at first mating months	5.5±0.27	4.1±0.45
2	Age at first laying months	6.33±1.12	5.85±0.81
3	Average number of clutches per year	3.82±0.63	_
4	Average number of eggs per clutch	12.67±2.19	_

Age at first egg laying: - Productivity of birds mainly depends on the production and management system followed in managing the chicken. Productivity of chicken can be compared in relation to the production system of the chickens. In the present study according to the information obtained from the respondents, the average age at first egg of local and exotic pullets was 6.33 months and 5.85 months.

Average number of clutch per year; Egg production based on the producer farmers response ,the overall average numbers of clutches per year in this study was 3.82 for local breed (Table 6).However, higher mean number 4.6 of clutches per year was reported by (Mengesha et al., 2008).

Average number of eggs per clutch; the overall average egg production per hen per clutch was 12.67 eggs for local breed. Similar research by Mekonen (2007) but higher average egg production per clutch reported for local breed hen 14.9.

Hen Broody Management

In the traditional backyard poultry production system, by its very nature hens are responsible for the new flocks. Likewise in the study area, it is common to see hens with their follower chicks. In the study area, almost all of the respondent (97.4%) use natural incubation. Natural incubation is the most commonly used method for replacing and increasing the size of flocks. A bird has to be broody after

laying eggs so that it would incubate, hatch the eggs and raise their young chicks. Local hens are good sitters and show a good mothering ability. The ability to hatch their own eggs together with high hatchability makes the local chickens appropriate for the prevailing farming system.

Table 7. Method of brooding

No	Method of Brooding	Frequency	Percentage
1	Traditional	114	97.4%
2	Modern	3	2.6%
	Total	117	100%

Housing System of Village Chickens

The housing systems of village chickens presented in table 11. According to this study majority farmers were housed their chickens in Separate shelter in the same room (41%). Also about (34%) housing systems of the study area was Separate shelter. The rest 15% and 9% respondents were used different shelter in the same room with the families and kitchen respectively.

Table11: Housing system of village chickens

No	**Housing system**	**frequency**	**Percentage (%)**
1	Separate shelter in the same room	57	41%
2	Separate shelter	47	34%
3	Share the room with perch	21	15%
4	Kitchen	13	9%
	Total	138	100%

Marketing system of chicken and products

There is no formal poultry and poultry product marketing channel in the in the study area and informal marketing of live birds and eggs involving open markets are common throughout the Woreda. The farmers directly sell their chicken to consumers and/or to small retail (traders) who take them to large urban centers. Live chickens and eggs are sold either at the farm gate, small village market (primary market), or at the larger Woreda market (Secondary market in the town).

Table 8. Chicken and egg marketing

Chicken and Eggs marketing systems	Marketable products			
	Chicken sale		Egg sale	
Sell chicken (HH)	frequency	%	frequency	%
yes	119	86%	107	78%
no	19	14%	31	22%
Place of selling chicken	frequency	%		
at farm/market gate	11	8%	23	28%
at local market	68	49%	43	53%
at regular market	30	22%	15	19%
Both local and regular market	29	21%	38	-
To whom you sell Chicken and Eggs	Chicken sale		Egg sale	
	frequency	%	frequency	%
To individuals	70	58%	64	38%
To both individuals and traders	45	37%	42	57%
To hotel	6	5%	6	5%

Based on the information obtained from the respondents, most of the households in the study area were sold their chickens through local market (49%), regular market (22%) and both local and regular market (21%) respectively and rest chickens sold at farm get/. On the other hand, most of the households in the study area were sold their eggs through local market (53%) , farm gate (28%) and at regular market (19%) respectively. Accordingly, it was found that about 58% of all transactions reported were local farmers selling their chickens to individuals' consumers whereas 37% of the transactions involved local farmers selling their chickens to both individuals' consumers and traders. Also About 5% transactions involved local farmers selling their chickens to hotels.

Table 9. Marketing characteristics of the studied area

No	Characteristics	Frequency	%
1	Price information	110	100%
	From neighbors	10	9%
	From market visit	59	54%
	Both neighbors and market visit	41	37%
2	Mode of transport	121	100%
	by human power	49	40%
	using vehicles	19	16%
	Both human power and vehicles	53	44%

Based on the information obtained from the respondents, most of the households in the study area were (80%) have information about the price of a chicken and eggs before they went to markets. About (54%) of respondents get price information from market visit. On the other hand about (37%) get price information both neighbors and market visit. The rest of respondent (9%) get price information from neighbors

Price of chickens and egg in study area.

Majority of farmers reported that there was no problem in selling chicken & eggs in the village. The respondents' estimation of chicken price during ordinary and holidays presented in Table 9. Variations in poultry prices are not only influenced by age of chickens and sex but also by during ordinary time and holidays. Farmers get better prices for both egg and live birds during holiday markets.

Table 10. Average selling price of chicken and eggs

Woredas	Average Selling Price of Chicken and Eggs							
	matured male/cock		matured female		grower/pallet		price of eggs	
	During holiday	during ordinary	During holiday	during ordinary	During holiday	during ordinary	During holiday	during ordinary
Bedele	285	239	197	166	125	112	3.45	3.25
Bure	345	301	218	199	156	135	4.15	3.75
Chora	311	237.5	215	195.8	144	131	3.8	3.34
Gechi	310.5	225	204	174.6	152	137.5	3.5	3
Omo nada	264	214	155	108	90.6	60	3.3	3
Shabe sombo	333	296	206	178	135	121.5	3.6	3.15
Overall average	309	249	198	170	134	116	3.63	3.25

The lowest price was observed in July while the highest price level was recorded in mid September. The lowest price level in July is closely associated with the incidence of poultry diseases. During this period supply of chickens to the market increases as the farmers strive to avoid risk of disease. The poultry price starts peaking up in early September and reaches its maximum in mid-September. The price rise coincides with the large demand for chickens during the Ethiopian New Year and Meskel holidays. The second price rise is in November and April this coincides with the Christmas festival and Easter holyday. According to the above table **t**he overall average price of adult cock, hen and young chicken were reached 309, 198 and 137 respectively during holyday in study areas. On the other hand, price of adult cock, hen and young chicken during regular time sold at birr 249, 170 and 116 respectively. The average price of egg was reached 3.63 birr during holyday period and sold at 3.25 birr during regular time, so the producers were earn good price during festival or holyday time.

According to this study, comparatively higher prices for adult cock, hen and young chicken birr 345/301, 218/199 and 156/135 per birds were given in Bure woreda during holyday as well as during regular time respectively. On the other hand, comparatively lower prices for adult cock, hen and young chicken birr 264/214, 155/108 and 90.6/60 per birds were given in Omo nada woreda during holyday and during regular time respectively.

Major constraints/challenges and opportunities of village chicken production

Major constraints/challenges of village chicken production

From the result of the this study the major constraints of poultry production in the study area were Disease, predators, skill gap, shortage feed, lack of proper housing, poor breed type, lack of marketing

access in the order of rank. The major constraints of village chicken production were partly due to poor management of the chicken (prevailing diseases and predators, lack of proper health care, poor feeding and poor marketing information (Hunduma *et al.*, 2010).

Diseases

The major causes of death for village poultry production were commonly disease. High incidence of chicken diseases is the major and economically important constraint for village chicken production system (Fisseha *et al.*, 2010*).* Mortality of village chicken due to disease outbreak is higher during rainy season, (Serkalem *et al.*, 2005).Poultry diseases were the major and economically important constraint of family chicken production in the study region. Based on Chaimiso (2018) it is reported as a disease (mainly New Castle Disease, locally referred to as 'Sombe/Fengil') and predator cause death for village chickens in the valley of Oromia, Ethiopia.

Predators

The other major constraints (shown in Table: 8) were those related with predators particularly eagles, cats, *lotu, iya,* dogs, monkey since under extensive system of management and mainly during scavenging birds became vulnerable to predator, particularly chicks and growers. The chicken production system in the rural area of the study woredas was predominantly scavenging feed resource. Most of the time village chickens scavenge under trees and field crops. All of these are full of risk to the chicken. The result is in line with the finding of Hunduma et al., 2010, that Predators such as birds of prey (locally known as "*Culullee"),* cats as well as dogs and wild animals respectively in decreasing order were identified as the major causes of village poultry in rift valley of Oromia, Ethiopia. Predators (snakes, rats, dogs, cats, and foxes) caused losses, especially in young birds, within the southern neighborhood of Ethiopia (Bekele and Shigute 2019a). Similarly, Tadesse (Sonnino 2017) reported wild birds (eagles, hawks, etc.) and wild cats (locally referred to as 'Shelemetmat') as dangerous predators in the southern part of Ethiopia.
On the other hand, major constraints of chicken production among poultry producers under an intensive system collectively were lack of knowledge to prepare mixed feed, disease and predators control, improved housing and Shortage of clean water, lack of improved feed the other problems in the study area.

Table 12. Major constraints of poultry producers.

No	Constraints	1st	2nd	3rd	4th	5th	6th	7th	Index	Rank
1	Disease	83	38	8					0.162	1st
2	Predators	23	63	11	22	9			0.161	2nd
3	Skill gap	13	5	35	15	21	25	9	0.155	3rd
4	Feed and water shortage	4	13	34	34	12	18	6	0.152	4th
5	Lack of proper housing	1	-	12	11	30	10	37	0.127	5th
6	Poor breed type	2	-	6	14	9	53	14	0.123	6th
7	Lack of marketing access	1	-	12	11	9	10	53	0.121	7th

Feed and water shortage

In Ethiopia, village chicken production systems are usually kept under free-range system and the major proportion of the feed is obtained through scavenging. The major components of Scavenging Feed Resource Base (SFRB) are believed to be insects, worms, seeds and plant materials, with very small amounts of grain and table leftover supplements from the household. According to this study poultry feed and water, shortage was one of the most critical constraints to poultry production in study areas. There is no purposeful feeding of chickens under the village conditions in study area and scavenging is almost the only source of diet. Scavenging feed resource base for local birds are inadequate and variable depending on season. According to Hunduma *et al*., (2010) feed shortage mostly occurs from June to August time of the year for village poultry as it is not harvesting season of cereal crops. Availability, quality, and price of feed ingredients are the main constraints on poultry production, no matter the system of production and geographical location. The main constraints on chicken production are poor nutrition and health problems. Poultry production is similarly inhibited by reduced contact with goods, markets, and services, poor institution commitment, and absence of skills knowledge (Ahiwe et al.2018)

Lack of proper housing

Proper housing does not only provide an environment that moderates environmental impact but also provides adequate ventilation for the birds to lay eggs in next boxes, as well as to feed and sleep in comfort and for security purposes (Yakubu 2010). Overnight housing, perched in trees or on roofs and overnight housing within the main house are the common patterns of housing prevailing in the study area. Lack of housing is one of the constraints of the poultry production systems in study area.

Poor breed type

Lack of productive breeds: The result of the survey revealed that the productive performance of local chicken breeds in the study areas was relatively low when compared to improved breeds. Farmers complained that efforts to improve the genetic potential of local birds by distributing cockerels, pullets, and fertile eggs from exotic birds had negative consequences, such as reducing hens' brooding ability, reducing adaptation to low-input feeding systems, and jeopardizing the village chicken population's genetic base. Because exotic poultry breeds are assumed to be insipid by the local genetic stock, the indigenous poultry genomic resources in Northwest Ethiopia are in grave danger due to the high rate of genetic erosion caused by the widespread and random dispersal of exotic poultry breeds by both governmental and nongovernmental organizations. Different reports show that (Tadesse 2015b) animal genetic resources in developing countries are largely being eroded through the quick alteration of the agricultural system, during which the most common cause of the loss of indigenous animal genetic resources is the indiscriminate importing of exotic genetic resources.

Lack of marketing access

The result of the survey revealed that the lack of marketing access ranked 7th in the study area. According to Fisseha et al. [2007] the marketing of chicken and egg in Ethiopia is constrained by poor management, low supply (output) due to disease and predation, seasonal fluctuation in prices, presence of only few/limited market outlets, lack of price information, and marketing activities. Lack of organized marketing system and the seasonal fluctuation of price are the main constraints of the poultry market in study area. The market price was fluctuating with cultural and religious festivals, dry season of the year and when disease outbreaks.

Opportunities of poultry production

Village poultry production also avail ample opportunities compared to other alternative investments in rural areas, particularly it requires less labor, less capital management in which rural

communities have comparative advantage and technical skills. Growing markets for poultry: driven by urbanization, population growth, expansion of catering services and various public institutions, income increases and lifestyle changes of population segments.

Sound agro-ecology: In the study area, the poultry population expected to be high due to the favorable ecological conditions. Integrated production and chickens provides opportunities for increase in protein production and income for smallholder farmers. They can also be transported with ease to different areas and are relatively affordable and consumed by the rural people as compared with other farm animals such as cattle and small ruminants. In some communities, village chickens are important as starter of livelihood improvement.

Poultry production contributes significant role to food security, poverty alleviation especially for the poorer members of the community by diversifying agricultural production including increased distribution of resources through involvement of women and ecologically sound management of natural resources.

Conclusion

Poultry production is one of income generation system and widely practiced by farmers in study area. It is practiced by every farmers as sideline with other farming activities and offer farmers with further income. It also used as starting point for young to establish business idea. The result of current study indicated that local chicken ecotype were dominant for the existing production system. As observed in this study chicken production in study area was hindered due to poor management like health care, predators, skill gap, feed shortage and lack of improved breed among the major constraint in study area. Chicken management practices on feed and feeding need improvement. This factor has direct impact in productivity and decreasing the direct benefit of the farmers. Scavenging with occasional and seasonal supplementary feeding of homegrown grains and household scrubs (food refusals) is identified feed and feeding system in the study area.

Therefore, appropriate intervention in chicken disease and predator control activities, breed improvement strategies, providing awareness about management of poultry production by training to farmers focusing on disease prevention, improved housing, feeding and watering of chicken for the farmers are recommended to improve productivity of chicken in the study area. Seasonality in prices of chicken products, lack of market outlets, lack of appropriate marketing information and lack of demand during fasting periods were the major chicken and egg marketing constraint of the study areas.

Recommendation

There is a strong need for appropriate intervention in diseases and predator control activities to reduce chicken mortality and improve the productivity of village poultry of the study woredas. The producers should provide adequate quality and quantity of feeds in regular manner for better production performance of chickens. Provision of proper trainings to chicken producers on modern husbandry practices could be important to improve the awareness of village chicken producers.

To improve existing housing system, research centers, agricultural office and producers should work in collaborating way to increase independent poultry house construction. Improvement of housing system (mainly use of hay-boxes for brooding) could reduce risk of loss of chicken flock by predators. Poultry breeding systems of the study area should be improved to ensure the contribution of the sector in the development of the country.

It is suggested that chicken and egg marketing of village chicken producers can be improved through development of market information system at farmer's level and strengthening of agricultural extension services, through trainings and advisory services. Government should strengthen poultry extension and education to develop communities 'awareness towards poultry contribution.

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Assessing the Impacts of Productive Safety Net Programme on Smallholder Farmers Expenditure in West Hararghe Zone, Oromia National Regional State, Ethiopia

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Abstract

Productive Safety Net Program is implementing smoothing consumption and protecting asset depletion in the study areas. Thus, the purpose of this study were to assess the impact of productive safety net program on smallholder farmer's expenditure and analyze factors affecting participation of smallholder farmers in productive safety net program in the study area. For this study both primary and secondary data were used. Primary data were collected from 264 households (114 users and 150 non-users) and supported by secondary data. To address the aforementioned objectives descriptive statistics and econometric models (Propensity score matching (PSM) and Logit model) were employed. The econometric result of Logit model indicated that the likelihood of participating in the program was positively affected by age and marital status, while income obtained from farm, food aid and extension service accessibility was affected negatively the participation of household in PSNP. The PSM estimation results revealed that participation in PSNP had brought significant impact on household expenditures. Those households participated in PSNP in the study area uses the PSNP income mainly for home expenditure purpose. It can be recommended that policy makers should have to give attention in designing and implementing PSNP through giving care for youth age participants, strength extension services and availing fund timely.

Key words: Expenditure, Logit model, PSM, PSNP, Impact

Introduction

Ethiopia remains vulnerable to a range of shocks and stresses that could undermine the impressive progress made in poverty reduction. The country remains one of the world's most food insecure countries, with all key dimensions of food security indicators (Gashaw and Seid, 2018). For this, institutional capacity has developed in country to deal with the hazards of shocks (Ibid).

According to World Bank (2019) report, Ethiopia's poverty levels fell by around 20% between 2011 and 2016 although they remain high especially in the rural areas. In the country food production was lagged behind the population growth over the last three decades. In responses to food insecurity conventionally emergency food-based interventions have been practiced (Tadele, 2011). As a result in 2005, the government of Ethiopia and a group of collaborators implemented PSNP against food insecurity and economic shocks as a social protection program whose transfers expected to provide predictable and smooth consumption insurance (Gilligan *et al*., 2009).

The Productive Safety Net Program designed to the needy households with primary goals as smoothing consumption, protecting asset depletion in times of shocks and thereby encouraging asset accumulation of eligible households that live in chronically food insecure woredas, and creating community assets through public works (labor-intensive community-based activities) (MoARD, 2006). In PSNP a food-insecure people are employed in public work for five days a month during the agricultural slack season. They also intended to create valuable public goods as well as stimulate investments by reducing seasonal liquidity constraints (Andersson *et al*., 2009).

West Hararghe Zone is the zone in which a great number of chronically foods in-secured households are found. In all rural woredas of the zone there were chronically food in-secured households. All of

(450) *kebeles* found in the zone were food insecure as well within which safety net programme are functioning. From a total rural population of the zone estimated as 1,917,945 (male 979,828 and female 938,117) 411,716 (366,029 public work clients and 45,687 direct supports (those who do not have other means of support)) were safety net users (WHANRO, 2019).

Productive safety net program aiming of graduating the poor beneficiary by improving their incomes and escape from the food insecurity. According to Alemayehu *et al*. (2008), Productive Safety Net Program together with the Other Food Security Program, encouraged households to engage in production and investment, increased use of modern farming techniques and entry into nonfarm own business activities; PSNP participants are more likely to be food secure in relative to the control group. However, in study area as observed farmers supported by the program within the last five years were still the beneficiaries of the program. It may due to drought and low agricultural production aggravate year to year, farmers in the area are supporting by the program in continuous way. And the climate change effects, shortage of land and absence of strong income generating jobs results increasing the number of beneficiary from time to time.

Safety net program enables the smallholder farmers not to oversee their annual income generating activities/ farming practices in the study area. The beneficiary oversees the program as main options for their livelihoods despite devoting their time and labor on farming practices. It was creating dependence of farmers on the program. It brings an impact directly or indirectly on the community livelihoods. Therefore, the study designed to investigate in the zone on the impact of safety net on smallholder farmer's expenditure.

Objectives of the study

- To assess the impact of productive safety net program on smallholder farmer's expenditure in the zone.
- To analyze factors affecting participation of smallholder farmers in productive safety net program in the study area.

Methodology

Description of the Study Area

The study was conducted in the West Hararghe zone of Oromia National Regional State, Ethiopia. The Zone have a total of 17 Administrative Woredas (15 rural and 2 urban administrates). Data were collected from three districts namely Gemechis, Doba and Mieso. These districts were selected based on the PSNP potential users in the zone in which Doba (35,245) ranked first followed by Mieso (33,480) and Gemechis (29,180), respectively (WHANRO, 2019).

Gemechis district is one of the 15 districts of West Hararghe Zone located at 343 km South-east of Addis Ababa and 17 km from Chiro, the zonal capital town. The district is found from 1300 to 3400 meters above sea level. The district covers an area of 77,785 hectares. The district has 26.9% high land, 35.5% midland, and the rest 37.6% lowland. The district has bi-modal distribution in nature. The minimum and maximum annual rainfalls are 650 and 1200 mm with an average of 850 mm. The minimum and maximum temperature of 15°C and 30°C with the average temperature is 22°C. The district is the most densely populated district in the zone. The district has black, brown, and red soils are the three dominant soil types based on color constitute 55%, 25%, and 20% respectively. Agriculture is the mainstay of the community (GDANRO, 2019).

Doba district is found in West Hararghe Zone located at 382 km South-east of Addis Ababa and 57 km from Chiro, the zonal capital town. The district is bordered on the south by Chiro, on the west by Mieso, on the north by the Somali Region, on the east by the East Hararghe Zone and on the southeast by Tulo. The district is found from 1400 to 2500 meters above sea level. The district covers an area of

700.47 square kilometers. The district has 8 *kebeles* highland, 7 *kebeles* midland, and the rest 25 *kebeles* were lowland. The district has bi-modal distribution in nature. The minimum and maximum annual rainfalls are 550 mm and 800 mm. The minimum and maximum temperature of 18°C and 26°C is 22°C (DDANRO, 2019).

Mieso district is found in West Hararghe Zone located at 300 km East of Addis Ababa and 25 km from Chiro, the zonal capital town. The rail way from Addis to Dire Dawa passes through the district. The district is found from 900 to 1600 meters above sea level. The district covers an area of 142,683 hectares. Agro ecologically the district is classified as (lowland).The district is classified totally as lowland (Kola). The district has erratic nature and limit crop production rainfalls. It receives a bimodal rainfall where small rains occur between March and April while the main rains occur between July and September. The mean annual rainfall ranges from 400 to 900 mm with an average of 790 mm. The mean annual temperature ranges from 24°C to 28°C (MDANRO, 2019).

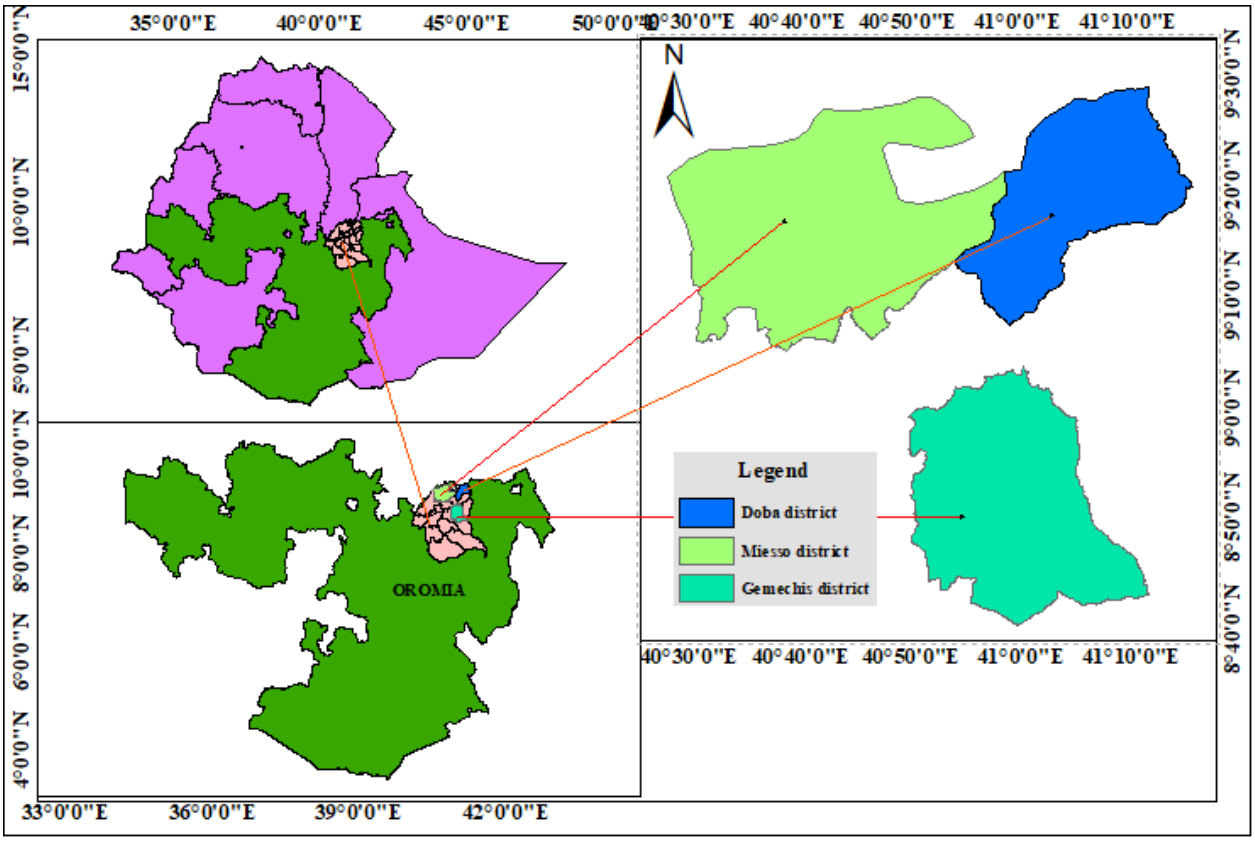

Figure 1: Map of the study area
Source: Own sketch from GIS data, 2021

Sampling Technique and Sample Size

A combination of purposive and random sampling technique was applied for this study. Firstly, three (3) districts were selected purposively based on high number of safety net beneficiaries. Secondly, out of high number of safety net user *kebeles* found in each district, 3 (three) *kebeles* were purposively selected from each district. Accordingly, a total of nine (9) *kebeles* were selected out of the three districts. Thirdly, representative sample households found in the selected *kebeles* were stratified into two (users and non-users). Finally, 264 sample households (114 users and 150 non-users) were randomly drawn from these strata based on probability proportional to size of the population in each stratum.

Table 1: Number of sample respondents

Districts	Kebeles	PSNP users	Percent	PSNP no-users	Percent
Doba	Ifa Aman	19	16.67	20	13.33
	Lenco Wadesa	26	22.81	33	22
	Baha Adu	8	7.02	11	7.33
Gemechis	Hida Dima	9	7.89	9	6
	Kuni Segariya	12	10.53	18	12
	Waltane	6	5.26	12	8
Mieso	Gulufa	10	8.77	11	7.33
	Harkonca	18	15.79	27	18
	Buri Mulu	6	5.26	9	6
Total		**114**	**100**	**150**	**100**

Source: Own computation, 2021

Data types, Source and Method of Collection

The study was used both primary and secondary data sources in collection of qualitative and quantitative data. Secondary data were collected from published and unpublished documents of the district and zone offices to support the primary data. The primary data was collected through focused group discussions and direct interviewing of the selected representative sample households by using semi-structured interview schedules and checklists. A total of 5 researchers were included to conduct survey. Prior to the administration of the questionnaire, awareness on the questions and about the objectives of the study were created for enumerators.

Method of Data Analysis

To answer the specific objectives of the research objectives both descriptive and econometric analyses were employed. The collected data was coded and entered into SPSS version 20 software for the data management and analyzed through STATA 15 software.

Descriptive Analysis

Descriptive statistics such as mean, standard deviation, frequency and percentage were employed to understand socio-economic situation and home expenditures of farmers. Qualitative data were also analyzed through description, discussion and narration. Garret score was calculated and used to provide overall ranking of major constraints of PSNP program participants.

Econometric Model

From econometric models propensity score matching (PSM) was used to analyze impact of PSNP on household home expenditures in the study area. The PSM technique enables us to extract from the sample of nonparticipating (non-users) households a set of matching households that look like the participating (users) households in all relevant pre intervention characteristics. In our study participation in PSNP is treatment and those participants are treatment groups while nonparticipant group members are counterfactual groups. This study attempts to estimate the average impact of treatment on treated (ATT). According to Bryson *et al*. (2002), ATT refers that mean impact of the program on individuals who actually participated.

Propensity Score Matching provides reliable estimates of program impact on smallholder farmers. In other words, propensity score expresses how likely a person is to select the treatment condition on a given observed covariates. This score is useful because match participants from treatment condition to participants from counterfactual condition who have a very similar estimated propensity

score creates a balance between treated and untreated participants. It also expected to create balance on covariates that used to estimate the propensity score. This balance property is a key aspect of propensity score method because a balanced pre-test covariate cannot be a confounder anymore, each that cannot bias the treatment effect estimate (Thoemmes, 2012).

According to Heckman and Todd (1998), the PSM model is specified as:

$$E(x) = P\ (D=1 \mid X) \qquad (2)$$

Where,

E(x) is the abbreviation for propensity score,

P is a probability,

D=1 a treatment indicator with values 0 for counterfactual and 1 for treatment, and

X is a set of observed covariates

While, logistic model was used to address the second objective (analyze factors affecting participation of smallholder farmers in productive safety net program) of the study. According to Lane *et al*., 2012 the logistic regression model was used to examine the quality of propensity scores. It used to determine the joint effect of different independent variables and to examine why some of the beneficiaries become food self-sufficient soon and others lag behind (Hayalu, 2014).

Results and Discussions

Results of the study were described using the STATA 15 computer program. It divided into two sections: descriptive statistics results and propensity score matching (PSM) results.

Descriptive Statistics Results

This section presents demographic and socio-economic characteristics of sample respondents in the study areas. Out of 264 total respondents utilized in this study, 114 were PSNP users and 150 PSNP non-users. According to FGD, PSNP in study area increased dependency and focus more on communal work while works of individual participants were ignored. As a result, most of PSNP user households in the study area are not reached their graduation from the program.

The major thematic areas of PSNP in the three districts (Gemechis, Doba and Mieso) were includes: soil and water conservation, soil structure (bund construction), cattle fattening, goat and milk trading, beekeeping, maintaining school, and construction of infrastructures (DA house, FTC and store).

Table 1 presents the result of the demographic socio-economic characteristics of participant and non-participant households. The result shows that statistically there was a significant difference between the two groups in terms of age, education status, household size, distance of market, and livestock owned. Compared to non-participants, PSNP participant households had smaller age, shorter distance, dependence ratio, off/non-farm income, farm income and owned fewer livestock size.

However, as compared to non-participants, PSNP participant households had larger in household size, amount of credit, and land owned. Among these three variables only household size was statistically significant at 1% significance level. In other words, amount of credit and land owned were similar in between the two groups (there was no significant difference); while there is a difference in participants and non-participants in household size.

Examining the demographic and socio-economic characteristics of sample respondents, we find that age and household size have negative and statistically significant effects on using PSNP. However, education levels, distance of market and livestock size have positive and statistically significant effects on using PSNP. Being users of PSNP is most responsive to age and household size. Livestock size owned has a positive contribution for households being out of PSNP users.

The sources of income for sample households come from both farm and off/non-farm income activities. Farm income consists of both incomes from sales of livestock and livestock products and sales of crops. Off/non-farm income sources are mainly from petty trade and daily works while hand craft in rare case. However, PSNP users' households derive income from public works participation which increases their off/non-farm income sources.

Table 1: Demographic and socio-economic characteristics of sample respondents (discrete and continuous variables)

Variables	**User (N=114)**		**No-user (N=150)**		**Total Mean**	**t-test**
	Mean	St. Dev	Mean	St. dev		
Age of household head	34.22	1.06	42.79	.86	37.92	-6.358***
Educational status (years of schooling)	3.01	.29	3.79	.28	3.45	1.914*
Household size (in number)	6.68	.22	5.86	.18	6.22	-2.959***
Distance of nearest market (walking hours)	1.27	.09	1.46	.08	1.38	1.667**
Amount of credit (number)	.12	.03	.09	.03	.11	-0.793
Dependency ratio (number)	111.84	9.17	124.30	7.10	118.92	1.092
Livestock owned (TLU)	1.97	.21	2.62	.16	.65	2.572**
Off/non-farm income (number)	1937.28	543.42	6011.47	2484.31	4252.16	1.410
Farm income (number)	11444.34	1247.15	20841.21	6309.64	16783.47	1.283
Land owned (timad)	4.45	.34	4.17	.26	4.29	-0.679

***, ** and * were significance level at 1%, 5% and 10% respectively.
Source: Survey result, 2021

Cattle, goats, donkeys and poultry are the main livestock reared by sample households in three districts. Few beehives (mostly traditional) are also reared in the study area. Table 1 reveals that there is a statistically significant difference in between the two groups (PSNP participants and non-participants). Land is an important means of agricultural production that plays a central role in producing crops and rearing livestock. But, in this study size of land owned is not statistically significant among the two groups.

Table 2 presents the results of chi-square for the dummy and categorical variable for the two groups (PSNP users and Non-users). Given the Pearson chi-square value are as expected have positive sign. Based on their values, food aid is the most important input, followed by marital status and accessibility of household to extension service.

According to Table 2, non-participating households had slightly higher percentage of male headed households and accessible to extension service as compared to PSNP participating households. Sex of household heads was statistically insignificant among PSNP users and non-users; while access to extension service was statistically significant at 5% significance level. In terms of marital status, both groups showed almost of households married and there is statistically significant difference in between the two groups at 5% significance level.

Table 2: Demographic and socio-economic characteristics of sample respondents (dummy and categorical variables)

Variables	Characteristic	User (%)	Non-user (%)	Overall %	Pearson chi^2
Sex of household head	Male	85.09	89.33	87.5	1.067
	Female	14.91	10.67	12.5	
Marital status of household head	Unmarried	.88	1.33	1.14	8.380**
	Married	92.11	98	95.45	
	Widowed	3.51	0	1.52	

	Divorced	3.51	.67	1.89	
Off/non-farm participation	Yes	20.18	26	23.48	1.223
	No	79.82	74	76.52	
Food aid	Yes	12.28	35.33	25.38	18.176***
	No	87.72	64.67	74.62	
Access to extension service	Yes	65.79	78	72.73	4.869**
	No	34.21	22	27.27	

***, ** and * were significance level at 1 %, 5% and 10% respectively.
Source: Survey result, 2021

Econometric Estimation Results

This section describes the econometric analysis results in the examination of the impact of productive safety net program on smallholder farmer's expenditure. This section explains the entire process to arrive at the impact of the program using propensity score matching model.

Before undertaking the economic estimation, different econometrics assumptions were tested using relevant techniques. First the presence of strong multicollinearity among the independent variables has been tested. According to the model result there is no serious multicollienraity among the variables (Mean VIF = 1.22 and less than two for each independent variables). There was no any explanatory variable dropped from the estimated model since no serious problems of multicollinearity were detected from the VIF. Secondly, to control the hetroscedasticity problem among the explanatory variable, instead of Bresch Pagan test (hettest), robust standard error calculation of logit model has been employed.

Propensity score matching (PSM) model was better over the Heckman's two stages model when there is no selectivity bias in the data set. The existence of selection bias occurred when mills lambda became significant. In this study, the mill's lambda was insignificant which indicated that there was no selectivity bias in the model (Mills lambda's coefficient was 190.811; P>z = 0.855). Hence, the Heckman two-stage model was found inappropriate for this data set.

Propensity score matching (PSM) model result

Propensity score matching (PSM) was applied to deal with the objective of assessing the impact of PSNP on household expenditures of the study. The matching process was performed for household expenditure.

Estimation of propensity scores

This part presents the results of the logistic regression model employed to estimate propensity scores for program participation of households. As specified earlier, participation of households in PSNP in this model is binary indicating whether the household was a participant in the PSNP which takes a value of 1 and 0 otherwise. STATA 15.1 computing software was used for the estimation purpose.

Table 3 shows the program participation estimation results of the logitic model. The pseudo-R 2 value of the estimated model result is 0.2233 which is fairly low. This low pseudo- R 2 value indicates that the allocation of the program has been fairly random (Pradhan and Rawlings, 2002). Therefore, the result suggests that treatment households do not have diverse characteristics overall and hence obtaining a good match between treatment and counterfactual households become easier.

Logistic regression was employed in order to see the larger extent variables contributor to the home expenditures of the households. The explanatory variables that were selected to measure its association with home expenditure were sex, age, marital status, level of education, distance of market, dependence

ratio, household size, off/non-farm participation and income, land owned, livestock owned (TLU), farm income, food aid and extension access. These variables were entered and processed to measure the relationship between those independent variables and the outcome variable.

As shown in Table 3, the estimated coefficient results indicate that participation in the PSNP was significantly influenced by five explanatory variables. The finding depicts among possible predictor variables stated age, marital status, farm income, access of food aid and credit access of households has significant effect on expenditure of households at 1% and 5% level of significance. Such strong positive relationship age and food aid in between participation in PSNP might be due to the fact that age increment is associated with higher house expenditures as well as availability of food aid has higher chance of being home expenditures as compared to small age households and those not accessible for food aid.

Households who are married and widowed had higher chance of being included in the program. This might be because respondents as being married it increase the members of family which increases home expenditures of households. In other word, being the household become divorced it leads a household more of aid dependence which increases the chance of participation in PSNP program. Households were selected to participate in PSNP program by kebele administration and the surrounding community in the study area.

Contrarily, access to extension contact and availability of food aid were found to have negative and significant effect on the program participation at 1% and 5% level of significances, respectively. This is due to household accessible to extension contact would decrease home expenditures using awareness created by DA on production. This suggests that rarely contacted households have lesser chance to be included in the program than more contacted households. Similarly, households accessible more for food aid have lesser chance of being participate in the program. As a result, more accessed household for extension contact and food aid probability of their inclusion in the program is low.

Table 3: Logit results of household program participation

Variables	**Coefficients**	**Std. Err.**	**Z**	**P>|z|**
Sex of household head	-0.0942	0.4634	-0.2	0.839
Age of household head	0.0717	0.0171	4.19***	0.000
Marital status of household head	1.4687	0.6118	2.4**	0.016
Education level	-0.0063	0.0500	-0.13	0.900
Distance from nearest market	-0.1393	0.1689	-0.82	0.410
Dependence ratio	0.0022	0.0019	1.16	0.247
Household size	0.1007	0.0798	1.26	0.207
Off/non-farm participation	0.1320	0.4309	0.31	0.759
Farm income	0.0000	0.0000	-0.93	0.355
Land owned	-0.0032	0.0517	-0.06	0.950
Livestock owned (TLU)	-0.0954	0.0899	-1.06	0.289
Farm income	0.0000	0.0000	-2.4**	0.016
Food aid	-1.3237	0.3941	-3.36***	0.001
Access extension services	-0.7280	0.3395	-2.14**	0.032
Constant	-5.1577	1.4767	-3.49***	0.000
Observation =264	LRchi2 (14)=80.63	**Prob>** chi2=0.000		
Log likelihood=-140.214	Pseudo R^2=0.2233			

***, **and * means significant at 1%, 5% and 10% probability levels, respectively.
Source: Survey result, 2021

Food aid was significant at 1 percent probability level. It has negative and significant relationship with expenditures of households. The negative relation indicates that households who have the access of food aid have low probability of expending expenditure.

Based on the above participation model the distribution of the propensity score for each household included in the treated and counterfactual groups was computed to identify the existence of a common support. Figure 1 depicts the distribution of the household with respect to the estimated propensity scores. The figure shows that most of the treatment user households were found in the right side and partly in the middle while most of non-user households are found in the left side of the distribution. It also reveals that there is no area in which the propensity score of the user and the non-user groups are similar.

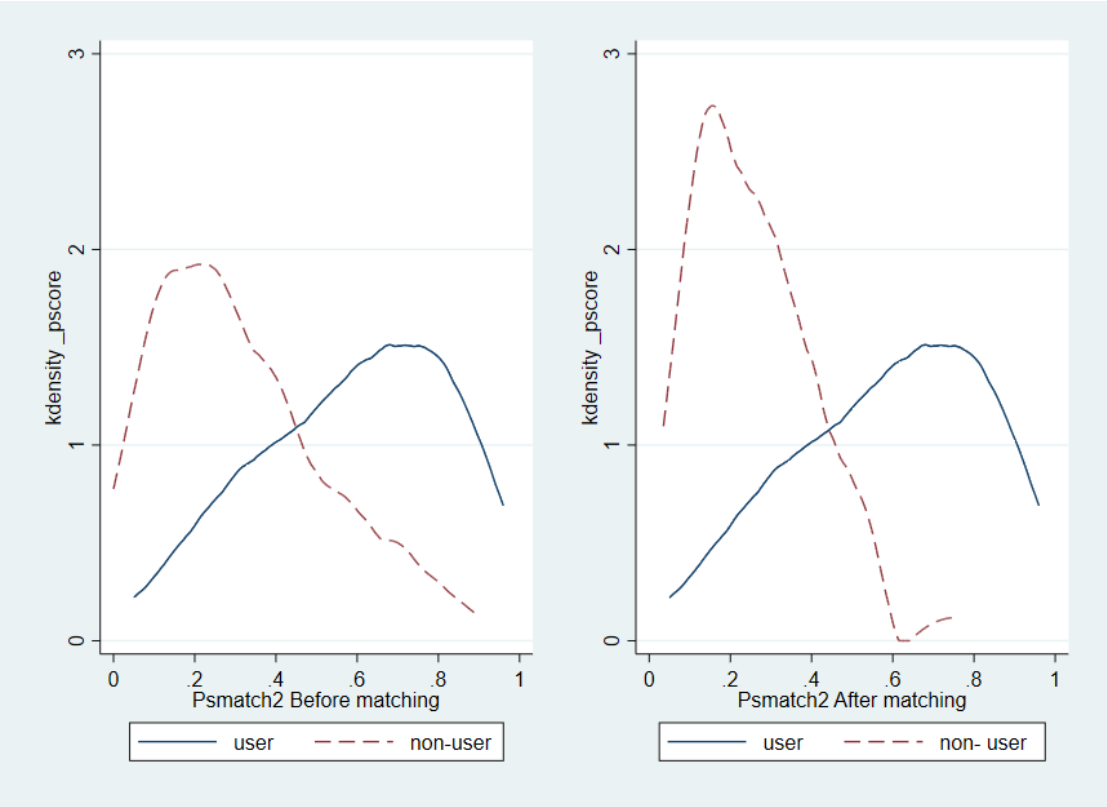

Figure 1: Kernel density of propensity score distribution

Matching program and non-program households

There are four important tasks that must be carried out before conducting the matching work itself. First, estimating the predicted values of program participation (propensity score) for all the sample households. Second, imposing a common support condition on the propensity score distributions of household with and without the program is another important task. Third, discarding observations whose predicted propensity scores fall outside the range of the common support region is the next work.

As shown in Table 4, the estimated propensity scores vary between 0.0565 and 0.9277 (mean = 0.553) for PSNP User households and between 0.0467 and 0.9595 (mean = 0.341) for non PSNP participant (control) households. The common support region would therefore, lie between 0.0565 and 0.9595 which means households whose estimated propensity scores are less than 0.0565 and larger than 0.9595 are not considered for the matching purpose.

Table 4: Distribution of estimated propensity scores

Groups	Obs.	Mean	STD	Min	Max
All households	264	0.451	0.247	0.0511	0.9704
User of PSNP	114	0.553	0.199	0.0565	0.9277
Non-user of PSNP	150	0.341	0.172	0.0467	0.9595

Source: Survey result, 2021

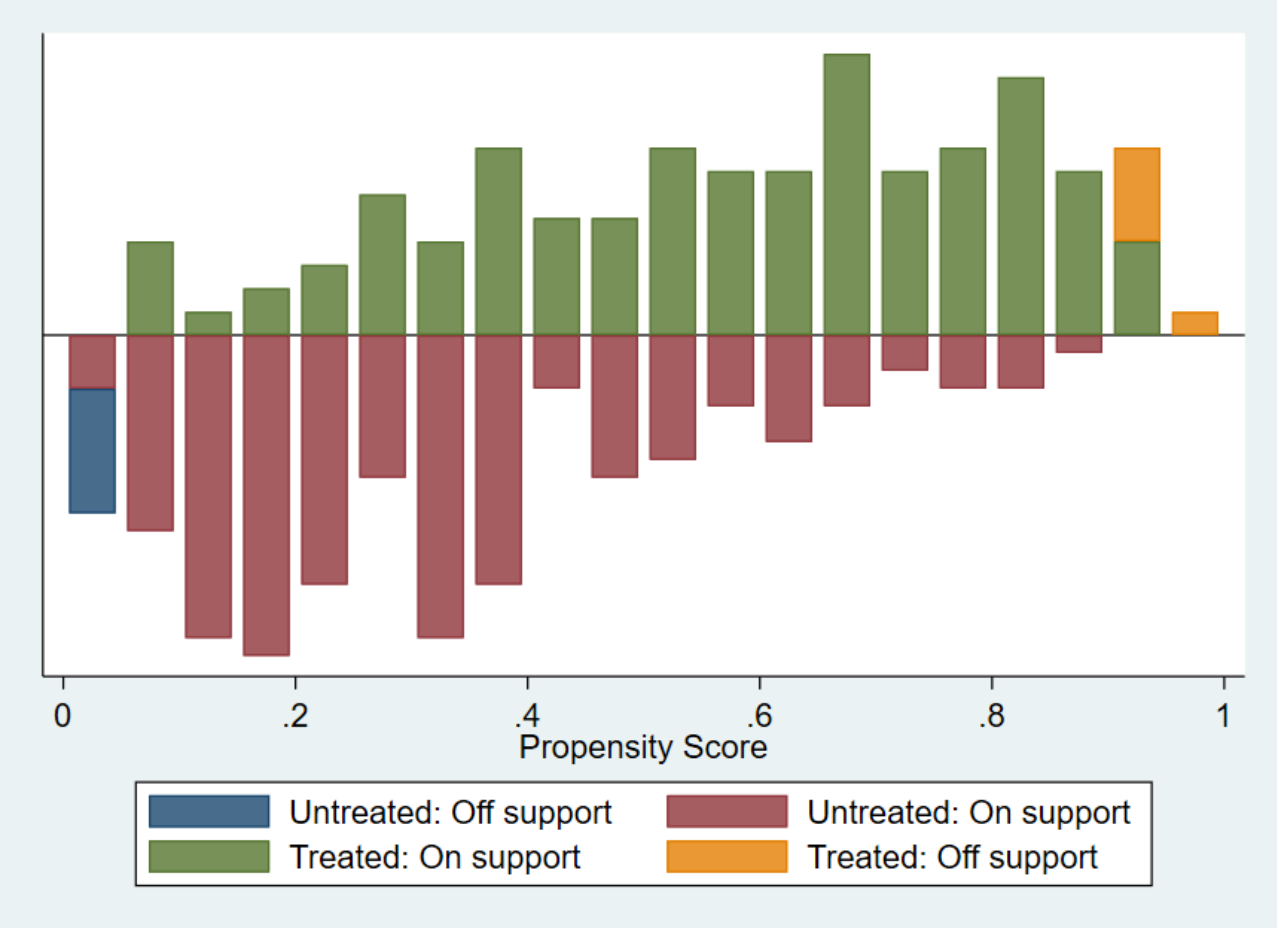

Figure 2: Graph of propensity scores of participant households

Figure 2 shows the distribution of estimated propensity scores before and after the imposition of the common support condition for participant and non-participant households, respectively. As depicted in these Figures, most of the participant households have propensity score around 0.6 while majority of the non- participant households have propensity score around 0.3.

Choice of matching algorithm

Different alternatives of matching estimators were conducted to match the treatment program and counterfactual households fall in the common support region. The decision on the final choice of an appropriate matching estimator was based on three different criteria as suggested by Dehejia and Wahba (2002). First, equal means test (referred to as the balancing test) which suggests that a matching estimator which balances all explanatory variables (i.e., results in insignificant mean differences between the two groups) after matching is preferred. Second, looking into pseudo-R 2 value, the smallest value is preferable. Third, a matching estimator that results in the largest number of matched sample size is preferred. To sum up, a matching estimator that balances all explanatory variables, with lowest pseudo-R^2 value and produces a large matched sample size is preferable.

Table 4 presents the estimated results of tests of matching quality based on the three performance criteria. Looking into the result of the matching quality, nearest neighbor matching (NN) of neighborhood 5 was found to be the best for the data we have at hand. Hence, the estimation results and discussion for this study are the direct outcomes of the NN matching algorithm with a neighbor of 5.

Table 4: Matching performance of different estimators

Matching algorithm	Balancing test	Pseudo- R^2	Matched Sample size
Nearest Neighbour			
NN-1	12	0.046	252
NN-2	12	0.048	252
NN-3	12	0.049	252
NN-4	11	0.049	252
NN-5	14	0.042	252
Caliper			
0.1	13	0.034	224
0.25	12	0.047	247
0.5	12	0.042	256
Kernel			
Band width of 0.1	13	0.032	224
Band width of 0.1	11	0.048	247
Band width of 0.1	12	0.038	256

Source: Survey result, 2021

Testing the balance of propensity score and covariates

Once the best performing matching algorithm is chosen, the next task is to check the balancing of propensity score and covariate using different procedures by applying the selected matching algorithm. It should be clear that the main intention of estimating propensity score is to balance the distributions of relevant variables in both groups.

Table 6: Propensity score and covariate balance

Variable	Sample	Mean		Standardized bias		t-test	
		Treated	Control	%bias	% reduced	T	p>|t|
Sex of household head	U	0.8509	0.8933	-12.7		-1.03	0.303
	M	0.8727	0.8881	-4.6	63.8	-0.4	0.69
Age of household head	U	42.7890	34.2200	78.6		6.36***	0.000
	M	36.1130	34.5240	14.6	81.5	1.43	0.155
Education level	U	3.0088	3.7867	-23.9		-1.91*	0.057
	M	3.0353	3.6783	-19.8	17.3	-1.64	0.101
Marital status	U	2.0965	2.0000	29.3		2.47**	0.014
	M	1.9664	2.0070	-12.3	58	-1.57	0.119
Distance to nearest market	U	1.2707	1.4622	-20.8		-1.67*	0.097
	M	1.3146	1.4685	-16.7	19.6	-1.44	0.15
Dependence ratio	U	111.8400	124.3000	-13.5		-1.09	0.276
	M	126.5300	122.8100	4	70.2	0.37	0.71
Household size	U	6.6842	5.8600	36.6		2.96***	0.003
	M	5.8129	5.8951	-3.6	90	-0.34	0.737
Off/non-farm participation	U	0.2018	0.2600	-13.8		-1.1	0.271
	M	0.3154	0.2378	18.4	-33.3	1.47	0.143
Land owned	U	4.4474	4.1650	8.4		0.68	0.498
	M	3.8815	4.0192	-4.1	51.2	-0.39	0.699
Livestock owned (TLU)	U	1.9687	2.6228	-31.7		-2.57**	0.011
	M	2.6803	2.5345	7.1	77.7	0.59	0.554
Income farm	U	11444.0000	20841.0000	-16.9		-1.28	0.2
	M	12052.0000	13936.0000	-3.4	80	-1.24	0.216
Food aid	U	0.1228	0.3533	-56		-4.4***	0.000
	M	0.4056	0.3427	15.3	72.7	1.1	0.273
Access to extension services	U	0.6579	0.7800	-27.3		-2.22**	0.027
	M	0.7406	0.7692	-6.4	76.5	-0.56	0.575

***, **and * means significant at 1%, 5% and 10% probability levels, respectively.
Source: Survey result, 2021

The balancing powers of the estimations are ensured by different testing methods. Reduction in the mean standardized bias between the matched and unmatched households, equality of means using t-test and chi-square test for joint significance of the variables used are employed here. The 5th and 6th columns of Table 6 above shows the standardized bias before and after matching, and the total bias reduction obtained by the matching procedure, respectively. The standardized difference in covariates before matching is in the range of 1% and 36.6% in absolute value whereas the remaining standardized difference of covariates for almost all covariates lies between -3.6% and 18.4% after matching. Therefore, the process of matching creates a high degree of covariate balance between the treatment and counterfactual samples that are ready to use in the estimation procedure. Similarly, T-values also reveal that all covariates became insignificant after matching while eight of them were significant before matching.

As indicated in Table 7, the values of pseudo-R^2 are fairly low. This low pseudo-R^2 value and the insignificant likelihood ratio tests support the hypothesis that both groups have the same distribution in the covariates after matching. These results indicate that the matching procedure is able to balance the characteristics in the treated and the matched comparison groups. Hence, these results can be used to assess the impact of PSNP among groups of households having similar observed characteristics. This enables us to compare observed outcomes for treatments with those of a counterfactual group sharing a common support.

Table 7: Chi-square test for the joint significance of variables

Sample	**Pseudo** R^2	LR	chi^2	p>chi2
Unmatched	0.222	80.24	0.000	27.7
Matched	0.042	16.77	0.269	9.9

Source: Survey result, 2021

All of the above tests suggest that the matching algorithm we have chosen is relatively the best for the data at hand. Therefore, we can proceed to estimating the average treatment effect on the treated (ATT) for the sample households.

Treatment effect on the treated

The estimation result presented in Table 8 provides a supportive evidence for the effect of the program on households' home expenditures. As shown in Table 8, the PSM estimation result shows that participation in PSNP had brought a significant impact on home expenditures in the study area. This might be because households in the study area use the PSNP transfer mainly for consumption smoothing purpose.

Table 8: Average treatment effects **for outcome variables of interest**

Outcome variable	**ATT on Treated**	**ATT on Controls**	**Difference**	**S.E.**	**T-stat**
Expenditure	5976.606	4620.416	1356.189	460.1047	2.95***

Source: Survey result, 2021

Graduation

In study districts, PSNP stayed more than 16 years since started. However, graduation arises from the program was not undertaken in study area. According to FGD, the beneficiaries were not showed any difference from being beneficiaries from the program in terms of graduation. PSNP brought a positive influence on increment of family size, high dependence and lack of self-esteem to leave the program. These resulted their degree of dependence rather their graduation from the program. Thus study result coincided with the result of Yitagesu (2014) who indicated that food aid was associated with a dependency syndrome due to it might change the behavior of recipients making dependent them on aid and less active on their socioeconomic activities particularly in developing countries. Households were believed that they haven't other options to leave the program. This is because of existence of drought, large family size, shortage of land owned and existing current inflation. According to district agriculture and natural resource office, PSNP brought high dependence, decrease in production and less focusing for private/ individual farms rather communal works.

Constraints

Table 9: Problems encountered in the PSNP program of the study area in Garret Ranking method

No	Problems	Scores				Sum score	Average score	Rank
		1	2	3	4			
1	Shortage of fund	148	56	0	0	204	68.0	1
2	Unfair on distribution	74	56	44	0	174	58.0	2
3	Corruption	0	0	44	27	71	23.7	4
4	Unavailability on time	0	56	44	0	100	33.3	3
5	Not family based (fixed at 5 max)	0	0	0	27	27	9.0	5

Source: Own computation, 2021

Summary, Conclusions and Recommendation

Summary, Conclusions

Ethiopia remains vulnerable to a range of shocks and stresses that brought food insecurity in the country. For this, among the food-based interventions PSNP were practiced through public work and direct support. However, it blamed by most of farmers as it encourages dependency. From observation farmers supported by the program within the last five years were not graduated from the program. The beneficiary oversees the program as main options for their livelihoods. Thus, it may bring an impact directly or indirectly on the community livelihoods.

The study was undertaken with the objective of assess the impact of productive safety net program on smallholder farmer's expenditure and analyze factors affecting participation of smallholder farmers in productive safety net program in the study area. To address the objectives of the study, both qualitative and quantitative data types were used which collected from both primary and secondary sources. Quantitative data were collected through interviews schedule from a total of 264 respondents using semi-structured questionnaires. Qualitative data were also collected through focus group discussions. For this study both descriptive and econometric analyses were employed.

Out of 264 total respondents utilized in this study, 114 were PSNP users and 150 PSNP non-users. According to FGD, the increased dependency through focusing more on communal work by ignoring works of individual participants. The descriptive results revealed that PSNP participant households had smaller age, shorter distance, dependence ratio, off/non-farm income, farm income and owned fewer livestock size. The t-test result showed that among the demographic and socio-economic characteristics of sample respondents age, education, household size, distance of market and TLU were statistically significant. While, the chi-square result indicated marital status, accessibility of food aid and access to extension service was statistically significant.

Econometric result of the logit model indicated that age, marital status, income obtained from farm, food aid and extension service accessibility were statistically affect the participation of household in the program. In the study area there is significant impact of PSNP on household expenditure obtained in this study might be because households in the study area use the PSNP income mainly for home expenditure purpose.

Recommendations

Based on the results of study the following recommendations forwarded:

- Households who are larger age more participants of the program than the smaller age. As the age of household increase the probability of he/she participate in PSNP also increases. Hence, policies makers would focus on ways of attracting youth's users who are agile and stronger to graduate the users from the program.
- Increasing access of extension services increases the capacity of households for threshold graduation from the program through working his/her tasks. Extension access services beyond making graduation of participants, avoiding the extravagance. Therefore, extension services access should have to be strength and encouraged.
- Unavailability of fund on time and existence of corruption on distribution was among the major constraints. Thus, program funding agents should have to bring funds timely and implementers at lower levels should have to consider the institutional guidance of the program.
- This study found that PSNP had not brought any graduation beneficiaries from the program. Thus, program designers, implementers and funding agents should have to re-evaluate the program design and implementation to bring the positive effect on graduation of the beneficiaries.
- Finally, this study was used cross sectional data. Therefore, it is better if it more validated using panel data to improve its level of prediction and applicability for policy makers.

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Appendix

Appendix 1: Conversion factors used to estimate tropical livestock units (TLU)

Livestock category	Conversion Factor
Calf	0.25
Donkey (Adult)	0.70
Donkey (Young)	0.35
Weaned Calf	0.34
Camel	1.25
Heifer	0.75
Sheep and Goat (Adult)	0.13
Sheep and Goat (Young)	0.06
Cow and Ox	1
Horse	1.10
Chicken	0.013

Source: Storck *et al*., 1991

Economic Efficiency of Smallholder Farmers in Maize Production in West Harerghe Zone, Oromia National Regional State, Ethiopia

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Abstract

The aim of the study was to measure the levels of technical, allocative and economic efficiencies and identify factors affecting efficiency levels of maize production in west Hararghe zone. The study was based on cross-sectional data collected from 160 randomly selected respondents. Stochastic frontier production model was used to estimate technical, allocative and economic efficiency levels, whereas Tobit model was used to identify factors affecting efficiency levels. Accordingly, the mean technical, allocative and economic efficiencies of sample households were 77%, 64% and 51%, respectively. The results indicated that there was substantial amount of efficiency variation in maize production in the study area.Land, seed and NPS were the variables that positively affected the production of maize.Results of the Tobit model revealed that education, number of livestock owned and social participation significantly affected technical efficiency. On the other hand, household size, proximity to maize farm, number of maize plot, landholding size, credit and social participation significantly affected allocative efficiency. The result of the study also showed that, proximity, landholding size, livestock and credit affected economic efficiency significantly. Results also indicate that there is a room to increase the efficiency in maize production of the study area. Therefore, government authorities, policy makers and other concerned bodies should take into consideration the above mentioned socioeconomic and institutional factors to improve the productivity of maize in the study area.

Keywords: Maize production, Efficiency, Stochastic frontier, Tobit

Introduction

Ethiopian agriculture is characterized by low productivity due to technical and socio-economic factors. Mostly the farmers with the same resources are producing different per hectare output, because of management inefficiency inputs, limited use of modern agricultural technologies, obsolete farming techniques, poor complementary services such as extension, credit, marketing, and infrastructure, poor and biased agricultural policies in developing countries like as Ethiopia (FAO, 2012).

Agriculture in Ethiopia can help in bringing down poverty. Nevertheless, vulnerability of returning to poverty remains high, particularly for rural livelihoods dependent on rained agriculture (World Bank, 2016). However, in spite of its poor performance the Ethiopian agriculture shoulders the major responsibility in the supply of cereals which makes analyzing cereal production systems in Ethiopia of paramount importance (FAO, 2012). In addition, in Ethiopian context, where agriculture derives the highest share of gross domestic product any concern for poverty alleviation would place substantial weight on the generation of rural income, which is mainly generated from its agricultural operations (Endrias, 2013).

Ethiopia, one of the world's centers of genetic diversity in crop germplasm (McCann, 2001) and produces more of maize than any other crop (CSA, 2020). Among the crops grown in Ethiopia, maize

(Zea mays L.) is the most important cereal crop in terms of production, area coverage and better availability and utilization of new production technologies (Kifle, 2017). Nationally, the area under maize cultivation in 2019/20 was 2.52 million hectares from which 100.68 million quintals of maize were produced (CSA, 2020). From the country's total grain production, maize shares more than 27 percent (ibid). It is the highly demanded food crop in different parts of Ethiopia. However, the levels of productivity of the crop have remained to be low (Ayalneh, 2013). Production inefficiency of smallholder farmers representing major supply of agricultural production in Ethiopia has been one of the key factors limiting agricultural productivity. High productivity and efficiency in maize production is critical to improve food security, reduce the level of poverty and achieve or maintain agricultural growth (Inuwa, 2018).

In order to improve maize production and productivity, an efficient use of production inputs has to be adopted by small holder farmers. An understanding of the relationships between efficiency, policy indicators and farm specific practices would provide policy makers with information to design programs that can contribute to increasing food production potential among smallholder farmers (Ouattara, 2012).

Maize is major food crop in west Harerghe zone. It ranks first among cereal crops produced in area coverage. However, the average yield of the crop was 23.5 quintal per hectare in west Harerghe zone; which is very lower than the national average yield (i.e., 39.44 qt/ha) of maize (Jima *et al*., 2020). The main reasons for the low productivity of maize include extensive use of unimproved maize seeds, depletion of soil fertility, erratic rainfall, prevalence of pests and diseases, little improvement in agronomic technologies, limited use of yield-enhancing purchased inputs such as fertilizers and agrochemicals. In addition, previous survey works shown that there is a yield gap in production among maize producer farmers in the study area. In the study area, similar survey studies and information on the levels of economic efficiency of small-holder farm households in maize production is lacking.

Therefore, this study attempted to determine and assess the economic efficiency levels of maize producer farmers and identify its determinant factors in west Harerghe zone.

Objectives of the study

The specific objectives of the study were as follows:

- To determine the technical, allocative and economic efficiency levels of small holder farmers in maize production
- To identify factors that determine efficiency of small holder farmers in the study area

Methodology

Description of the study Area

The study was conducted in Habro, Tullo and Boke districts of West Harerghe Zone which have potential in production of maize.

Habro district

Habro district is one of the fifteen districts of West Harerghe administrative zone of the Oromia National Regional State.It is located404 km to East of Addis Ababa, which is capital city of Ethiopia and 75 km to South of Chiro. The district is boarded by GubaKoricha district in West, Boke district in East, DaroLebu in South and OdaBultum in North. Gelamso town is the administrative seat of the district. The population of the district is estimated to be 244,444 of which women account for 118,268 (48.4%) and men account for 126,176 (51.6%)of the population (HDANRO, 2019). The altitude of the

district ranges from 1600 to 2400 masl. The annual average rainfall the district is 1010 mm & the mean temperature ranges between 16 and 32 ^{0}C (HDANRO, 2019). There are two cropping seasons in the area, Belg (short rainy season) from March to June and Meher (main rainy season) from June to September. Belg rains are mainly used for land preparation and planting long cycle crops such as maize. The Meher rains are used for planting of cereal crops like barley, teff, wheat and vegetable crops. Meher rains are also the major source of moisture for the growth anddevelopment of perennial crops such as mango, coffee and chat. Haricot bean is grown in both of the cropping seasons (HDANRO, 2019).

Tullo district

Tullo is located at 370km southeast of Addis Ababa and about 40 km South of Chiro, which is capital town of the Zone. Hirna town is the administrative seat of the district. Tullo district has a total population of 178,245 out of which 90,746 and 87,499 are male and female, respectively. The district is found at an average altitude of 1750 meters above sea level with mean annual rainfall of 1850ml and mean annual temperature of 23°C. Agro-ecologically, the district has three sub-climatic zone highland, midland and lowland (TDANRO, 2019). The production system is mixed type in which extensive husbandry management of livestock have been practiced (Tulu and Lelisa, 2016).

Boke district

Boke district is found at a distance of 70 km to the South West direction of Chiro town. It bordered by district of OdaBultum in North East, DaroLebu in South West, Habro in North and Burka Dimtu in South having an area of 123,188.06 hectares. Boke Tiko town is its administrative seat. The district has a total population of 134,687 of whom 66,671 were males and 68,016 were females among 23,914 are households whereas 18,134 are males and 5,780 are females' households. The topography of the district is mainly midland (80%) while the rest is lowland (20%) zones. The district receive annual rain fall minimum of 600mm and maximum of 800mm per year having bimodal rainfall in Summer during mid of June to mid of September and in *Belg* February up to April. Its altitude stretches between 1100 and 1980 *m.a.s.l.* (BDANRO, 2019). The major economic activity of the district was depends on agricultural activity among production of Maize, Sorghum and Teff for food; Coffee and Khat for cash crops (BDANRO, 2019).

Sampling technique and Sample size

Multistage sampling technique was applied for this study. Firstly, three (3) districts were selected purposively based on their potential in maize production. Secondly, depending on their potential in maize production three (3)*kebeles* were randomly selected from each district. Accordingly, a total of nine (9) *kebeles* were selected among/out of the three districts. Namely, ReketaFura, Buraksa and Kirakufis*kebeles* from Tullo; Chebi, Mildhab and Kiltu-ilala*kebeles* from Boke; AbdiGudina, Lagabera and Haro-chercher*kebeles*from Habro district were selected. Finally, a total of 160 maize producer farmers were randomly selected based on probability proportional to size. For the drawn sample respondents, the simplified formula provided by Yamane, (1967) was employed to determine the required sample size at 95% confidence level with degree of variability = 0.5 and level of precision (e) = 7.5%.

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

Where *n* is the sample size, N is the population size (total household size), and e-is the level of precision.

Table 1: Total number of sample households

Districts	Number of sample households
Tullo	45
Habro	75
Boke	40
Total	**160**

Data source and Method of data collection

Both primary and secondary data sources were employed. Secondary data source was collected from published and unpublished documents of district Agricultural Office to support the primary data. The primary data was collected from the selected sample representative households through direct interview. Both qualitative and quantitative primary data were collected by using structured questionnaire administered through personal interviews with the selected respondents. Prior to the administration of the questionnaire, enumerators were informed about the objectives of the study.

Method of data analysis

The collected data were analyzed with STATA 13.1 software. In this study, descriptive statistics such as mean, standard deviation, frequency distribution and percentage were used for the analysis.

Stochastic Frontier Production (SFP) and tobit model were also used to estimate level of efficiencies and identify factors that determine efficiency of maize producer farmers, respectively.

Econometric Model

For this study stochastic frontier production model was used to estimate efficiency levels. Following the Aigner et al. (1977) and Meeusen and Van den Broeck (1977) method of estimating a stochastic frontier production function, with a Cobb-Douglas type production function specification can be represented as:

$$lnY_i = \beta_0 + \beta_1 ln(land) + \beta_2 ln(oxen) + \beta_3 ln(labor) + \beta_4 ln(seed) + \beta_5 ln(NPS) + \beta_6 ln(UREA) + \beta_7 ln(chemicals) + v_i - u_i \quad (2)$$

Where, Y_i -measures the quantity of output of the i^{th}farmer, X_{ij} -refers to the farm inputs of the ith farmer, β is a vector of parameters, V_i is the symmetric error term, accounts for factors outside the control of the farmer U_i is the technical inefficiency, accounting for random variations in output due to inefficiency.

Tobit model was also used to identify factors that affect efficiency of smallholder farmers in maize production in the study area. As the distribution of the estimated efficiencies is censored from above at the value 1, Tobit model (Tobin, 1958) is specified as:

$$E = E^* = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \ldots\ldots\ldots\ldots\ldots\ldots + \beta 14X14 + v \quad (3)$$

$E = 1$ if $E^* \geq 1$, and $E = E^*$ if $E^* < 1$

Where: E is the efficiency measures representing technical, allocative and economic efficiency, E* is the latent variable, β's are unknown parameters to be estimated, v is a disturbance term and X is explanatory variables used in the model.

Table 2: Summary of variables and hypotheses

Variables	Measurement	Expected sign
Dependent variables		
Technical Efficiency (TE)	Continuous	
Allocative Efficiency (AE)	Continuous	
Economic Efficiency (EE)	Continuous	
Explanatory variables		
Experience (years)	Continuous	+
Sex (1=male, 0=female)	Dummy	±
Household size (number)	Continuous	±
Education level (years)	Continuous	+
Landholding size (ha)	Continuous	+
Access to training (1=yes, 0=no)	Dummy	+
Off/non-farm occupation (1=yes, 0=No)	Dummy	+
Livestock holding (TLU)	Continuous	+
Proximity of maize farm (km)	Continuous	+
Extension contact (1=yes, 0=No)	Dummy	+
Access to credit (1=yes, 0=No)	Dummy	+
Number of maize plot (number)	Continuous	-
Irrigation use (1=yes, 0=No)	Dummy	+
Social participation (1=yes, 0=No)	Dummy	-

Results and Discussion

Descriptive Analysis Results

Age, land holding size, household size and experience of the respondents

The mean age of sample households was 39.84 years with standard deviation of 11.46, while the average family size was 6.49. The maximum age for the sample farmers was 73 years while the minimum was 20 years. On average, the sampled respondents have 16.32 years of experience in maize cultivation with a range of 2 to 50 years. The result of the study also shows that, average land holding size of households in the study area was 0.80 hectares with standard deviation of ± 0.608. The result of one way ANOVA test (which is depicted in table 3) has indicated that there was significant mean difference (F-value =14.711, p-value=.000) in total landholding size among the three districts, whereas there is no significant mean difference (F-value = 1.206, p-value = 0.302) in experience of maize producers across the three districts.

Table 3: Age, land holding size, household size and experience of the respondents

Variable	Min	Max	Mean	St.dev	F-value
Age (year)	20	73	39.84	11.468	
Experience in maize production (year)	2	50	16.32	10.440	1.206
Land holding size (ha)	0.125	4	0.80	0.607	14.711***
Household size (number)	1	13	6.49	2.384	

Sex and Educational status of the respondent

The result of the study shows that, out of the total sample households about 143 (89.4%) were male while 17 (10.6%) were female. From the sample households, 42 (26.3%) of the respondents were illiterate, 13 (8.1%) of them can read and write whereas 105 (65.6%) respondents attended formal education in the study area. Education is expected to sharpen managerial capacity and lead to a better assessment of the importance and complexities of good decisions in farming.

Table 4: Sex and Educational status of the respondent

Variables	Category	Frequency	Percentage
Sex	Male	143	89.4
	Female	17	10.6
Total		**160**	**100**
Education	Illiterate	42	26.3
	Read and write	13	8.1
	Formal education	105	65.6
Total		**160**	**100**

Estimation of the Cobb-Douglas production function

Technical, allocative and economic efficiency levels of smallholder farmers in maize production were estimated using stochastic frontier production function (SFP). Input variables such land (hectares), oxen labor (number), human labor (man-equivalent), amount of seed (kilogram), inorganic fertilizers (NPS and UREA in kilogram) and chemicals (liters) were used in the model for estimating technical efficiency, while price of each inputs in birr were used for estimating allocative efficiency.

Table 5: Estimation of the Cobb-Douglas frontier production function

Variable	Coefficient	Standard error
Constant	1.624	0.713
Land	0.569 ***	0.126
Oxen	0.047	0.088
Labor	0.048	0.115
Seed	0.212 *	0.121
NPS	0.447***	0.135
UREA	0.028	0.110
Chemicals	0.078	0.114
Sigma square(σ^2)	1.016***	0.181
Gamma(γ)	0.848***	
Log likelihood	62.021	

From the total of seven variables considered in the production function; land, seed and NPS had positive and significant effect in explaining the variation in maize output among farmers and are significant variables in shifting the frontier output to the right or moving along the frontier. This indicated that a unit increase of these variables; increase the level of maize production. As a result, 1% increase in size of land, seed and NPS will increase maize production by 0.569%, 0.212% and 0.447%, respectively in the study area. This result is in line with the finding of Tolesa (2021) in his study of Analysis of Maize Production Efficiency in Maize Production in Ethiopia in the Low Land of Gudeya Bila district.

Technical, Allocate and Economic efficiency scores

The result of mean efficiency scores indicated that farmers in the study area were relatively good in TE than in AE or EE. Generally, there is a considerable amount of efficiency variation among maize producer farmers.

Table 6: Summary statistics of efficiency scores

Type of efficiency	Minimum	Maximum	Mean	Std. dev.
EE	0.23	0.72	0.51	0.106
TE	0.40	0.98	0.77	0.195
AE	0.26	0.99	0.64	0.196

The mean technical efficiency level of 77% indicated that maize producing farmers have a chance to efficiently utilize resources and hence they could increase the current maize output by 23% using the existing technology. The TE among farmers varies from 40% to 98%, with standard deviation of 0.195. This shows that there is a wide disparity among maize producer farmers in their level of technical efficiency. This result is in line with the finding of Gosa (2016) in his study of Economic Efficiency of Sorghum Production for Smallholder Farmers in Eastern Ethiopia.

The mean allocative efficiency of farmers in the study area was 64% indicating that on average, maize producer farmers can save 36% of their current cost of inputs if resources are efficiently utilized. In other words, maize producer farmers increased their cost of production by 36% because of allocative inefficiency. This implies that there is a great opportunity to increase the efficiency of maize producers by reallocation of resources in cost minimizing way. This result is in line with the finding of Kifle (2017) in his study of Economic Efficiency of Smallholder Farmers in Maize Production in Bako Tibe District, Ethiopia.

As designated in the above table, mean economic efficiency level of sample households was 51% with minimum and maximum efficiency scores of 23% and 72%, respectively. This result shows that on average, an economically efficient farmer can reduce his/her cost by 49% in maize production.

Determinants of Efficiency in Maize Production

The estimates of the Tobit regression model showed that among the fourteen 14 variables used in the model; education, livestock and social participation were found to be statistically significant in affecting the level of technical efficiency of farmers. The result also revealed that, household size, proximity, number of maize plot, landholding size, credit and social participation were found to be significantly influence allocative efficiency of maize producer farmers. The result also indicated that, proximity, landholding size, livestock and credit were important factors influencing economic efficiency of smallholder farmers in the study area. This result is in line with the finding of Meftu (2016) in his study of Economic Efficiency Of Groundnut Production in Gursum District.

Table 7: Determinants of Efficiency in Maize Production

Variables	TE		AE		EE	
	ME	P-value	ME	P-value	ME	P-value
Sex	-0.0002	0.951	-0.0005	0.852	0.0004	0.755
Education	0.0066*	0.095	-0.0057	0.406	0.0003	0.938
Experience	0.0039	0.250	-0.0045	0.154	-0.0013	0.421
Household size	-0.0084	0.440	0.0255***	0.010	0.0064	0.209
Proximity	0.0174	0.339	-0.0324**	0.050	-0.0136*	0.100
Off/non-farm	0.0391	0.305	0.0246	0.480	0.0243	0.173
Maizeplot	-0.0129	0.621	-0.0385*	0.100	0.0193	0.114
Land size	0.0055	0.871	0.0727**	0.022	0.0645***	0.000
Irrigation	-0.0592	0.274	0.0530	0.284	0.0162	0.520
Livestock	0.0280***	0.000	-0.0094	0.161	0.0070**	0.044
Extension	0.0400	0.367	-0.0247	0.541	-0.0086	0.675
Credit	0.0462	0.596	0.2252***	0.006	0.1153***	0.006
Training	0.0044	0.916	0.0097	0.800	0.0132	0.500
Socialparticipation	-0.1327**	0.020	0.0009	0.580	0.0006	0.980
Constant	0.7876***	0.000	0.7309***	0.000	0.4756***	0.000

*, ** and *** imply 10%, 5% and 1% significance levels, respectively.
Source: Model output

Education: Education of the household head has a positive and significant effect on technical efficiency of maize production at 10% level of significance, suggesting that better educated household head can understand agricultural instructions easily, have higher tendency to adopt improved agricultural technologies, have better access to information, good use of production inputs, improve the efficient use of inputs and able to apply technical skills than uneducated ones (Mustefa *etal,* 2017). Marginal effect of education can be interpreted as a one year increase in educational level of the household head increases their technical efficiency on average by 0.66%. This result is in conformity with the findings of Hassen (2014) and Tolesa (2021).

Household size: The coefficient of family size has a positive and significant effect on allocative efficiency at 1% probability levels. The possible reason for this result might be that a larger household size guarantees availability of family labor for farm operations to be accomplished in time. At the time of peak seasons, there is a shortage of labor and hence household with large family size would deploy more labor to undertake the necessary farming activities like ploughing, weeding and harvesting on time than their counterparts and hence they are efficient in maize production. This might be because farmers with large family size had better capacity for optimal allocation of resources. This suggests that larger households may utilize family labor and reduce cost incurred in hiring labor. This result was consistent with the findings of Awol (2014) and Sisay (2016).

Proximity of maize farm: The coefficient of the distance of maize farm from the home of household head was negatively and significant effect on both allocative and economic efficiencies at 5% and 10% probability level. This might be due to, the sample household that near maize farm were delivery input timely, reduction of transport cost of inputs and easily disposal of output compared to his counter-parts. Thus, leads to maximum output at least cost. The marginal effect of proximity to homestead indicates a unit change in distance of maize farm from farmer's home by one kilometer would decrease his allocative and economic efficiencies on average by 2% and 2% respectively. The result was consistence with the findings made by Alemayehu (2010).

Number of maize plot: The result of the study also shows number of maize plotis one among the explanatory variables which affected allocative efficiency negatively and it is significant at 10% level. The increasing number of plots leads to increased inefficiency or decreased efficiency by creating

shortage of family labour, wastage of time and other resources that should have been available at the same time. Additionally, having large number of plots may lead to wastage of time resource and cost inefficiency than having less number of plots. The result agreed with the previous research works of Fekadu (2004).

Land size: The result also shows that farm size have a significant and positive impact on AE and EE, at 5% and 1% level of significance, respectively. This positive relationship was also observed in several other studies (Alwang, 2003). This could probably be because of farmers with larger area of cultivated land have the capacity to use compatible technologies that could increase the efficiency of the farmer. On the other hand, the smaller-sized farms are populated heavily by young and inexperienced people and therefore, they are expected to have lower average efficiency levels than large and more experienced farmers. Moreover, farmers who have large farm size would have an opportunity to use and allocate the maximum available resources efficiently because theydo not have land size limitation. Additionally, farmers with large farm size may also have an easier access to new improved agricultural technologies introduced in to the area. Generally, large farm size owners are more efficient as compared to small land size owners.

Livestock (TLU): The amount of livestock owned, which is a proxy for estimating wealth status of a farmer, has a positive and significant effect on both technical and economic efficiencies at 1% and 5% levels of significance. Farmers who owned more number of livestock were more efficient than those who owned a few number of livestock in the production of maize. This might be due to that livestock provides traction, manure and is a source of cash that can be used to purchase consumption goods and production inputs. Others also argue that when all types of animals, poultry and beehive production are considered, its supplementary effect could diminish and it is likely to become competitive. This result was consistent with the finding of Solomon (2012) and Musa (2013).

Credit: The coefficient of access to credit had a positive and significant effect on both allocative and economic efficiencies at 1% significance level. It is an important element in agricultural production systems. Credit availability shifts the cash constraint outwards and enables farmers to make timely purchases of those inputs that they cannot provide from their own sources. In other words, credit utilized permits a household to enhance efficiency by removing money constraints which may affect their ability to apply inputs, implements and farm management decisions on time. The finding is consistent by Hasan (2006) and Gbigbi (2011).

Social participation: The study also indicated that social participation had a significant and negative impact on technical efficiency at 5% probability level.

Conclusion and Recommendation

This study was aimed at estimating the technical, allocative and economic efficiency levels and identifying factors affecting efficiency levels of maize production in west Hararghe zone. The study was based on cross-sectional data collected from 160 randomly selected respondents using semi-structured interview schedule. Out of the total sample households about 143 were male while the rest 17 were female maize producer farmers. The descriptive statistics result showed that mean age of sample households was 39.84 years, while the average family size was 6.49. The result also showed that on average, the sampled respondents have 16.32 years of experience in maize cultivation. The result of the study also shows that, average land holding size of households in the study area was 0.80 hectares.

The stochastic production frontier model output showed that among input variables land, NPS and seed were significant variables that significantly affect the production of maize. This indicates that increased use of these inputs will increase the production level to a greater extent. Technical efficiency scores

range from 40 percent to 98 percent while allocative and economic efficiency scores range from 26 percent to 99 percent and from 23 percent to 72 percent, respectively. This shows that there is efficiency variation among sample farmers in the study area. Average technical efficiency stands at 77 percent while the average allocative and economic efficiency stands at 64 percent and 51 percent, respectively.

Tobit model results showed that education, livestock and social participation are significant determinants of technical efficiency. Furthermore, the results revealed that household size, proximity, number of maize plot, landholding size, credit and social participation significantly influence allocative efficiency of smallholder farmers in the study area. The result also showed that proximity, landholding size, livestock and credit are important factors that significantly affect economic efficiency of the smallholder farmers in the area. Such farm, socioeconomic and farmer characteristics should be encouraged to enhance efficiency among smallholder maize producing farmers.

The study recommended that:

- The concerned body should have to give more attention to provide educational service for all to attain educated farmers in order to increase efficiency and agricultural productivity.
- The above significant variables related to farm, socioeconomic and farmer characteristics should have to be encouraged to enhance efficiency among smallholder maize producing farmers in the study areas.
- Policies and strategies designed and implemented to increase the efficiency of smallholder farmers in maize production in the study area should focus on the above mentioned factors.

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Economic Analysis of Potato Production in Bale Highlands, Southeastern Ethiopia

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Abstract

The study was initiated to identify costs and benefits or economic profitability of potato production and factors affecting potato production under small scale farmer's level. This study was conducted in three districts. Purposive and random sampling techniques were applied to select 113 respondents. Primary data was collected directly from respondent, through interview schedule, key informant interview and focus group discussion. Both descriptive statistics and econometric model, Cobb-Douglas production function model were used to analyse collected data. The average age of the sample respondent was 42.75 years, while the average household size was found to be 7.27 family members. *The result of cost benefit analysis implying that, potato production is profitable in the study area and farmers produce potato to improve their livelihood. The result from Cobb-Douglas production function model shows that seed, fertilizer, and fungicide were significantly affect potato output at 1%, 1% and 5% respectively, while human labor was insignificant. The model result depicts that, 56% of the variations in output of potato production could be explained by the explanatory variables included in the model. The most problem or constraints faced by potato producer farmer in the area was lack improved variety.* Therefore, *Agricultural Research center should have to generate improved variety that is appropriate to the needs and desires of smallholder farmers.*

Introduction

Potato (Solanum toberosum L.) is a source of both food and income in the growing countries of the world which able to change greatly the food security of countries because of its high productivity per unit area and time compared to other crops (Tolessa, 2018). Nutritionally, the crop is considered to be a well-balanced major plant food with a good ratio between protein and calories. It is one of major food crops grown in most of the developing countries

Potato has the potential to be cultivated on about 70% of the 10 Mha of arable land in Ethiopia FAO (2008) as cited by (Hirpa et al., 2010b). There are improved varieties that yield about 19 to 38 Mg ha^{-1}, but the current area under potato cultivation is very small with average yield of less than 10Mg ha^{-1} which is much less than the potential. The problem of lower yield can be attributed to many factors among which, lower quality seed potatoes plays the major role Lemaga et.al, (1994) as cited by (Hirpa et al., 2010b). Many factors like inadequate technical and managerial production skills, poor contract enforcement (weak institutional framework), imperfections in the marketing chain and very few market related institutions and weak infrastructure (Bekele, S. 2017).

Compared to cereals, potato is short duration crop that can yield up to 30-35 t/ha in 3-4 months in Ethiopia (Emana, B., & Nigussie, M. 2011). Rapid growth in agriculture is essential for broad based economic growth, but acceleration growth requires sound use of science and technology embodied in improved seed, fertilizer, agrochemical and other agronomic practices. However without an efficient and cost effective supply of these inputs at the farm gate, science based growth in agricultural productivity cannot be achieved. The average tuber yield of potato was almost constant between 6-8 t/ha in the last 20-30 years while the area planted with potato increased from 30,000 ha to about 160,000ha in 2012 (Teshome B, et al., 2019).

According to Agajie et al., 2010, potato is one of the most important sources of on-farm income for the farmers in Ethiopia. Potato is rapidly becoming a valuable source of cash income due to an increasing demand of food processing sector to meet demand of fast food, snack and convenience food industries. The raised in demand of food processing sector is due to growing of urbanization, income rising and diversification of diets (FAO, 2010).

Oromia is the major potato producing region in Ethiopia that constitutes 51% of the national potato production (Esmael Y et al., 2016). Bale zone is one of the potential potato producing zones in Oromia region. Farmers chose to increase the production and marketing of these enterprises, among others based on the potential that the crops had in the study area (Dinsho District Agricultural Office (DDAO), 2014). However, given the mounting pressure on land, sustaining higher rates of growth in agriculture production requires substantial improvements in factor productivity. Consequently, transformation in the structure of production (mostly subsistence-based) to more commercially-oriented production will be key in sustaining growth. In an economy where resources are scarce and opportunities for new technologies are limited, efficiency studies will be able to show that it is possible to raise the productivity by improving efficiency without raising the resource base or developing new technology (Tijani, 2006). This will create an advantage of breaking the mono cropping phenomena and also creates enterprise diversification that helps to minimize risk. So, if this study is undertaken in this potential area of potato production farmer's profitability and benefit is better improve.

Objectives

The general objective of this study was to carry out an economic analysis of potato production in Bale highlands.

The specific objective includes;

- ✓ To identify and quantify the costs and benefits of potato production in the study area
- ✓ To analyse factors affecting potato production under small scale farmers

Methodology

Description of the study area

Bale zone is one of the 24 (twenty four) administrative zones in Oromia Regional state which is located in south-eastern Ethiopia. The zone is found in Southeast of Oromia Regional State that extends from 5º 22'S – 8º 08'N latitude and 38º 41'W – 40º 44'E longitudes. It has borderlines with Arsi, Guji, West and East Hararge zones as well as Somali and Southern Peoples' Regional States. The altitude ranges from below 1000 in the lowlands to 4377m above sea level in the highlands. **This study was conducted in three districts of Bale zone which potential in terms of potato production.**

Total area of Bale zone is about 63,555 km^2 which is 16.22% of Oromia region. About 10.6% of the land is arable land used for crop production, 24.6% grazing land, 41.8% forest, and others 25% (Usman S., & Zeleke, A., 2017). Crop production and livestock management is the major livelihood making of the households in rural areas of the zone. Cereal, pulse and horticultural crops are the major crops produced in Bale zone. Potato is among horticultural crops majorly under expansion currently. The study was conducted in three major districts of potato producer in Bale zone. Sinana, Goba and Dinsho were the three districts selected for the study.

Sampling Techniques

The study employed multistage sampling techniques in selecting representative of household. The first stage, three districts were selected purposively based on potential potato production areas from highland Bale zone. Accordingly Dinsho, Sinana and Goba districts were selected. The second stage, five (5) potato producing kebeles (Mi'o, ayidda, Karrari, Qaso and Walta'i Azira) were also selected purposively based on potentiality of potato production kebele. The third stage: 113 representative

number of sample respondents were selected using simple random sampling method from total households of all selected kebeles. The total population of these five selected kebeles was 2840 households. The simplified sample size determination formula provided by Yemane (1967) was employed to determine the required sample size with level of precision (e) = 9%.

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

Where; n is sample size, N is Total population size and e is level of precision.

Table 2.1 Sample size taken

District	Kebele	Total Population	Sample Size
Dinsho	Mi'o	688	31
	Ayidda	500	25
	Karrari	316	4
Sinana	Qaso	913	26
Goba	Walta'i Azira	406	27
Total			113

Hence, three kebele was selected from Dinsho districts and one kebele from each of Sinana and Goba districts. Among those districts, Dinsho have more selected kebeles rather than both Sinana and Goba. This is due to their potentiality of districts and kebeles by the potato production.

Types and method of data collection

Both primary and secondary data were used for this study. Primary data was collected from sample households through interview as well as focus group discussion and key informant interviews. Those primary data includes, demographic, socio-economic and institutional factors, while secondary data collected from published and unpublished documents and other relevant data sources.

Method of Data analysis

Collected data was analyzed with SPSS software version 20. Descriptive statistics such as mean, frequency, standard deviation and percentage were employed for describing data on demographic, socio-economic and institutional characteristics of the sample households in the study area

Gross margin analysis (GMA): The gross margin analysis involves evaluating the efficiency of an individual enterprise or a farm firm so that comparison can be made between enterprises of different farm plans. The purpose of this analysis was to identify the cost, returns and profitability or loss per hectare. It is a very useful planning tool in situation where fixed capital is a negligible portion of the farming enterprise as is the case in subsistence agriculture (Olukosi and Erhabor, 1988). The gross margin by definition is the difference between the gross farm income (G F I) and the total variable cost (TVC) i.e G.M = GFI - TVC. The gross margin analysis was used to determine the profitability of potato production in the study area (Adewumi, M. O., & Adebayo, F., 2008)

Cost benefit analysis was calculated from the variable quantitative data collected from potato producer farmers during survey

Econometric Model

A classical Cobb-Douglas (C-D) production function is employed to estimate the degree of influence of the inputs/factors of production with respect to the agricultural output. The production function is determined by the resources available to the farmer. In agriculture continuous factors of

production are land, labour and capital. Other factors such as fertilizer, pesticides, rainfall and soil also play a role in the production of agricultural output (Mózner, Z., Tabi, A., & Csutora, M., 2012)

Production is defined as the process of transforming the two inputs into the economically useful output. The first empirical analyses of production functions, by (Burkett P, 2006) were precisely studies of the functional distribution of income between capital and labor in the context of an aggregate (macroeconomic) production function.

Production function analysis PFA (Koppenberg, M., & Hirsch, S. 2022, Pendharkar, P. C., Rodger, J. A., & Subramanian, G. H. 2008, Proietti, T., Musso, A., & Westermann, T. 2007, Pendharkar, P. C. 2006, Koutsoyiannis 2001), affirmed that the production function describes the law of proportion that is, the transformation of factor inputs into products or output at any particular time period. The production function depicts the technology of a firm, an industry or of the economy as a whole.

The production function includes all the technically efficient methods of production. It describes not only a single isoquant but the whole array of isoquants each of which shows how output varies as the factor inputs changes. Production function provides measurement of useful economic tools such as marginal productivity of factor of production, marginal rate and elasticity of substitution, factor intensity, efficiency of production and return to scale (Klump, R., McAdam, P., & Willman A., 2012). Consequently, the Cobb-Douglas production function was used to estimate the returns to scale in potato production and the extent of resource use efficiency in potato production in the study area.

Model specification

To determine the contribution of variable input to the potato production, Cobb Douglas production model was employed. Cobb Douglas production model was specified to determine possible relationship between the production of potato and inputs used in production.

$$y = AX_1{}^{\beta 1}X_2{}^{\beta 2}X_3{}^{\beta 3}X_n{}^{\beta n} + U^e$$

Where;

Y= quantity of potato produced (output)
$X_1 = Xn$ = factors of production
$\beta 1 - \beta n$ =parameters to be estimated
$e =$ Error term

The equation shows that relationship between output and the inputs is non-linear. So further the Cobb Douglas production function was transformed into log-log form to assess empirically. Log-log model is made it popular in empirical work is that the slope of dependent variable with respect to explanatory variable. The equation derived is given as

$$\boldsymbol{lnY = A + \beta_1 lnX_1 + \beta_2 lnX_2 + \beta_3 lnX_3 + \cdots + \beta_n lnX_n + e}$$

Result and Discussion

This section presents the major findings of the study and discusses it in comparison with the results of other studies. Both descriptive and econometric methods were used to analyze the primary data. Descriptive statistics were employed to describe the general demographic, socio-economic and institutional characteristics of sample respondents. Econometric

analysis was also used to identify factors affecting potato production in the study areas. Cost-benefit analysis was used to assess the profitability of potato production in the study areas.

Demographic and Socio-Economic Characteristics of sample Household

Demographic Characteristics of sample Household

Demographic characteristics entail the fundamental back ground of household sample. The result indicates that, the overall average year of formal schooling of the total sampled household heads had up to only 5 years of formal education and family size is one of the variables that characterize farm households. The average household size was found to be 7.27, with minimum of 1 and maximum of 29 family members, showing that family size were large and had labour intensive for the agricultural practice in the study area. The age of samples respondent household were ranged from 19 to 85 with the average of 42.75 and standard deviation of 14.54. Survey result showed their average level of education and family size was 5.51 and 7.27 respectively; while with standard deviation of 2.77 and 5.36 respectively.

Table 3.1 Description Statistics for continuous variables of demographic characteristics of the sample households

Variable	Min.	Max.	Mean	Std. Deviation	Variance
Age of household head in year	19.00	85.00	42.7	14.54	211.492
Level of education in a year	-	12.00	5.51	2.77	7.678
Family size	1.00	29.00	7.27	5.36	28.747

Source: Own survey *result, 2021*

The study required to find out the gender distribution among the respondents in the study area. The result indicates that majority of respondents among the total sample were male 110 (97.35%); while the remaining 3 (2.65%) were female. With regards to religion, from the total sample respondents 97 (85.84%) were Muslim and the remaining 16 (14.16%) were Christian respondents.

Table 3.2 Frequency table for nominal variables of demographic characteristics of the respondents

Variable	Frequency	Percent	Cum. Percent
Sex of household head			
Female	2	2.65	2.65
Male	110	97.35	100.00
Total	113	100.00	
Religion of household head			
Muslim	97	85.84	85.84
Christian	16	14.16	100.00
Total	113	100.00	

Source: Own survey result, 2021

Socio-Economic Characteristics of sample Household

The socio-economic factors chosen for the study included total land holding, land allocated for potato production and livestock holding. The result of the study revealed that the average total landholding of sample respondent was found to be 3.60 hectares, while the average land allocated for potato production was 1.75 hectares.

To help with the analysis, the livestock number was converted to a tropical livestock unit (TLU). The number of livestock owned is accounted for all types of livestock possessed by the household. Accordingly, the average number of livestock owned by sampled households which were measured by tropical livestock unit (TLU) is 11.71 tropical livestock units. This is relatively implies that respondents uses livestock production with crop production (crop-livestock mixed farming system).

According to Abdulai, A., & CroleRees, A. (2001), livestock is one of the major assets for the farmers and also indicate the wealth of farmers. In this study farmers owned a wide range of livestock types that include like, milking cow, non-milking cows, trained oxen, bull, heifer, calves, donkey, horse, matured sheep, and young sheep and matured chicken.

Table 3.3 Description Statistics of socio-economic characteristics of the sample households

Variables	Min	Max	Std. Deviation	Variance
Total land holding(hectare)	0.20	7.00	3.60	1.76
Land Allocated for potato production	0.67	2.83	1.75	0.52
TLU	0.82	35.58	11.71	6.37

Source: Own survey result, 2021

Out of the total sample households, only 8.85% had utilized credit in the study area during the study year. This was due to credit services were providing with an interest rate. However, according to Islamic teachings, earning interest on credit is forbidden. Moreover, households used the credit to purchase inputs, buy livestock and food items as well as a start-up capital for petty trading. Access to timely information on prices and quantities play a crucial role in reducing the risk of losing money on a market transaction. However, the result of study revealed that only 24.78% of the sample household had access to markets information. The survey data indicated that only 9.73% of the total households have been receiving training. Low access to training leads to reducing the managerial ability of the farmers. Out of the total household interviewed, only 41% respondents were membership of multipurpose cooperative.

Table 3.4 Frequency table for nominal variables of institutional characteristics of the respondents

Variables	Response	Frequency	Percent	Cum. Percent
Access to credit service	no	103	91.15	91.15
	Yes	10	8.85	100.0
	Total	113	100.00	
Access to market information	No	85	75.22	75.22
	Yes	28	24.78	100.00
	Total	113	100.00	
Access to training	No	102	90.27	90.27
	Yes	11	9.73	100.00
	Total	113	100.00	
Membership of multipurpose cooperative	No	67	59.29	59.29
	Yes	46	40.71	100.00
	Total	113	100.00	

Source: Own survey result, 2021

Cost, Return and profitability analysis

The costs, returns and profitability analysis are presented on Table 3.5.

Gross Return

The gross return was computed by multiplying the total output from the sampled farmers in average per hectare by the farm gate price of potato per quintal at what they sold after harvested. The average price was 797.64 Birr per quintal while the average output obtained per hectare was 134.53 quintals. The gross return was 107,306.51 Birr per hectare.

Cost of Production

In estimating the total cost of production, only the variable costs components were considered. Since, fixed costs are negligible in small scale crop production (Nandi et al., 2011) Furthermore, the farmers used different inputs (i.e. seeds, fertilizer, and fungicide, labor and land cost.) to boost production and productivity of potato in the study area.

Cost of Seed

The farmers were accessed potato seeds from different sources like multipurpose cooperatives, local market, **and farmer-to-farmer seed exchanges**. The average market price for seed was 688.44 birr per quintal (6.88birr/kg) of potato seed. The total cost of potato seed for the farmers was 13,672.42 birr per hectare.

Cost of Fertilizer

Potato production, like any other crop, requires the use of different inputs. Fertilizer application is one of the most important practices that need to be used by potato growers. The average amount of fertilizer

used by the respondents were 5.03 quintals per ha. The average price of fertilizer was 1629 birr per Quintal. The total cost of fertilizer for all the farmers was 8,194.07 birr per hectare.

Cost of agrochemical (Fungicide)
Fungicide is the most chemical used for potato production in this study area.

Labour Costs

The labor cost includes the cost of land preparation, fertilizer application, planting, weeding and harvesting or human labor cost from pre cultivated to post cultivated. The average wage rate was 130.83 Birr per man-day and with the average of 40.35 men or labor used for a hectare starting from land preparation to harvesting. The total cost of labour for potato production was 5,278.99 Birr per hectare.

Land Cost
Land is one of the most important inputs in agricultural practices. Land cost was 6820 birr per hectare on average.

Total Variable Cost.

The total variable cost of potato production consists of the costs of fertilizers, seeds, agro chemicals and labour. Table 3.5 shows that the total variable cost was 36,905.59 per hectare. The high cost of production could be said to be responsible for the underutilization of the inputs by farmers.

Gross Margin

The gross margin represents the difference between the total returns (Gross returns) and the total variable cost. Table 3.5 depicts that potato producer farmer earned or profitable with a gross margin of 70,400.92 Birr per hectare. The result implying that potato production is profitable in the study area and farmers produce potato for improves their livelihood like as other crop.

Table 3.5 Gross margin per Hectare of potato production

Input variable(Items)	Average Quantity per ha	Price per unit	Total Value
I) Total(Gross) Return 1) Average Yield Qt/ha	134.53	797.64	107,306.51
II) Variable Cost 1) Seed Qt/Ha 2) Fertilizer Qt/ha 3) Agro-chemical (fungicide) Kg/ha 4) Labour man day/ha 5) Land Cost /ha	 19.86 5.03 4.16 40.35	 688.44 1629.04 599.41 130.83	 13,672.42 8,194.07 2,940.11 5,278.99 6,820.00
Total Variable Cost		36,905.59	
Gross Margin		**70400.92**	

Source: Own survey result, 2021

In the study area the major crops produced were include potato, wheat and barley. For producing a crop, costs and return are important factors which dominate the decision making process of the farmers. According to data collected during focus group discussion (FGD), Potato production is the most profitable as compared to wheat and barley production in this study area.

Econometric model analysis Results

In this subsection, the results of Cobb-Douglas production function were presented and discussed to analysis factor affecting potato production in the study area. The total potato production of farm household was influenced by different factors. The result depicts those three explanatory variables which have been found to significantly influence the dependent variables while one explanatory variable (Labour) was no statistically significant. Those three explanatory variables includes seed, fertilizer and agro-chemical were presented as followed.

Table 3.7 the result of Cobb-Douglas production model

Variable	Coef.	Std. Err	T	P>|t|	[95% Conf. Interval]	
Lnseed	.0003341***	.0000591	5.65	0.000	.0002167	.0004515
Lnfertilizer	.0010238***	.0002663	3.84	0.000	.0004947	.0015529
Lnagrochemical	.0492458**	.022655	2.17	0.032	.0042307	.0942609
Lnlabor	.0019608	.0043359	0.45	0.652	-.0066546	.0105761
Cons	3.230669	.1619641	19.95	0.000	2.90885	3.552488
R-squared = 0. 5615						
F(4, 89) = 28.49						
Prob > F = 0.0000						

Source: Own survey result, 2021

The result depicts that seed, fertilizer and agrochemical were an independent variable which is significantly influence total amount of potato output at 1%, 1% and 5% level of precision respectively. The result showed that R^2 value (0.5615) implies that about 56% of the proportion or variation of the potato output (dependent variable) were explained by explanatory variable included in the model. Similarly F-value (28.49) of the equation was significant at 1% level of probability and implies that the model was well defined.

The practice of appropriate input rate use is the main practice of potato production in the study area. The contribution of specified variable that affect output of potato production can be seen from estimated coefficient result of Cobb-Douglas production model above.

Seed(X_1): the value of production coefficient for seed was 0.0003341 which was significant at 1% level and had positive relationship with potato output. Positive significance indicates that as increase one unit of seed in potato production process resulted in boost increases the total output of potato production by 0.0334%. However, the seeding rate of potato is depends on the size of potato seed, by keeping other factor constant in study area.

Fertilizer(X_2): the coefficient of fertilizer was 0.0010238 points that as increase a unit of fertilizer in potato production process resulted in increases potato output by 0.1024% and this was significant at 1% level, by keeping other factor constant.

Fungicide(X_3): the value of coefficient of fungicide was direct relationship with potato output and significant at 5% level. The result shown that the value of coefficient of fungicide was 0.0492458 indicates that an additional a unit of fungicide in potato production process resulted, an increase 4.9246% of potato output, by keeping other factor constant in study area.

The summation of all coefficients of input in potato production was 0.0525. If the sum of all coefficient of input was less than one and greater than zero ($0 < \sum\beta_i < 1$) prevails that potato production was found in diminishing return to scale. If allocate their resource in second stage production zone, indicates that if all input used increased by one percent (1%), the total output of potato is increased by 0.0525%.

Pearson Correlation Analysis Between input used and potato output

The correlation analysis was ran to show the exact nature of the relationship between input and potato output. Table 3.7 shows that, all input has direct relationship with potato output level. However, two variables have strongly significant and positive relationship with each other. This depicts that, there were complementary nature of the input used in the potato production.

Table3.7. Pearson Correlation Coefficients

	Total output	Seed	Fertilizer	Fungicides	Labor
Total output	1.0000				
Seed	0.6167*	1.0000			
Fertilizer	0.5748*	0.5183*	1.0000		
Fungicides	0.2900	0.1230	0.2104	1.0000	
Labor	-0.0629	-0.0170	-0.1274	0.1486	1.0000

Source: Own survey result, 2021

Constraint faced by potato producer farmers

Table 3.8 shows that about 16% of sample respondent's faced the problem of land shortage , 6% were faced with problems of low productivity and about (65%) percentage of the respondents were faced the problem with lack of agricultural technologies like improved variety, fertilizer, and disease management technologies. However, 54% of the respondents faced a problem of Disease prevalence. About 12%, 34%, 4% and 60% of the respondents faces with the problems of weed prevalence, frost and insect prevalence and market problem prevalence respectively. The majority of the respondents were faced the problem associated with lack of agricultural technologies especially there is no potato harvesting technology in the study area.

Table 3.8 Constraints faced by the respondents

Problems	Frequency	Percentages	Rank
Land shortage	18	15.93	6
Low productivity	7	6.19	8
Lack of agricultural technologies	73	64.60	1
Disease prevalence	61	53.98	3
Weed prevalence	13	11.50	7
Frost prevalence	38	33.63	4
Insect prevalence	5	4.42	9
Wild life attack being bio-diversity hotspot	19	16.81	5
Market problem	68	60.17	2

Source: Own survey result, 2021

Conclusion and Recommendation

Conclusion

The study was initiated to carry out the economic analysis of potato production in Sinana, Goba and Dinsho districts of Bale high lands. Descriptive statistics and Econometric model, Cobb-Douglas production function were used by converting to log-log model to analysis factor affecting potato production. For producing a crop, costs and return are important factors which dominate the decision making process of the farmers and Economic analysis was followed for final decision making about competing economic enterprises profitability.

The finding shows that 97.35% of respondents were male and only 2.65% of respondents were female. The major inputs used to produce potato in study area were seed, fertilizer, fungicide and human labor and land. The total cost of potato production was 36,905.59 birr per hectare of land. The average gross return from potato production was 107306.51 birr. Accordingly, gross margin of production of potato was 70400.92 birr per hectare. Similarly, according to data obtained or gathered from FGD, potato production is the most profitable as compared to other crop produced in the study area.

The result of Econometric model, Cobb-Douglas production function model shows three explanatory variable which are seed, fertilizer and agrochemical were significant at 1%, 1% and 5% respectively with positive relationship to potato output while one explanatory variable which is labor was statistically not significant. Accordingly, R-square (0.56) shows that 56% of the variations in the total output of potato production could be explained by the explanatory variables (seed, fertilizer, agrochemical and labor) included in the model.

Currently, farmers faced with different constraints of potato production include; lack improved variety, market problem, disease prevalence, frost prevalence, wild life attack being biodiversity and other constraint were the more farmers' problem in the study areas. Especially unsuitable roads during rainy season with high cost of transportation were major marketing problems as per the information from FGDs, KII and household survey. The production and productivity along with profitability of potato production could be increased if the above mentioned problems are managed properly from the effort of all the responsible and concerned stakeholders.

Recommendation

Based on the findings of the study, the following recommendations were given:

- ✓ Majority of respondents were could not use the credit service from the credit institution. This is due to credit was given with an interest which is not allowable or unsuitable as Muslim religion and due to high interest rate. To minimize this problem, government should have to build or initiate credit service which is free from interest.

- ✓ More of respondents couldn't access to participate in different agricultural training in the area. There is need for more training of farmer by extension workers who need to be greater attention by government. In addition, if demonstrations on potato production is expanded and reach around this area by research center, farmer's awareness and their productivity is more increase.

- ✓ Market information and marketing system plays a great role in profitability of potato producer farmer in the study area. Market price is fluctuating with time to time and seasonally. However, farmers have limited market information and they sell their product to local trader with unsatisfied price. In order to sustain and improve those problems, concerned body should have to distribute updated market information among farmer especially with the time of harvesting.

- ✓ The practice of appropriate input rate use was the main practice of potato production in the study area. But potato producer farmers could not followed the input rate use which caused by poor awareness and poor linkage with DA and other agricultural experts. So, DA and other agricultural experts should have to capacitate farmers awareness about input rate use of potato production will boost potato output and increase farmers' profitability in this area.

- ✓ The most problem or constraints faced by potato producer farmer in the area was lack improved variety. Therefore, Agricultural Research center should have to generate improved variety that is appropriate to the needs and desires of smallholder farmers.

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Value Chain Analysis of Fish in Selected Water Bodies of central rift valley Oromia Region of Ethiopia

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Abstract

A value chain is a sequence of related enterprises conducting activities (functions) so as to add value to a product from its primary production, through its processing and marketing to the final sale of the product to consumers. At the household level, capture fishery plays a critical economic, nutritional, healthy and social role in the lives of smallholder households. This study was undertaken in West Arsi zone (Nagele Arsi district), East shoa zone (A.T.J. K, Lume and Bora district) and Arsi zone (Ziway dugda district) of Oromia region, with the title of Fish Value Chain Analysis in Selected Water Bodies of Oromia Region (Langano lake, Ziwai Lake and Koka reservoir). The main objective of this study is to assess the value chain analysis of fish in selected Oromia Water bodies of the three selected zones and to analyse market performance of fish along the chain actors. Both primary and secondary data were collected for this study. The data were collected by means of a semi-structured questionnaire from 240 respondents (180 fishermen, 5 fishing equipment supplier, 10 primary processors, 15 fish marketers, 15 fish consumers, 10 fish restaurants and 5hotels). Multi-stage sampling technique was followed to select households for the study purpose. During the first stage all districts where fishery production were taken place were identified purposively and at the next stage about 180 fishermen and marketing actors were selected randomly. Key informant interviews and focus group discussion were undertaken during the period of 2019 and 2020. The main functions in the fish value chain in the central rift valley area includes: input supply, production, processing, marketing and consumption of fish and fish products. The main value chain actors identified by the study were input suppliers, fish harvesters, fish processors, fish marketers and individual consumers in the study area.Total gross marketing margin in fish marketing is highest in channels VIII; it accounts a TGMM of 75.2%. Fishery cooperatives enjoy the highest net marketing margin that is 37 birr in channel VI. Producers share from the price paid by consumers is highest in channel III, which accounts 67.5% & followed by channel II which accounts 66% of the price paid by consumers. The lowest net marketing margin, which accounts 11Birr, is associated with fish processor in channel VIII of fish marketing channel in the study area. Binary probit model indicated that the fish processing and value addition were significantly affected by Access to modern transportation services, Access to the credit services, Education level of household head, Frequency of extension contact, household size, Availability of fish processing & equipment in the nearby town and selling price of fish in 2020. Illegal fish and fish product harvester and marketers, presence of illegal fishing equipment in lake Dambal and Koka reservoir, which can cause the serious over fishing problem, presence of bad weeds (water hygicienith) and chemicals from different factory which can cause fish disease in the Dambal Lake and Koka reservoir, high purchase prices of fishing equipment, Poor fishing nets, poor boating services, over fishing and low price were found to be the fish production and marketing constraints along the value chain actors in the study area. To point out the possible investment and research entry points so as improve the position of smallholder fishermen in the value chain system. Fish producers, Fishery cooperatives and other stakeholders should strongly work on value adding activities instead of selling whole fish. The policy implication is that the fishermen should be educated through extension services, providing modern input and technologies, strengthening of market extension and linking them with financial service providers and empowering fishery cooperatives to improve the fishery value addition development; thus income of individual fishermen could be enhanced. Government intervention should be needed to control illegal production and marketing of fish in the study area

Keywords: Fish, fish Value chain map, Marketing margin, marketing cost, Value addition

Introduction

Ethiopia covers a total area of 1.1 million km2 and an estimated population of 100 million in 2010 (Belay, 2010). Ethiopia is endowed with several water bodies that contain a high diversity of aquatic fauna. The inland water body of Ethiopia is estimated to be 7,400 km2 of lake area and about 7,000 km total length of rivers. The main drainage basins of Ethiopia are flowing away from the rift system either towards the Nile system in the west or to the Indian Ocean in the Southeast. The Ethiopian fresh water systems can be classified into seven drainage basins. These are the Abay, Awash, Baro Akobo, Omo-Gibe, Rift Lakes, Tekeze and Wabishebele-Genale basins (Tola et al, 2017).

Oromia's key assets are its diverse natural (water, soils, forests and wildlife) and human resources. The region has enormous water resources, with high potential for irrigation, hydroelectric generation, fishing, and other uses. The Oromia regional state has ample natural resources; water bodies constitute perennial and intermittent rivers, lakes, reservoirs and ponds with diversified fish species and potential for fish production. It appears that the potential for the development of river in fishery is vast (Alemu, 2014).

The fishery sector's contribution to the local economy is tremendous. Despite significant contributions that fisheries make to employment, nutrition, and trade in the developing world, it is rarely included in national development policy and donor priorities. This is largely due to the problems with valuation of small scale fisheries, as a policy makers often does not have access to data which reflect the importance of fisheries to the development. The availability of information on value chain analysis of fish production and marketing system is scanty. Therefore conducting value chain analysis of fish will be necessary in developing value chain of fish and prioritizing fisheries constraints in Oromia region.

Statement of the Problem

Ethiopia has many lakes, rivers and reservoirs and its approximately 960km at red coast line are fertile fishing grounds. Traditional processing of fish, sun drying, smoking has been tried to meet the market demand to the temporary or permanent settlement of community. The critical problem for decline of fish production and marketing system in different lake and river in Ethiopia are over harvesting, lack of proper knowledge, lack of modern fishing gears, siltation, seasonal factors, disposal of waste materials from industries and households home in to water bodies. This decreases biological activities of fish and creates shortage of special people live in and around the coastal area (Pattnaik, 2016).

In Ethiopia, the major problems that were identified by the stakeholders (the producers, consumers and hotel owners) involved in the fishing activities were lack of proper fishing gears; most of them use hook for fishing, Poor post-harvest handling and lack of proper fish processing and storage facilities, low price of fish as a result of low bargaining power of producers, lack of awareness, lack of transportation facilities, Poor culture of eating fish in the community, lack of enough boat in the area and lack of permanent fish market places or shops (EFASA,2011).

According to Tola *et al* (2014), the fishing sector of the economy has various problems, among others, mismanagement of the resources, inappropriate policies and institution, inadequate technical and material backup to the sector and market are the major ones.

Objectives of the Study

I. To identify major fish value chain actors and their roles and to draw map of fish value chain
II. To analysis market performance of fish along the chain actors
III. To identify determinants of value addition of fish production in the study areas
IV. To assess the major challenges and opportunities of fisheries sectors in the study areas

Research Methodology

In this chapter, description of the study area, sample size and sampling techniques, types and method of data collection were presented

Description of the Study Area

The study was conducted in selected districts of Arsi zone (Ziway Dugda district), West Arsi zone (Nagele Arsi district) and East Shoa Zone (A.T.J K, Bora and Lume district) of Oromia region. The study was conducted in three major water bodies (Langano lake, Dambal lake and Koka reservoir) of Oromia regional state and adjacent town including Arsi Nagele, Batu, Maqi, Alemtena, Modjo, Adama and Addis Ababa.

Lake Dambal is one of the freshwater Rift Valley lakes of Ethiopia. It is located about 160 Km South of Addis Ababa. The districts holding the lake's shoreline are A.T. J K, Dugda, and Ziway Dugda. On average, the lake is located at an elevation of 1650 masl and the lake is shallow and has an open water area of 434 Km^2 and shoreline length of 137 Km, a maximum depth of 8.9 m and an average depth of 2.5 m (Von Damm and Edmond, 1984). The maximum length and width of the lake is 32 km and 20 km, respectively (LFDP, 1997). There are two main feeder rivers to Lake Dambal, namely, Meki originating from Gurage Mountains in the Northwest and Ketar from the Arsi Mountains in the East; and it has one out flow in the South through Bulbula River, draining into Lake Abijata. Lake Dambal contains five main Islands: Tullu Guddo (4.8 Km^2), Tsedecha (2.1 Km^2), Debresina (0.3 Km^2), Funduro (0.4 Km^2) and Gelila (0.2 Km^2). Debresina and Gelila have only a few inhabitants, the other three are inhabited by several hundreds of people (Yared Tigabu, 2003).Technologies such as fish smoking technology was demonstrated at Tullu Gudo under Lake Dambal condition.

Koka Reservoir is located in the Awash River Basin in central Ethiopia (8 26^0N, 39 02^0 E). The 1200 Km-long Awash River, which has its headwaters in the plateau near Addis Ababa at 2300 masl, discharges below sea level into Lake Abbe in the Danakil Desert. Koka Reservoir is located at 90 Km South of Addis Ababa at an elevation of 1600 m. The districts holding the lake's shoreline are Bora, Lume, Adama and Doddota. It has a surface area of about 200 Km^2 and a capacity of 1650 mm^3. Koka reservoir consists of concrete with a length of 458 m and a maximum height of 47 m. It was created by the construction of the Koka Dam across the Awash River. The reservoir has an area of 180 km^2. The reservoir supports a fishing industry; according to the Ethiopian Department of Fisheries and Aquaculture,
625 tones of fish are landed each year, from which the department estimates is 52% of its sustainable a mount. Both the reservoir and dam is threatened by increasing sedimentation caused by environmental degradation as well as the invasive water hyacinth.

Langano Lake
Langano is a lake in the Oromia Region of Ethiopia, exactly 200 Km by road South of the capital city of Addis Ababa, on the border between the East Shoa zone and West Arsi Zones. It is located to the East of Lake Abijata in the Main Ethiopian Rift at an elevation of 1,585 meters (Lake Langano is 18 kilometers long and 16 km wide, with a surface area of 230 km^2 and a maximum depth of 46 meters (CSA, 2005). The lake has a catchment 1600 square kilometers in size, and is drained by the Hora Kallo river, which drains into the adjacent Lake Abijata (Robert et al, 1992). Lake Langano is popular with tourists and city-inhabitants. The lake is brown in color and at first sight one may think that the

lake is not clean. However this is not the case, the reason for the color is due to the richness of minerals including high sulphur levels which have led many to believe that the lake water has medicinal properties. There are a number of resorts around the lake like Africa vacation, Daka Langano, Bekele Mola, Sabana beach resort and water sports are popular.

There are variety of wildlife around the lake, which includes Hippos , Monkeys, Baboons, Warthogs, and a huge variety of Birds. The area around the lake is largely deforested, however, a large number of Herders live around the area (Samuel, 2002). Two Earthquakes had their ep icenter near this lake, the first in 1906 (a magnitude 6.8 on the Richter scale), and the second in 1985 (magnitude 6.2). Edo Laki Island (25-30m tall)is created after the Earthquake of 1906 GC. The geyser disappeared since 1966 – 1970, leaving a hot spring.

Sample size and sampling technique

Multi-stage sampling techniques were employed for this study. At the first stage representative districts like Nagele Arsi, A.T.J.K, Bora, Lume and Ziwai Dugda were selected purposively based on the potentiality of fish production and marketing. In consultation with respective agriculture and rural development offices, potential kebeles having a fish production and marketing were listed. In the second stage, the 3kebele were selected randomly from listed kebeles based on the potentiality of fishing activities and presence of individual fishermen and potential fish cooperative from the selected water bodies.

At the third stage a total of 180 fish producers were selected using proportionate simple random sampling methods from a total of 326 fish producer of the five selected districts. Finally; 5 fishing input supplier (2 from Batu town, 1 from Maqi town and 2 from Addis Ababa) , 10 fish processors (2 fish processors from each selected five districts), 15 fish and fish product marketers (3 fish and fish product marketers from each five districts) and 15 fish and other fish products consumer individual (3 fish and other fish product consumer individual from each five selected districts), 10 restaurants (each 2 restaurants from Batu, Maqi, Mojo, Adama and Addis Ababa) and 5 Hotels (each 1 Hotels form Batu Maqi, Mojo, Adama and Addis Ababa town) were purposively selected after specifying their name based on the information collected from the target respondents that for whom they sell their fish. In addition to this , key informants interview and 5 focus group discussions were held which contain 5-9 farmers were selected and involved in this study.The sample size determination was resolved by means of Yamane (1967) sampling formula with 95% confidence level.

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

Where: - n is sample size, N is the total number of fish producers in the selected districts (from Nagele Arsi 39 Fish producers, from A.T.J.K 87 Fish producers, from Bora 72 Fish producers, from Lume 81 Fish producesr, and from Ziway Dugda 47 Fish producers) and e is the desired level of precision which is 0.05.

Types of data and Method of Data Collection

In this study, both qualitative and quantitative data types were collected from primary and secondary sources. Secondary data were collected from zonal and district office published and unpublished material by using check list. Primary data was gathered from the fishermen, fish processors, fishery cooperatives, fish consumers and fish and fish product marketers (brokers, wholesalers and local collectors). The formal survey was done using semi-structured questionnaire and checklist prepared for each group (i.e. fish producers, fishery cooperatives, local collector, individual consumers, wholesalers, retailers, and restaurants/hotels). The group included all individuals participating in the value chain of fish in the study area. The informal surveys were done using Rapid Market Appraisal (RMA) technique

using checklists. Field observations also conducted to supplement primary data collected through individual interviews and group discussion in the study area.

Methods of data analysis

Based on the objectives of the study, both descriptive statistics and econometric models were employed to analyse data and come up with the results. Statistical tools such as Stata version 14 were used for analysis and provide output for the descriptive as well as for econometric models. Descriptive analyses were used to analysis characteristics of sample respondents. Costs and margins along the value chains were analyzed.

Value chain mapping: Value chain mapping is the process of developing a visual depiction of the basic structure of the value chain.
Market margin: marketing margin measures the share of the final selling price that is captured by a particular agent in the marketing chain
Value chain actors: are those involved in producing, processing, trading or consuming a particular agricultural product. The value chain actors are the main market actors related to specific product(s) exporters/importers, traders/retailers and end consumers (Feyera, 2013).

Results and Discussion

This chapter discusses the results obtained from the primary and secondary data. It consists the descriptive and econometric analysis of the sampled household characteristics in the study area.

Demographic and Socio-economic Characteristics of the sampled households

In this section descriptive analysis were used to describe characteristics of the sample households in the study area**.** Both continuous and categorical variables were used in order to describe the sample households included in this study. Table 1 shows, the percentage of the sample respondents based on household head sex in the selected survey districts.

Table1. Sex of sample respondents in the study area

Zone	Districts		Sex of household head		Total
			Female	Male	
West Arsi	Nagele Arsi	Count	7	19	26
		% within Survey district	26.92	73.08	100
East Shoa	A.T.J.K	Count	13	27	40
		% within Survey district	32.5	67.5	100
	Bora	Count	15	43	58
		% within Survey district	25.86	74.14	100
	Lume	Count	17	57	74
		% within Survey district	22.97	77.03	100
Arsi	Ziway Dugda	Count	9	33	42
		% within Survey district	21.43	78.57	100
	Total	Count	61	179	240
		% within Survey district	25.41	74.589	100
		% of Total	25.41	74.59	100

Source: Own survey result of 2020

Sex of household head: Out of 240 sample respondent, 25.41% were female household head where as 74.59% of them were male headed household. In Nagele Arsi District, 26.92 % were female and

73.08% were male headed household. In A.T.J.K district out of 40 respondents 32.5% were female while 67.5% were found to be male headed household. In Lume district out of 74 respondents 22.97 % were female headed while 77.03% were male headed household. In Bora district 25.86% were female while around 74.14% were male headed household head. In the case of Ziway Dugda district, 21.43% were female headed while about 78.57 were male headed household in the study area.

Table 2 shows the percentage of the sample respondents based on household head`s access to the modern transportation services in the selected survey districts.

Zone	Districts		Household head`s access to the modern transportation services		Total
			Accessed	Not accessed	
West Arsi	Nagele Arsi	Count	9	17	26
		% within Survey district	34.62	65.38	100
East Shoa	A.T.J.K	Count	11	29	40
		% within Survey district	27.5	72.5	100
	Bora	Count	9	49	58
		% within Survey district	15.51	84.49	100
	Lume	Count	40	34	74
		% within Survey district	54.05	45.95	100
Arsi	Ziway Dugda	Count	16	26	42
		% within Survey district	38.09	61.90	100
	Total	Count	85	155	240
		% within Survey district	35.42	64.58	100
		% of Total	35.42	64.58	100

Source: Own survey result, 2020

Household head`s access to the modern transportation services: Out of 240 sample respondent, 35.42% of them have got access to modern transportation services on fishing activities where as 64.58% of them had not obtain access to modern transportation services on fishing activities in the study area. In Nagele Arsi District out of 26 sampled respondents, 34.62 % of the respondents have got access to modern transportation services on fishing activities and 65.38% of them have not obtain access to transportation services on the fishing activities in the area. In A.T.J. K district out of 40 respondents 27.5% of the respondents have got access to the modern transportation services on fishing activities and 72.5% of them have not obtain access to it on the fishing activities in the area. In Lume district out of 74 respondents 54.05% of the respondents have got access modern transportation services on the fishing activities and 45.95% of them had not obtain access to it on the fishing activities in the area. In Bora district 15.51 % of the respondents have got access to modern transportation services on fishing activities and 84.49% of them have not obtain access to it on the fishing activities in the study area. In the case of Ziway Dugda district out of 42 respondents, 38.09% of the respondents have got modern transportation service access on fishing activities and 61.90% of them have not obtain access to it on the fishing activities in the study area.

Table 3 shows, the percentage of the sample respondents based on household head`s access to the market in the selected survey districts.

Zone	Districts		Market access		Total
			Accessed	Not accessed	
West Arsi	Nagele Arsi	Count	10	16	26
		% within Survey district	38.46	61.54	100
East Shoa	A.T.J.K	Count	18	22	40
		% within Survey district	45	55	100
	Boora	Count	22	36	58
		% within Survey district	37.93	62.06	100
	Lume	Count	30	44	74
		% within Survey district	40.54	59.46	100
Arsi	Ziway Dugda	Count	12	30	42
		% within Survey district	28.57	71.43	100
	Total	Count	92	148	240
		% within Survey district	38.33	61.67	100
		% of total	38.33	61.67	100

Source: Own survey result, 2020

Household head`s access to the nearest market: In the study area out of 240 sample respondent, 38.33% of them have an access to the market to sell their fish and other fish products where as 61.67% of them had not access to market to sell their fish products in the study area. In Nagele Arsi District out of 26 sampled respondents, 38.46 % of the respondents have got access to the market to sell their fish and other fish products and 61.54% of them have not obtain access to market to sell their fish and other fish products in the study area. In A.T.J. K district out of 40 respondents 45% of the respondents have got access to market to sell their fish and other fish products and 55% of them had not obtain market access to sell their fish and other fish products in the study area. In Lume district out of 74 respondents 40.54% of the respondents have got access to market to sell their fish and other fish products and 59.46% of the had not obtain market access to sell their fish and other fish products in the study area. In Bora district, 37.93% of the respondents have got access to the market to sell their fish and other fish products whereas 62.07% of them had not obtain market access to sell their fish and other fish products in the study area. In the case of Ziway Dugda district out of 42 respondents, 38.09% of the respondents have got access to market where as 61..90% of them have not obtain market access to sell their fish and other fish products in the study area.

Table 4 shows, the percentage of the sample respondents based on the availability of fishing equipment in the selected survey districts.

Zone	Districts		Availability of fishing equipment		Total
			Yes	No	
West Arsi	Nagele Arsi	Count	8	18	26
		% within Survey district	30.77	69.33	100
East Shoa	A.T.J.K	Count	25	15	40
		% within Survey district	62.5	37.5	100
	Bora	Count	27	31	58
		% within Survey district	46.55	53.45	100
	Lume	Count	39	35	74
		% within Survey district	52.70	47.30	100
Arsi	Ziway Dugda	Count	15	27	42
		% within Survey district	35.71	64.29	100
	Total	Count	114	126	240
		% within Survey district	47.5	52.5	100
		% of Total	47.5	52.5	100

Source: Own survey result, 2020

Availability of fishing equipment in the district: Out of 240 sample respondent, 47.5% of them have said yes whereas 52.5% of them have said No response about the availability of the fishing equipment in the study area. In Nagele Arsi District out of 26 sampled respondents, 30.77 % of the respondents had given yes response whereas 69.33 have given No response on the availability of fishing equipment in the district. In A.T.J. K district out of 40 respondents 62.5% of the respondents had given yes response whereas 37.5% have given No response on the availability of fishing equipment in the district. In Lume district out of 74 respondents 52.70% of the respondents had given **Yes** response whereas 47.30% have given **No** response on the availability of fishing equipment in the district. In Bora district 46.55% of the respondents had given Yes response whereas 53.45% have given No response on the availability of fishing equipment in the district. In the case of Ziway Dugda district out of 42 respondents, 35.71% of the respondents had given yes response whereas 64.29% have given No response on the availability of fishing equipment in the district.

Table 5 shows, the percentage of the sample respondents based on household head`s access to the credit services in the selected survey districts.

Zone	Districts		Access to credit services		Total
			Access	No access	
West Arsi	Nagele Arsi	Count	11	15	26
		% within Survey district	42.30	57.70	100
East shoa	A.T.J.K	Count	16	24	40
		% within Survey district	40	60	100
	Bora	Count	23	35	58
		% within Survey district	39.65	60.35	100
	Lume	Count	40	34	74
		% within Survey district	54.05	45.95	100
Arsi	Ziway Dugda	Count	12	30	42
		% within Survey district	28.57	71.43	100
	Total	Count	102	138	240
		% within Survey district	42.5	57.5	100
		% of Total	42.5	57.5	100

Source: Own survey result, 2020

Household head`s access to the credit services: In the study area out of 240 sample respondent, 42.5% of them have an access to the credit services for enhancing their fishing activities where as 57.5% of them had not access to the credit services for enhancing their fishing activities in the study

area. In Nagele Arsi District out of 26 sampled respondents, 42.3 % of the respondents have got access to the credit services for enhancing their fishing activities where as 57.7% of them have not obtain access to credit services for enhancing their fishing activities in the district. In A.T.J.K district out of 40 respondents, 40% of the respondents have got access to the credit services whereas 60% of them had not obtained credit for enhancing their fishing activities in the district. In Lume district out of 74 respondents 54.05% of the respondents have got access to credit services whereas 45.95% of them have not obtain access to credit services for enhancing their fishing activities in the area. In Boraa district, 39.65% of the respondents have got access to the credit services whereas 60.35% of them have not obtain access to credit services for enhancing their fishing activities in the area. In the case of Ziway Dugda district out of 42 respondents, 28.57% of the respondents have got access to credit where as 71..43% of them have not obtain credit access for enhancing their fishing activities in the area.

Table 6 shows, the percentage of the sample respondents based on household head`s membership in the fishery cooperatives in the selected survey districts.

Zone	Districts		Fishery cooperative membership of household head		Total
			Yes	No	
West Arsi	Nagele Arsi	Count	10	16	26
		% within Survey district	38.46	61.54	100
East Shoa	A.T.J.K	Count	27	13	40
		% within Survey district	67.5	32.5	100
	Bora	Count	27	31	58
		% within Survey district	46.55	53.45	100
	Lume	Count	39	35	74
		% within Survey district	52.70	47.30	100
Arsi	Ziway Dugda	Count	13	27	42
		% within Survey district	30.95	69.05	100
	Total	Count	116	126	240
		% within Survey district	48.33	51.67	100
		% of total	48.33	51.67	100

Source: Own survey result, 2020

Household head`s membership in the primary fishery cooperative (Yes/No Answer): In the study are, Out of 240 sample respondent, 48.33% of them have said yes whereas 51.67% of them have given No response whether they were a member of primary fishery cooperatives or not in the study area as a whole. In Nagele Arsi district out of 26 sampled respondents, 38.46% of them have said yes whereas 61.54% of them have given No response whether they were a member of primary fishery cooperatives or not in this district. In A.T.J.K district out of 40 respondents, 67.5% of them have said yes whereas 32.5% of them have given No response whether they were a member of primary fishery cooperatives or not in this district. In Lume district out of 74 respondents 52.70% of them have said yes whereas 47.30% of them have given No response whether they were a member of primary fishery cooperatives or not in this district. In Bora district 46.55% of the respondents have said yes whereas 53.45% of them have given No response whether they were a member of primary fishery cooperatives or not in this district. In the case of Ziwai Dugda district out of 42 respondents, 30.95% of the respondents had given yes response whereas 69.05% have given No response whether they were a member of primary fishery cooperatives or not in this district.

Table 7. Description of demographic characters for continuous variables

Variables	Nagele Arsi	A.T.J.K	Bora	Lume	Z.dugda	Overall	p-value
	(N=26)	(N=40)	(N=58)	(N=74)	(N=42)	(N=240)	
	Mean (SD)	mean (SD)	mean (SD)	Mean (SD)	mean (SD)	Mean (SD)	
Female in household	3.1(1.6)	3.3(1.8)	3.4 (1.9)	3.2 (1.4)	3.8(1.3)	3.3(1.5)	0.912
Male in household	4.4 (1.4)	3.6(1.5)	3.7(1.3)	3.4 (1.5)	4.7(1.6)	3.9(1.3)	0.047
Total household size	7.5 (2.4)	6.9(2.7)	6.7(2.2)	6.6 (2.8)	8.5(3.2)	7.2(2.3)	0.357
Female B/n 15-64 years	1.6(1.1)	1.4(1.8)	2.2(1.4)	1.4 (1.6)	2.1(2.4)	1.7(1.6)	0.743
Male B/n 15-64 years	1.8(1.3)	1.3(1.7)	1.5(1.8)	1.7 (1.8)	1.1(2.0)	1.3(1.7)	0.537
household size B/n 15-64	3.4(1.7)	2.7(1.9)	3.6(1.5)	3.1 (1.7)	3.0(1.9)	2.9(1.8)	0.235

Source: Own survey result, 2020

Household size: The average family size of the sample respondents was found to be 7 person in the study area. The average male member in the sampled household was around 4 person. In Arsi Nagele District it was 4 person, in A.T,J.K district 4 person, in Bora district 4 person, in Lume district 3person and in Ziway dugda district was around 4 person. The significance value of the t-test shows rejection of hypothesis that the average number of male in household is equal across the districts. So the average number of male in household is significantly different across the study districts at 10 % of significant level (Table 7).

Table 8. Description of demographic and socio-economic characters of sample respondents

Variables	Nagele	A.T.J.K	Bora	Lume	Z.dugda	Overall	p-value
	(N=26)	(N=40)	(N=58)	(N=74)	(N=42)	(N= 240)	
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
Household head education level	3.0(2.3)	3.8(3.1)	3.4 (2.9)	3.2(3.0)	3.8(3.5)	3.3(1.9)	0.003
Household head Fishin g experience	8.0 (6.3)	9.2(7.8)	9.4.7(7. 3)	8.4(7.5)	5.7(5.1)	8.2(7.4)	0.000
Household head`s Farm size	0.6(0.4)	0 .5(0.8)	1.0(0.7)	0.2(1.0)	0.4 (0.2)	0.5(1.0)	0.001
Fish caught by kg per day	45(21.1)	68(24.8)	64.2(19. 4)	50(22.1)	47.3 (20.4)	54.9 (29.6)	0.751
Frequency of extension contact per year	4.2(3.5)	3.2(2.4)	4.7.(3.8)	5.7(4.8)	6.1 (5.2)	4.7(3.7)	0.043
Fish price per kg in 2019/20 G.C	21(13.7)	30.5(17.9)	26.4(18. 5)	28.1 (14.7)	25 (11.9)	26.2(17.4)	0.035
Income from fish per month in 2019	2500.2(135 0.1)	2708.1(130 7.3)	2503.7(1333.2)	2642.5(129 7.3)	2591.4(1428.7)	2589.18(128 61.9)	0.079

Source: Own survey results of 2020

Education of household head: Education equips individuals with the necessary knowledge of how to make living decision. Literate individuals are very ambitious to get information and use it**.** As agriculture is a dynamic occupation conservation practices and agricultural production technologies are always coming up with better knowledge. The average year of formal schooling of total sample respondent is grade 3.The average year of formal schooling is grade 3, grade 4, grade 3, grade 3 and grade 4 in Arsi Nagele, A.T.J.K, Bora, Lume and Ziway dugda districts respectively .The mean difference of the groups is statistically significant at 1 % of probability level. It shows that, on average sample respondents has significance mean difference of year of schooling across all districts at 1 % of probability level.

Fishing Experience of Household head: In the study area, the average fishing experience of the respondents were found to be 8 years, while that of Nagele Arsi, A.T.J. K, Bora, Lume and Ziway Dugda districts were 8,9,9,8 and 6 years respectively. It showed that the average difference between the group is significant at 1% significance level. This showed that the average fishing experience of the respondents in all districts is not equal (see table 8).

Frequency of extension contact per year: The result of the study indicated that the average frequency of extension contact per year for the total sample on the fishing activity was 5 times. The average frequency of extension contact per year on the fishing activities is 4, 3, 5, 6 and 6 time in Nagele Arsi, A.T.J. K, Bora, Lume and Ziway dugda districts respectively. The mean difference of the groups is statistically significant at 5% of probability level. It shows that, on average sample respondents has significance mean difference across all districts at 5 percent of probability level.

Farm Size: On average total sample respondents have 0.5 ha of farm size for crop production in the study area. The average farm size of respondents is 0.6 ha, 0.5ha, 1, 0.2 and 0.4ha in Nagele Arsi, A.T.J.K, Bora, Lume and Ziway Dugda districts respectively. The mean difference between all groups was found to be significant at 1% probability level. This shows that the average land holding of sample households across all districts is not equal.

Price of fresh fish per kg in 2019 G.C by ETB: The average fish price per kg in 2019 production year for the total sample respondents was 26 ETB in the study area. In Nagele Arsi District it was 21 ETB, in A.T.J.K district 30.5 ETB, in Bora district 26.4ETB, in Lume district 28ETB and in Ziway dugda district it was around 25ETB per kg respectively for all commercial fish species (Nile tilapia, African catfish, Common carp and crucian carp) found in the selected in the selected water bodies. The significance value of the t-test shows rejection of hypothesis that the average fresh fish price per kg is equal across the districts. So the average whole fish price per kg of household head is significantly different across the study districts at 5 percent of significant level (Table 8).

Income from fish per month in 2019 G.C (ETB): The average monthly income of the total sampled respondents in 2019 production year was 2589 ETB in the study area. In Nagele Arsi District it was 2500 ETB , in A.T.J.K district 2708 ETB , in Bora district 2504 ETB , in Lume district 2643 ETB and in Ziway dugda district it was around 2591 ETB respectively for all commercial fish species in the study area. The mean difference between all groups was found to be significant at 5% probability level. This shows that the average monthly income from fresh fish of sample households across all districts is not equal.

Fish Value chain analysis

In value chain analysis, it is important to select potential value chain, which could create a potential impact on the livelihood of the target society or industry. This demands, analysis of value chain, which have a practical implementation in the development intervention from different perspectives. The selection of potential value chain could be considered from market potential, economic and social value and enabling environment. The market potential is proving the competitiveness of the intervening business from the perspectives of growth potential into industry, existences of unmet demand, potential for value adding, involvement of number of peoples, comparative advantage, and presence of leading firms and sustainability of the market.

Similarly, the economic and social perspective represents the target of an intervention into a designed business. The target indicates whether the interventions are to the priority challenges of a society to enhance their livelihood. From the target perspective, potential for employment generation, potential for income generation, potential for poverty reduction, potential to scale up, potential for outreach (cover larger area) and low risk from the major. The enabling environment is the existing favourable condition that supports the implementation of the interventions. These includes government/and donor involvement, favourable business environment, institutional mandates, environmental suitability, government strategies and social acceptances (Valuable) form the major

Similarly, Fish value chains include all inputs and services that enable fish production through harvesting from water bodies, processing and marketing of outputs, to the creation of added value products through consumption of fish and fish products. Value chains also include the institutional and governance arrangements that enable these systems to function. The study on fish value chains has identified the core functions, actors, market channels, constraints and existing opportunities.

Main Functions and actors in the Value chain of fishing activities in the study area

The main functions in the fish value chain in the central rift valley area includes: input supply, production, processing, marketing and consumption of fish and fish products, thus different activities were performed by the different actors.
The fish value chain passes through 5 key functions to reach the final consumer in general. However, these key functions are not mandatorily undertaken at a point of time and node but at different time.
Moreover, the whole fish and fish products supplied to the final consumers is not mandatory passes through these functions.

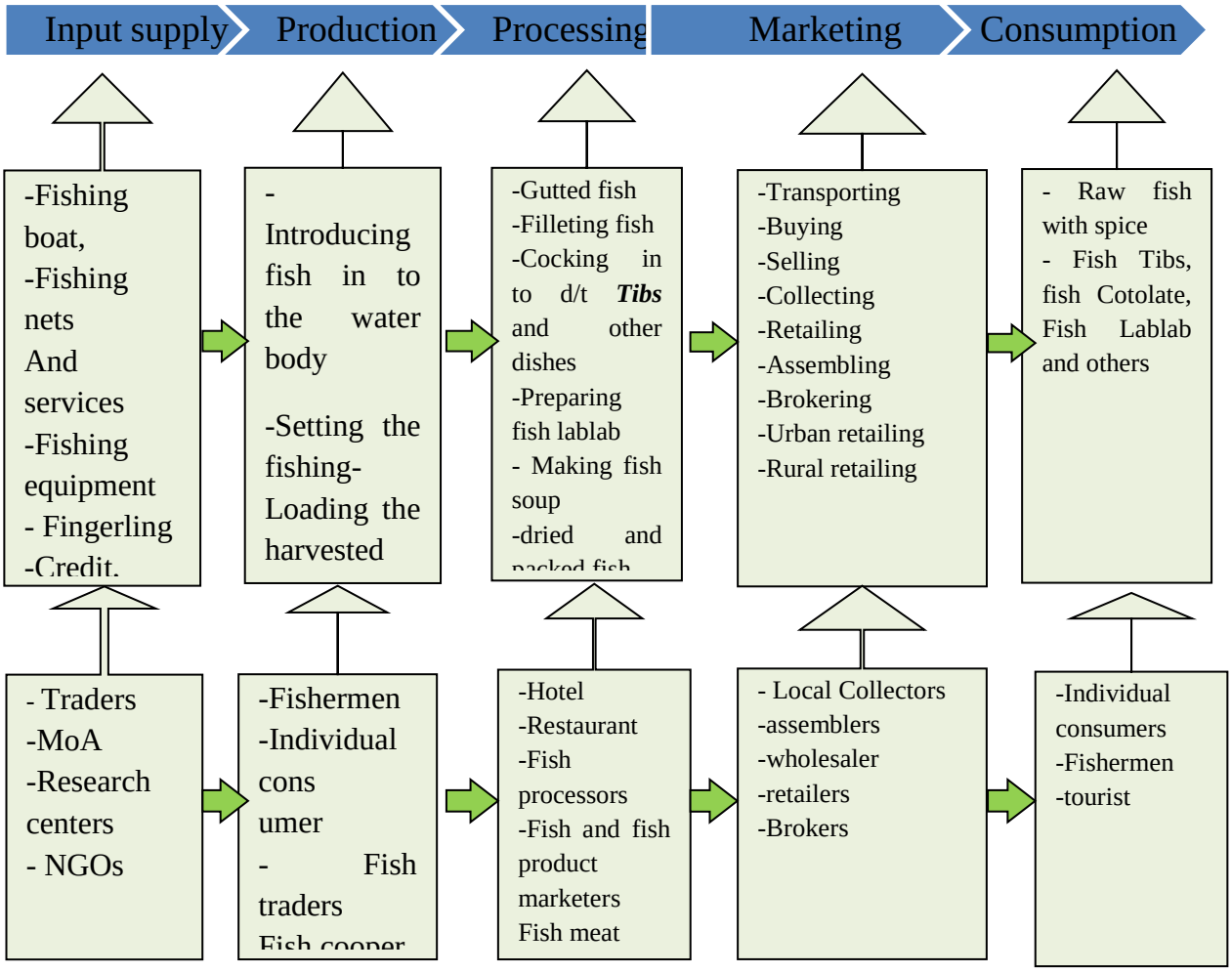


Figure 1. Main fish value chain function, marketing chain Actors and supporting actors

Actors and their role in fish value chain

There are several actors in fish value chains in the study area who engaged in various activities from fishing up to consuming. These actors have defined roles specific to the activities they perform and/or services they provide within the chains. The value chain map highlighted the involvement of diverse actors who are participated directly or indirectly in the value chain. According to KIT et al. (2006), the direct actors are those involved in commercial activities in the chain (producers, traders, processors and consumers) and indirect actors are those that provide financial or non-financial support services such as input suppliers, credit agencies, business service providers, government, NGOs, researchers and extension agents. In the case of this study area fisheries sector, an attempt had been made to analyze the current fish production and marketing channels and key actors involved in these chains and other relevant issues. Based on their roles and responsibilities the actors participating in this chain are discussed as follows.

Primary actors: The primary actors in fish value chain in this study area were input supplier, individual fish producers', fish producer cooperatives, fish processor, fish and fish product marketers and consumers. Each of these actors adds value in the process of changing product title. Some functions or roles are performed by more than one actor and some actors perform more than one role.
Input supplier: At this stage of the value chain, there are many actors who are involved directly or indirectly in fish input supply in the study area. Currently, individual fishing equipment trader at different town, district and zonal Office of Livestock and fishery development agency, Batu fish and other aquatic life research center, Sebeta fish research center, government and NGO's such as world

vision Ethiopia and fish for all are the main fish input supplier. The World Vision Ethiopia and Batu fish and other aquatic life research center is also supporting the fishermen on the lake and reservoir in giving the training and funding for provision of training and fishing equipment purchasing. All these actors are responsible to supply fish seeds and fishing equipment which are essential inputs at the production stage. There are also fishing input supplier from Batu town and Addis Ababa city to the study area.

Fish producers/Fishermen: Fishermen are people who earn their living by exploiting fish resources. Individual fish producers are the first link and major actors who perform the work of fish production and supply to the market in this study area's fish value chain. Their major functions in this value chain are mainly processing of fish at preliminary stage such as: putting the fishing net in to the lake, loading the caught fish on the fishing boat, fish harvesting, washing, cleaning, gutting, filleting and transport to their next customer. Their mode of transportation is using head load, hand load "Bajaj, lorry, car, bicycle and motor cycle. Since the products are very seasonal and perishable in nature, producers sell their produce immediately after harvest

Fish production overview: In the study area there are four commercial fish fish species such as: Nile Tillapia, Common carp, African Cat fish, and Crucial carp. The most productive and preferred species of fish in the study area is Nile tilapia fish species because of its availability and more sweet and can be easily filleted and gutted than the other species in the study area. The fishing equipment that the producers used were: gillnets, beach scene, long line, hook line, monofilament fishing net which is imported from Abu Dhabi, motorized fishing boats, locally made boat (Yabaloo) which is made of local materials, filleting and gutting blades were the main fish production equipment in the study area. The majority of the sample producers used the fishing equipment which was previously offered by support provider (supporting agents such as NGO: World vision Ethiopia and Batu fish and other aquatic life research center). The equipment's are timber made boat, fishing net, and motorized boat, additionally some of the individual fish producer uses locally constructed boat. As the respondents indicated they are responsible for the supply of **71,720kg** fresh fish/month of fish to the market in this study area. From Langano Lake, as the survey result indicated us the fishermen are responsible to supply **8,580 kg** of fish to the Nagele Arsi and Batu market in 2019/2020 production year monthly. In Dambal lake as the survey result indicated us the fish producers are responsible to supply **29,480** kg of fresh fish to the Batu, Maki and Addis Ababa city in 2019 production year monthly. In Koka reservoir the survey result showed us **33, 660 kg of** fresh fish were supplied to the Maki, Alemtena, Modjo, Adama and Addis Ababa market in 2019/2020 production year monthly.

Fishing Frequency: In the Langano Lake from the total of target respondents the average fishing day's frequencies per week of individual fish producer were 4 days per week with the minimum and maximum of 2 and 6 days per week respectively. In the Dambal Lake From the total of target producers the average fishing day's frequencies per week of individual fish producer were 5 days per week with the minimum and maximum of 3 and 7 days per week respectively. In the Koka reservoir from the total fishermen, which are selected from Bora and Lume district the average fishing day's frequencies per week of individual fish producer were 5 days per week with the minimum and maximum of 3 and 7 days per week respectively. It is discussed in table below. Table 9: Fishing frequency of the respondent fishermen per week in the study area

Water bodies	Production Days/week	Frequency	%age	Min	Max	Mean
Langano lake	2	4	16	2	6	4
	3	4	16			
	4	7	28			
	5	6	24			
	6	4	16			
	Total	25	100			
Dambal Lake	3	16	18.8	3	7	5
	4	21	24.7			
	5	15	17.65			
	6	18	21.17			
	7	15	17.65			
	Total	85	100			
Koka reservoir	3	13	18.57	3	7	5
	4	17	24.29			
	5	10	14.29			
	6	16	22.86			
	7	14	20			
	Total	70	100			

Source: own survey result, 2020

Fish Production, selling and Consumption overview: Fish production in the study area takes place all year round. However, the peak period for fish harvesting is between January and June. Based on the survey result the daily average fish production of an individual fish producer was 5.92kg/person and the average monthly volume of production was 71,720kg and 45,890kg (10,200kg from Langano, 21,100 kg from Dambal Lake and 14,590kg from Koka reservoir) for whole and semi-processed (filleted) fish respectively.

Some fishermen produces a combination of whole and filleted fish and very few fishermen produce only one of the two i.e. whole or filleted fish only. Accordingly from the total volume of fish produced monthly in the study area 19.5% were used by fishermen for home consumption, 5.5% were lost in different ways and the remaining 75% was supplied to the market through different market chan nels.

Table 10: Monthly average fish production, consumption, sale and their average sale price during fasting and non-fasting season of fish in the study area

Water bodies	Type of fish produced	Average monthly p roduced	Monthly consu mption (%)	Average monthly sale	Average sale price per kg	
					Fasting season	Non fasting season
Langano la ke (n=25)	8,580 +10, 200					
	Whole fish	343.2kg			35 ETB/kg	28.5ETB/k g
	Semi processed	408kg			100 ETB/KG	70.2ETB/k g
	Total	**751.2kg**	4.5%	17.25%		
Dambal La ke (n=85)	29,480 +21, 100					
	Whole fish	346.82kg			37.5	31
	Semi processed	248.23kg			105.3	77.5
	Total	**595.05kg**	9.5%	34.5%		
Koka reservoir (n= 70)	33,660+14,5 90					
	Whole fish	480.86kg			39.4	33.7
	Semi processed	208.4			105	79.5
	Total	**689.3kg**	5.5%	23.25%		

Source: Own survey of 2020

Fish processors: Individual fish processors are the second link and major actors who perform the work of harvested fish washing, cleaning, gutting, filleting and packing after harvesting.

Individual raw Fish and fish products consumers: Consumers are those who purchase the fish and other fish products from different sources of fish supplier for individual and home consumption purpose. They consume fish as a substitute protein food. Especially at Christian fasting season the preference of consumer to fish is highly increases. They prefer fresh, dried and filleted fish for consumption. They particularly buy from the fishermen, fishery cooperative, wholesalers, fish shops, retailers, restaurants and hotels at the markets often in small quantities. Those who live near the lake and reservoir and passengers who travel from Hawasa to Addis Ababa also buy from the fishermen themselves at different landing site.

Fish marketers: This actor consists Local collectors, wholesalers and retailers.
Local Fish Collectors: These are traders in assembly markets who collect fish from individual fisher at their production/landing site area and fishery cooperative for the purpose of reselling. As indicated from this study, they use their financial resources and their local knowledge to handle and transport their fish to their customer area. They play an important role in fish value chain in linking producer with traders and responsible for trading of fish and fish products from production area to wholesaler, retailers and consumer markets in the study areas. The other function of these actors is doing for time and place utility. Their role is buying and assembling, transporting and selling to the next actors in this value chain.

Wholesalers: In case of this study area most of fish whole sellers are averagely found 3 km far from the selected lake and reservoir in the selected districts and village and they are who buys whole fish, gutted, and filleted fish from the fishermen, local collector and fish producer cooperatives. They are the main assembly centers for fish in their respective surrounding areas and play an important role in linking fish producer with the other actors in the chain and doing for value addition as time and place utility. As this study indicated they are responsible for trading of **37,728.4kg** of fish monthly. They were involved in collecting a large volume of fish from their supplier and supply to fish retailers, fish products traders. They also, supply fish to traders who came from Addis Ababa, Mojo and Adama and restaurants and hotels at Batu, Maqi, Mojo, Adama and Addis Ababa town. They can transport to where their customer is located. Their mode of transportation is mainly using Lorry, Bajaj, bicycle, motor cycle and car to collect from their supplier and passenger car and minibus to transport to Batu, Maqi, Modjo, Adama and Addis Ababa town. They have better storage facility, transport and communication access than other actors in the chain.

Retailers: They are key actors in this value chain who link between producers and consumers. Mostly they buy from wholesalers and sell to consumers. As indicated from this survey their role in this study area is that; they clean and stores, provides fish and their products directly to the final consumer and sometimes they supply to restaurant and hotels at Batu, Maqi, Mojo, Adama and Addis Ababa town when there is shortage of fish supply. Consumers usually buy the product from retailers as they offer according to requirement and their purchasing power.

Fishery Cooperatives: Fishery cooperatives are one of the fish value chain actors in this study area and have a great role in this value chain. They are the second fish collector from fish producer. Their role in this fish value chain includes buying of fish from the individual producer at their store house and selling for their customer such as for wholesaler and direct consumer. Most of the fishery cooperatives have an opportunity to sell their fish to Hawasa to Addis Ababa voyagers at their shop since they are at the side of the main road. They are responsible to supply averagely 15,276.4kg of whole fish monthly to the restaurants, Hotels, final consumers and other market chain actors in the area.
Restaurants and hotels: The restaurants and hotels are where the consumers consume value added fish. Once they buy fresh fish from wholesalers; they store in refrigeration, prepare by roasting and pickling (addition of spice and vegetable) and called ‘’Asa batikilt, Asa Tibsi, Asa dulet, Asa soup, Asa lablab, raw fresh Asa by adding spice and liqour and Asa Kotelete’’ to satisfy their customer. They are more responsible for time, place and form utility for their customer. In rare case when there was shortage of supply of fish from their regular customer (whole seller) they collect fish from retailers. Since they do more value addition on their fish and incur additional costs during processing and preparation they gain more profit margin.

Supporting actors: are those who provide supportive services for fish producers on the selected lake and reservoir including supplying fish seed, fishing net like beach siene, gillnet hook line, long line and other inputs, training and extension, different information, financial and credit services and legality concern services. According to Martin et al. (2007), access to information or knowledge, technology and finance determines the state of success of value chain actors. District, zonal and state level livestock and fishery development office, Batu fish and other aquatic life research center, Banks, and rural micro finance are the main supporting actors who play a central role in the provision services in fish value chain of this study area. Different NGO’s who are performing their work on natural resource conservation henceforth for the sustainability of the lake and reservoir provides economic support to fishermen.

Fish processing and post-harvest handling: Fish which is produced in the study area was supplied to the market either as gutted, whole fish or filleted fish. As the survey result indicated there were no further fish processing activity undertaken but mostly the fish producer accomplish only the preliminary fish processing activity such as: washing, filleting, gutting, cleaning and sorting and very

few of them add some processing and preservation activity such as plastic packing and storage facility. Once the fish is caught they do only for preliminary processing (i.e. washing, gutting, cleaning) and taken directly to the market for selling without any further processing and value addition. The situation therefore impact on the next actors in the chain to find ways of preventing the fish from going bad because there was no preservation for their fish. Therefore; the cumulative result of this study shows they do only for preliminary fish processing.

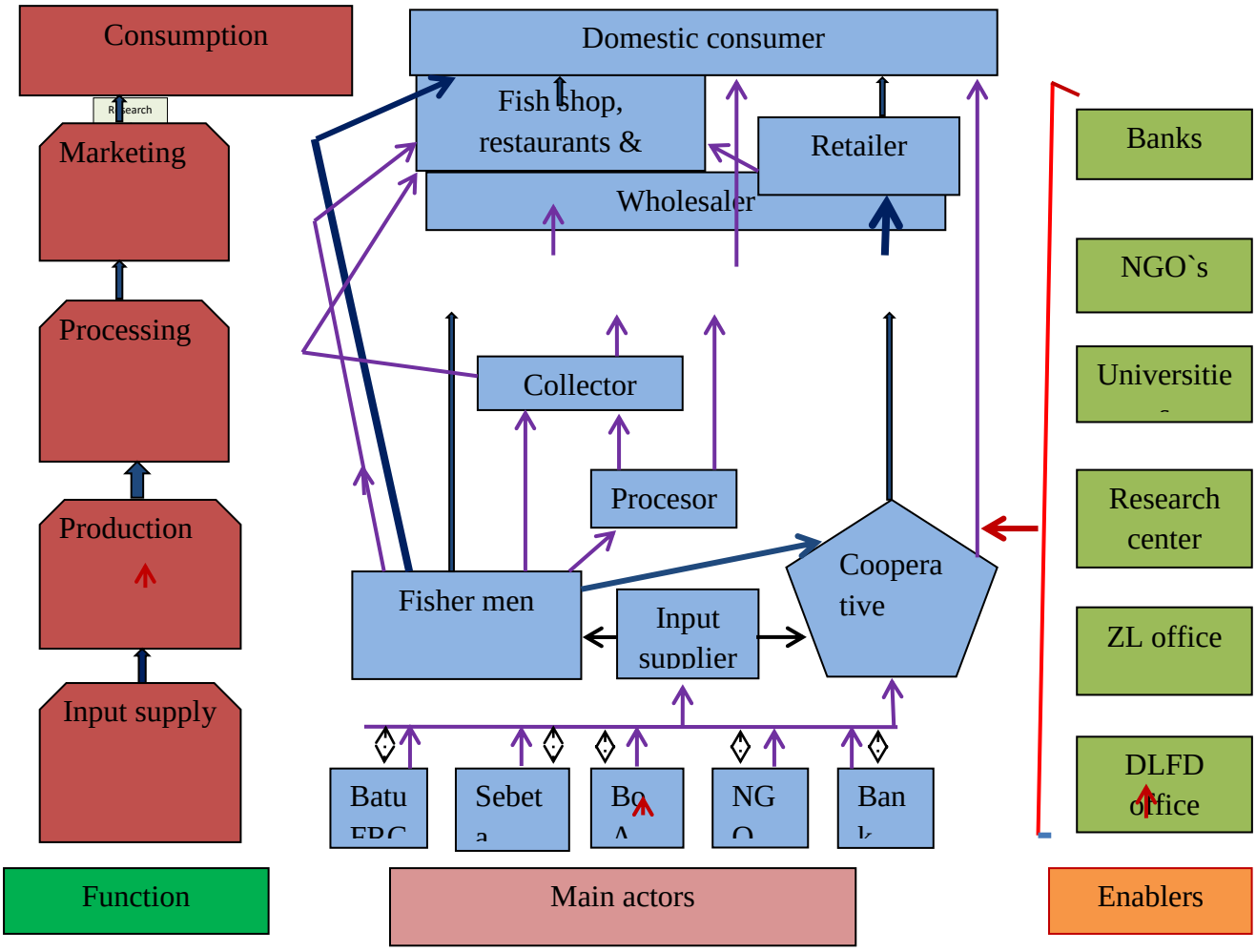
The following table 11 shows the existing ways of fish processing and value addition in the study area

Type of fish processing and value addition	Respondent response	
	Frequency	Percentage (%)
Washing	205	85.5
Cleaning	192	80
Gutting	174	72.5
Filleting	125	52
Sorting	90	37.5
Plastic Packing	38	15.8
Smoking	12	5
Salting	32	13.5
Storage and Refrigeration	35	14.7

Source: Own computation from survey result, 2019/20.

Value chain mapping

According to McCormick and Schmitz (2001), value chain mapping enables to visualize the flow of the product from conception to end consumer through various actors. It also helps to identify the different actors involved in the fish value chain, and to understand their roles and linkages. The value chain isn't necessarily straight it has vertical relationships as the product moves through different processing stages and it has various horizontal relationships as the product passes to multiple markets (Hempel, 2010). An important concept is that no matter its direction, all decisions made at one step have consequences thereafter. Value chains can be mapped and analysed further using a value chain analysis framework. Consequently, the current value chain map of fish in study area is depicted in Fig. 2 below.



Represents much flow of fish & fish products through the chain
Represents flow of fish products
Represents two way flow of information and technology
Represents one way flow of fishing input & equipment

Source: Own sketch from survey result, 2020

Figure 2: Map of fish and fish product value chain in the study area

Fish Market performance along the chain actors

Marketing performance of fish market was analysed by estimating the marketing margin, by taking into consideration associated marketing costs for key marketing channels. The marketing margin refers to the difference between prices at different levels in the marketing system. The total marketing margin is the difference between what the consumers pays and what the producer/fishermen receives for his fish, in other words it is the difference between retail price and farm price. A wide margin means usually high prices to consumers and low prices to producers (Mendoza, 1995). Performance of the market is reflection of the impact of structure and conduct on product price, costs and the volume and quality of output (Cramers and Jensen, 1982). Market performance can be evaluated by analysing costs and margins of marketing agents in different channels. A commonly used measure of system performance is the marketing margin or price spread. Margin or spread can be useful descriptive statistics if it used to show how the consumer's price is divided among participants at different levels of marketing system.

Marketing costs refers to those costs, which are incurred to perform various marketing activities in the shipment of goods from producers to consumers. Marketing cost includes: Handling cost (packing and unpacking, loading and unloading putting inshore and taken out again), transport cost, product loss (particularly for perishable fruits and vegetable), storage costs, processing cost and capital cost (interest on loan), market fees, commission and unofficial payments (Heltberg and Tarp, 2001).

Estimates of marketing margin are the best tools to analyses performance of market. The cost and price information used to construct marketing cost and margin have been gathered from fish value chain actors such as, producers, collectors, retailers, wholesalers and consumers. Computing the total gross marketing margin (TGMM) is always related to the final price paid by the end buyer and is expressed as percentage (Mendoza, 1995).

Fish marketing channel in the study area

The marketing channels of fish identified below shows how commodity fish and fish products passes through eight complicated routs of intermediaries on the way from point of fishermen to reach ultimate users. From the Figure 3 below, one can understand that the main receivers of fish product from the producers were Central wholesalers (52.6%), Fishery cooperatives (21.3%), consumers (16.1%), Hotel and restaurants (7%) and fish processors (3%). Based on the volume of fish products flown, the marketing channels were compared with each other. Accordingly, the producer- fishery cooperatives-central wholesalers-retailers-consumer channel, (channel 6) carries the larger volume of fish products transacted followed by producer- central wholesalers — retailers -- consumer channel, (channel 4). The major identified channels of fish and fish products during the survey were explained as follows in Figure 3 below.

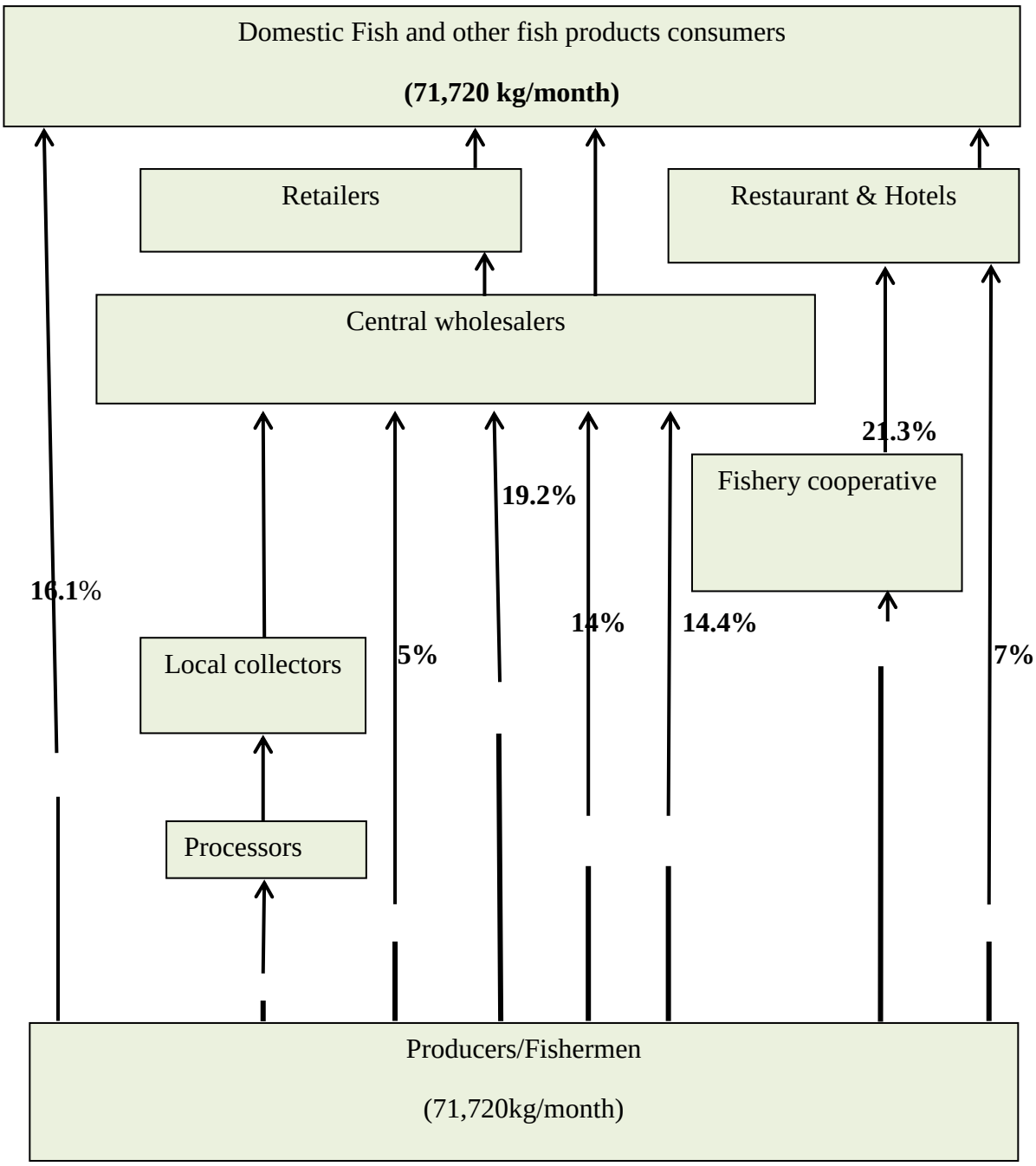


Figure 3. Fish and fish product marketing chain in the study area

Chanel I Producer ⇨ Consumer
Chanel II Producer ⇨ Central Wholesalers ⇨ Consumers
Chanel III Producer ⇨ Restaurants & Hotel ⇨ Consumers
Chanel IV Producer ⇨ Wholesalers ⇨ Retailers ⇨ Consumers
Chanel V Producer ⇨ Wholesalers ⇨ Hotel & Restaurants ⇨ Consumers
Chanel VI Producer ⇨ Cooperative ⇨ Wholesaler ⇨ Retailers ⇨ Consumers
Chanel VI I Producer ⇨ Collector ⇨ Wholesalers ⇨ Restaurant& Hotels ⇨ Consumers
Chanel VIII Producer ⇨ Processor ⇨ Collector ⇨ Wholesaler ⇨ Restaurant ⇨ Consumer

Figure 4. Major identified channels of fish during the survey

Fish gross marketing margin and value share

Fish market performance in the study area was examined by analysing marketing costs and price margins among the different fish marketing activities in order to measure the degree of fish marketing efficiency. Computing the total gross marketing margin (TGMM) is always related to the final price paid by the end buyer and is expressed as percentage (Mendoza, 1995).

$$\text{TGMM} = \frac{\text{Final Consumers Price} - \text{Producers Price}}{\text{Final Consumers Price}}$$

Where, TGMM is total gross marketing margin

In addition to margins, the share of each participant from the final price paid by the consumer will also computed for each participant in the channel by dividing their respective profit margin with the consumer price. The comparison of this information with marketing costs incurred at each level in the channel helps to suggest the point where problems may exist in the marketing channel, thereby indicating where improvements can be made to achieve efficient coffee marketing. The producer's margin or share in the consumer price (GMMp) is calculated as:

$$\text{GMM}_{\text{P}} = \frac{\text{Consumers Price} - \text{Marketing Gross Margin}}{\text{Consumers Price}} \quad \text{Or} \quad \text{GMM}_{\text{P}} = 1 - \text{TGMM}$$

Table 3. Marketing margins maintained by marketing actors in fish marketing channel.

Marketing actors	Fish marketing channels (Birr/Head)							
	I	II	III	IV	V	VI	VI I	**VI I I**
$\text{NMM}_{\textbf{proc}}$	-	-	-	-	-	-	-	**11**
$\text{NMM}_{\textbf{col}}$	-	-	-	-	-	-	17	14
$\text{NMM}_{\textbf{cop}}$	-	-	-	-	-	**37**	-	-
$\text{NMM}_{\textbf{ws}}$	-	19	-	33	31	20	23	27
$\text{NMM}_{\textbf{rt}}$	-	-	-	34	-	25	-	-
$\text{NMM}_{\textbf{rs}}$	-	-	28	-	24	-	20	24
TGMM (%)	35	34	32.5	55	55.3	70.8	71.7	**75.2**
Producers margin or share (%)	65	**66**	**67.5**	45	45.6	29.2	28.3	24.8

Source: own survey result, 2020

The above table, Table 3 summarizes marketing margins maintained by each actor in various fish marketing channels. Total gross marketing margin in fish trading is highest in channels 8; it accounts a TGMM of 75.2%.Fishery cooperatives enjoy the highest net marketing margin that is **37** birr in channel VI . Producers share from the price paid by consumers is highest in channel III, which accounts 67.5% & followed by channel II which accounts 66% of the price paid by consumers. The lowest net marketing margin, which accounts **11Bir**r, is associated with fish processor in channel VIII of fish marketing channel in the study area.

Determinants of fish value addition along the chain actors in the study areas

Thirteen variables were hypothesized to explain the determinants of fish value addition of individual fish producer in the study area; such as household size, access to the modern transportation services, Education level, fishing experience, availability of fishing equipment, sex of household head, farm size, household head annual income, access to extension service, selling price of fish in 2019, membership of fishery cooperative, access to nearest market information and access to credit service. Out of these eight (household size, education level, access to the extension services, access to credit services, selling price of fish and other fish products in 2019, access to the modern transportation services and access to the nearest market information and availability of fishing equipment) of the variables were found to be significant, while the remaining six were less powerful in explaining the determinants of fish producer's processing and value addition on their fish and other fish products in the study area. The maximum likelihood estimates of the logistic regression model show that household size, education level, access to the extension services, access to credit services, selling price of fish and other fish

products in 2019, access to the modern transportation services and access to the nearest market were important factors influencing fish value addition in the study area. The following table 9 shows the probit model results of this study. The Pseudo R^2 shows approximately 0.78. Indicating that variations in probabilities of value addition of fish by the actors in the sample surveyed were explained by about 78 % of the probit model.

Table 9: Estimated binary probit model and the effects of explanatory variables on the probability of fish value addition along the chain actors

Variables	Coefficient	Robust Std. Err	Z	Marginal effect
Access to the credit services	**0.8893*** **	0.3168	2.81	0.2301
Access to the market information	**0.0798*** **	0.0271	2.94	0.0207
Access to the modern transportation services	**0.7695** **	0.3497	2.20	0.1805
Education level of household head	**0.3138*** **	0.1163	2.70	0.0814
Access to extension services	**0.0564** **	0.0242	2.32	0.0146
Household size	**0.603** **	0.;281	2.150	0.137
Selling price of fish in 2019 G.C	0.0004	.1265	0.003	0.251
Fishing experience	-0.8513	0.6328	-1.35	-0.1634
Availability of fishing equipment	**1.4504*** **	0.4246	3.41	0.3465
Sex of household head	0.0004	0.0224	.0224	0.0001
Membership of fishery cooperative	0.1265	.092	1.37	0.0328
Farm size	0.0923	0.2338	0.39	0.0239
Annual income of household head	0.2352	0.3852	0.61	0.0612
Pseudo R^2	0.78			
Log likelihood	-31.53			
Prob > Chi^2	0.0000			
Wald chi2(13)	110.33			
Number of observation	180			

***, ** and * represent level of significant at 1%, 5% and 10% respectively

Source: Computed from the field survey data, 2020.

Access to modern transportation service: It had a positive and statistically significant effect on the producers` participation production and in fish value addition in the study area. The model result indicated that the probability of participating in fish value addition increases by 18% if the head gets access to modern transportation service. Modern transport improves the quality of fish product by minimizing the perishability of the product and facilitates the interaction between surplus and deficit geographical areas. This indicates that transportation service is a crucial factor to create a market for fish production and processing, which improves the living standards of the households. According to Kumolu-Johnson and Ndimele (2011), fish is the most perishable food item especially in the tropical climates of developing countries. Therefore, modern transportation service is a viable solution to minimize the degree of perishability. Similarly, most of the fish catch from the lakes reach the market by traditional means of transportation which causes mechanical stress to fish products (Hirpho, 2017). This entails that modern transport service enables farm households to supply raw and processed fish in different areas where fish products have higher demand. This helps them to receive a better price for their product and increase their benefit from their product which leads to the improved living standard of their household members. The discussion by Asmah (2008) reported that fish is one of the most perishable of human food item, which starts spoiling soon after death. The perishability nature of fish after death and lack of modern transport service heavily hamper the participation of farm households in fish production. Therefore, effective transportation service coupled with value addition activities minimizes the spoilage of fish after death. This entails that modern transport services increase farm households' participation in fish value addition in the study area.

Access to the credit services: The results of the probit model show that this variable affects the processing and value addition of individual fish producer on their fish product is positively and significant at 1% probability level. The marginal effect value shows that whenever the producers' access to credit service increases by 1% the processing and value addition on their fish product increases by 23%. This means accessing credit of individual fish producers increases the capacity to purchase fishing and processing equipment of the fishermen to accomplish further processing and value addition on their fish.

Access to the market information: It affected the process of value addition of individual fish producer on their fish positively and significantly at 1% significance level. This is the binary probit estimate for a one unit increase in market information; given the other variables in the model are held constant, increases the value addition on the fish by 2%. This means whenever fishermen try to get market information they collect about the type of product the customers want.

Education level of household head: This variable was found to be an important variable in fish value addition of individual fish producer on their fish and other fish products and affects positively and significant at 1% significance level. The marginal effect of this value shows the probability of value addition of fish and other fish products is found to be increased by 8 % when the level of education increases by 1 % of who learnt formal education. Therefore, if individual fish producers' gets formal education and learn more, there is a possibility to apply more fish processing and value addition activity in the study area. This is in-line with (Odebiyi et al., 2013) who found that education is an important factor which can determine level of awareness on the value addition in fish and other fish products.

Access to extension services: The results of the probit model show that this variable affects the processing and value addition of individual fish producer on their fish product is positively and significant at 5% probability level. The marginal effect shows that whenever the producers' access to credit service increases by 1 unit, the processing and value addition on their fish product increases by of 1.46%. This means accessing credit of individual fish producers increases the capacity to purchase fishing and processing equipment of the fishermen to accomplish further processing and value addition on their fish and other fish products.

Household size: This variable had a positive and statistically significant effect on households' participation in fish and fish products processing and value addition. The model result revealed that the probability of participating in fish processing and value addition increases by 13.7% for a unit increase in household size. This relationship indicates that large household size increases the households' participation in fish and fish products processing and value addition. This is because having a large household size requires more food and income to satisfy their basic needs. In the study area, fish production is the dominant income and food source. As a result, the household head who has a large household size has to participate in different fish production, fish and fish products processing and value addition activities to full fill the basic needs of his/her household members. The result of this study is consistent with previous studies (Birhanu, 2015).

Availability of fishing processing &equipment in the nearby town: Fishing and processing Equipment is another variable which is significantly related to the dependent variable and that affects positively and significantly at 1% probability level. The marginal effect of this variable shows that the probability of fish processing and value addition of an individual fish producer increases by 34% when an individual producers having more fishing equipment increases by 1 unit. The reason behind this is that an individual fish producer farmers accessing more fish processing and handling equipment's have more opportunity to do more processing and value addition for their fishes and other fish products; because when the fishermen own more fishing equipment they can further process and do for more value addition on their fish and fish products.

Major Constraints and opportunities in fish Value chain in the study area

Major Constraints in fish Value chain in the study area

Accordingly major constraints faced by fish production system, based on interview of respondents, focus group discussion and key informants interview, in the study areas were identified and are presented in the following table

Table 10. Major Constraints along the fish value chain in the study area

Major Constraints	**Frequency**	**Percentage (%)**	**rank**
Expansion of illegal fishermen, traders and illegal fishing nets, which leads Overexploitation of fish stock	55	22.91	1st
Lack of improved fishing technologies and training services on the fishing activities	43	17.91	2nd
Fishery regulation problem	39	16.25	3rd
Low price of fish and fish products and weak bargaining power	35	14.59	4th
water hyacinth and waste disposal problem at Dambal Lake & Koka reservoir	31	12.91	5th
agricultural expansion and wetland degradation	20	8.33	6th
climate change, fish disease and low yield of fish species	17	7.08	7th

Source: own survey result, 2020

Major opportunities in fish Value chain in the study area

According to the respondent, focus group discussion and key informant interview response, the major opportunities for fish production, processing and value addition in the study area include creation of job opportunities for the youth (22.5%), Presence of Oromia saving and credit institute in the area and this may give some insight to the fishers to become economically more influential (3%). Likewise, the pres ence of fishery proclamation contributes to ban illegal fishing instruments and protect the fishery (2.5%), Presence of different resorts, fishery cooperative and international and domestic tourists in the area (15.36%), presence of Batu fish and other aquatic life research center at Batu town, which mainly support fishery development sector and establish a lot of fish cooperative within which fishing activities are encouraged (15%), presence of indigenous knowledge of the farmers about the fishing activities (7%), increased fish product demand by international and domestic tourists (9%), expansion of Arsi Nagele, Batu, Meki, Alemtena, Modjo and Adama city and nearside of the city of the above mentioned lakes and reservoir makes the sector more efficient and effective (11%) and the presence of Bofofe (type of tree) used for the production of a traditional boat called Yabala helps fishermen to operate fish and use it in moving around the shores of lakes (14.54%). Fishery cooperatives are one of the fish value chain actors in this study area and have a great role in this value chain. They are the second fish collector from fish producer. Their role in this fish value chain includes buying of fish from the individual producer at their store house; store it in refrigeration, plastic packing and selling for their customer such as for wholesaler and direct consumer. Most of the fishery cooperatives have an opportunity to sell their fish to Hawasa to Addis Ababa voyagers at their shop since they are at the side of the main road.

Conclusion and Recommendation

The analysis of fish value chain revealed that the main value chain actors are input suppliers, fishermen, fish producer cooperatives, local fish collectors, wholesalers, retailers, restaurants and hotels and finally consumers. Currently the district and zonal office of agriculture, Batu fishery research center, Bureau of agriculture, micro financial institution, and NGO's such as world vision Ethiopia are the main support provider. The value chain supporters or enablers provide facilitation tasks like awareness creation, facilitating joint strategy building and action and the coordination of support. Therefore; based on analysis results mapping of fish value chain were developed.

With regard to econometrics results the determinants of fish value addition were found to be an important element in the study of fish value chain. Thirteen variables were hypothesized to explain the determinants of fish value addition of individual fish producer. Finally; the result of binary probit model shows that only seven variables were important factors influencing positively and significantly individual fish producers' value addition on their fish in this study area.

Therefore, to promote fish value addition in a sustainable way some policy implications are suggested to be addressed by stakeholders: effort should be made to strengthen fishermen cooperative and encourage collective action of stakeholders to make the fishermen benefited, Supporting the fishermen in providing a continuous awareness creation and training through extension, facility for access of modern input and fishery technologies, encourage the producer to participate in competitive market and strengthening of market extension (linking fishermen with competitive fish markets, building marketing capacity of fishermen, etc.) and promote the financial service providers and accordingly extension workers should give attention to encourage them. Hence, it improves their skill to further processing and value addition on their fish. Finally, the future research need to be conducted on production and value addition of fish to identify the existing limitation on market need based fish production, further processing and encouraging them for commercial fishing system by using of modern fishing equipment to make the fish producer more benefited.

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Perception and Adaptation Strategies of Fishing Communities to the Impacts of Climate Change in the Rift Valley of Oromia Region

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Abstract

The effects of climate change have negatively affected Ethiopia`s agricultural production. Therefore, this study was proposed on the Dambal Lake and Koka reservoir to assess the perceived effects of climate change on the fishing communities and their coping strategies. In this context, fisheries have been providing alternative livelihoods. This study used quantitative and qualitative methods to determine the extent to which fishers around the selected water bodies in the rift valley were copying with perceived changes in climate variables and the impacts on their livelihoods, to generate knowledge to enable the fishers increase resilience and sustain their livelihoods. Fishers were aware of changes in climate manifested by unpredictable seasons, floods and droughts. Fishing was the main livelihood activity. However, there is a knowledge gap around the responses of small-scale fishers to climate-related changes. It is evident that the fishers are aware of long-term changes in climatic factors (temperature and rainfall). There were also adaptation and mitigation measures practiced by the fishers which if promoted and their constraints addressed, could increase resilience of fishers to climatic change and sustain their livelihoods. Out of 10 adaptation strategies identified by the fishermen, the 5 main identified adaptation strategy decisions were subsequently used as the dependent variables in the multivariate probit model. The result of the Multivariate Probit Model showed that some fishers` household and socio economics characteristics, and access to services factor were statistically influenced the choice of coping strategies used by the fishermen in the study area. The positive pair wise correlation matrix from the MVP model indicates complementarities among all the coping strategies used by the fishers. The government could build the capacity of agricultural extension systems and make available climate change education arrangement with ICT innovations. Government policies and investment strategies must be geared towards the support of education, credit services and climate related information about adaptation to climate change, including technological and institutional methods, mainly for fish producers in the study area.

Keywords: Fishers, fisher`s perception, climate change, Determinants, adaptation strategies

Introduction

Climate change is projected to impact broadly across ecosystems, societies and economies, increasing pressure on all livelihoods and food supplies, including those in the fisheries. There is an urgent need to better understand where climate change is most likely to reduce livelihood options for fishers and where there is the greatest need to invest in alternative rural and urban enterprises. Climate change is among the problems that hinder sustainable livelihoods and economic development, particularly for developing countries (Shemsanga et al., 2010). Ethiopia is highly vulnerable to climate change and low capacity to adopt and perceived. Climate change is a natural phenomenon which influences agricultural production and negative effect on the social and economic activities and lead to food insecurity in particular (MoFED, 2010).

Climate change affects all aspect of economic growth especially in least developing countries. To reduce the impact of climate change and enhance food security, adaptation measures are urgently required. The process of adaptation options are needed to be location, integrated and flexible. This climate change affects to all agricultural sector in a multitude ways. For example, changing weather pattern such as heavy flood and storms makes the agricultural production low and leading to extreme events of poverty and slow down economic development. In general, there is a relationship between climate vulnerability, poverty and food insecurity (FAO, 2011). Climate change poses significant threats to fisheries on top of many other concurrent pressures such as overfishing, habitat degradation, pollution, introduction of new species and so on (Brander, 2010). Changes in biophysical characteristics of the aquatic environment and frequent occurrence of extreme events have significant effects on the ecosystems that support fish.

Adaptation to climate change indicates processes taken to enable communities to have ability to survive with the state of climate shift. IPCC (2007a) defined adaptive capacity as the ability of the systems to adjust to climate change and has three components: awareness, ability and action. Adaptive capacity is among the determinants of vulnerability of a system, others being exposure and sensitivity (Metzger et al., 2006). It is possible that vulnerable farmers organise livelihood resources and develop adaptation strategies, with the existing institutions being taken into the context (Naess et al., 2005). This study is very important for identifying and formulating measures that would enable the fisheries sector to develop appropriate adaptation measures to address impacts on fishing communit ies, fisheries resources, and associated ecosystems. There are no previous related studies conducted on adaption strategies of fisheries in the study area. This study, therefore, seeks to analyse the determinants of choices of adaptation strategies to climate change by fisheries community in central rift valley of Oromia region, Ethiopia.

Objectives of the Study

The main objective of this study is to assess farmers' perception and adaptation strategies of fishing communities for impacts of climate change on fish production in rift valley area of Oromia region
More specifically, this study will attempt: -

I. To find out how fishermen in central rift valley of Oromia region perceive climate change
II. To identify adaptation strategies used by fishing communities' in response to climate change and variability in central rift valley
III. To determine factors that influence fishers in choice of adaptation strategies in rift valley area

Research Methodology

In this chapter, description of the study area, sample size and sampling techniques, types and method of data collection were presented.

Description of the Study Area

This study was conducted in the two major water bodies, which are found in the East shoa zone (Dambal Lake & Koka reservoir) of Oromia regional state. The two water bodies are very potential in fish production in the study area. From the two water bodies, the fishermen for this study were selected from the fishing communities and as well those farmers who were shifting their livelihood from fishing to others types of production systems around the two water bodies.

Lake Dambal is one of the freshwater Rift Valley lakes of Ethiopia. It is located about 160 kilometres South of Addis Ababa. The districts holding the lake's shoreline are A.T.J. K, Dugda, and Ziway Dugda. On the average, the lake is located at an elevation of 1650 masl and the lake is shallow and has an open water area of 434 km^2 and shoreline length of 137 km, a maximum depth of 9 m and an average depth of 2.5 m (Von Damm and Edmond, 1984). The maximum length and width of the lake is 32 km and 20 km, respectively (LFDP, 1997). The lake has high economic importance for its natural resources (such as water, fish, wildlife, etc.), bio-diversity, recreational value and horticultural crops production as it is easily accessible and situated near the main asphalted highway, which is extended from the southern part of the country to Addis Ababa market outlets. Lake Dambal located in mid-altitude regions. The climatic conditions are not uniform throughout the watershed. The mean annual rainfall of Dambal Lake and its surroundings varied from 600-800 mm with high fluctuation. The mean annual evaporation with 1600 mm is higher than mean annual precipitation. The mean annual maximum and minimum temperatures are 27 and 13 degree Celsius respectively. The temperature is higher from November to April and lower from June to October. February and March are the hottest months of the year. There is no clear trend (increase or decrease) in rainfall characteristics in the region during the last 40 years (Alemayehu et al., 2006). The minimum and maximum annual precipitation in the watershed is 729.8 mm and 1227.7 mm respectively with the mean annual temperature of 18.5 °C. The wet season – June to September – accounts for about 55% of the annual precipitation, while the dry season contributes 45% (Billi and Caparrini, 2006). The predominant land use in the watershed is smallholder agricultural lands, although other land uses types such as settlement, woodlands, etc. are present. Sparse acacia trees, patches of grassland, and extensive cultivated crop fields cover the watershed rift floor and lower slopes. The vegetation cover is characterized by extensively overgrazed Acacia combretum in open woodland (Zerihun and Mesfin, 1990), whereas deciduous woodlands occupy the escarpments (Mohammed and Bonnefille, 1991). The settlement pattern is typical of rural communities across Ethiopia (Stellmacher, 2015) where the average household farm land holding size is 1.98ha ((CSA and World Bank, unpublished, 2017).

There are two main feeder rivers to Lake Ziway; namely, Meki originating from Gurage Mountains in the northwest and Ketar from the Arsi Mountains in the east; and it has one out flow in the south through Bulbula River, draining into Lake Abijata. Lake Ziway contains five main Islands: Tullu Guddo (4.8 km^2), Tsedecha (2.1 km^2), Debresina (0.3 km^2), Funduro (0.4 km^2) and Gelila (0.2 km^2). Debresina and Gelila have only a few inhabitants, the other three are inhabited by several hundreds of people (Yared Tigabu, 2003).Technologies such as fish smoking technology was demonstrated at Tullu Gudo under Lake Zeway condition. Bulbula River is an outflow from Lake Dambal to the south, feeding the terminal lake, Lake Abijata. Groundwater flows from Lake Dambal towards the north-south gradient feeding Lakes Langano, Abijata, and Shala (Tenalem, 2001), all of which lie at lower altitudes, with Lake Shala being the final recipient. Therefore, Lake Dambal has great geochemical and hydrological significance for these immediate lakes. Land use change is massively and rapidly taking place, as elsewhere in the Ethiopian CRV (Dadi et al., 2016).

Koka Reservoir is located in the Awash River Basin in central Ethiopia (8 26^0N, 39 02^0 E). The 1200 km-long Awash River, this has its headwaters in the plateau near Addis Ababa at 2300 masl, discharges below sea level into Lake Abbe in the Danakil Desert. Koka Reservoir is located 90 km south of Addis Ababa at an elevation of 1600 m. It has a surface area of about 200 km ^{2} and a capacity of 1650 mm^3. The Koka dam consists of concrete with a length of 458 meters and a maximum height of 47 meters. It was created by the construction of the Koka Dam across the Awash River. The reservoir has an area of 180 km^2. The reservoir supports a fishing industry; according to the Ethiopian Department of Fisheries and Aquaculture, 625 tones of fish are landed each year, which the department estimates is either 52% or 89% of its sustainable amount. Both the reservoir and the dam are threatened by increasing sedimentation caused by environmental degradation as well as the invasive water hyacinth.

Sample size and sampling technique

The study was conducted on selected water bodies of Oromia region. Data for this study were collected from fishing communities and as well those farmers who were shifting their livelihood from fishing to other types of production systems. For this study, a three stage purposive and random sampling technique was used for the selection of representatives sample household heads. In first stage purposive sampling technique were used for selection of lake and reservoirs at which livelihood of fishing communities depending on from Rift valley. The second stage was purposive selection of districts, kebeles and fishery cooperative from each selected water bodies depending on severity of climate change and variability of fish production. In this stage, Based on the potentiality of the area and consultation with the district fish experts, 5 districts namely A.T.J.K, Dugda, Lume, Adama and Ziway dugda was selected purposively.

Two kebeles from each selected district and one fishery cooperative was selected from each selected kebeles purposively. In third stage, based on lists of the household heads in each kebeles, a probability proportional to sample size sampling procedure was employed to select 167. Sample households were randomly selected and used in the analysis, after preparing sample frame of fish producers in the selected village administrations.

To determine the sample size from the study area, the formula for sample size determination adjusting the degree of precision to 0.07 due to the shortage of resource, following Cochran (1977) has been used. Cochran (1977) stated that if there is heterogeneity and high population this formula is appropriate for sample size determination. The sample size from each village administration was determined by proportionality formula.

$$n = \frac{Z^2 * (p)(q)}{d^2} \text{----------} (1)$$

n - Sample size

Z – Standard normal deviation (1.81 for 93% confidence level)

p = 0.5 (The proportion of the population participating in modern beekeeping, that is 50% due to unknown variability)

q = 1-p = 0.5 (50%)

d – Desired degree of precision level, which is 0.07 in this case

Proportional sampling method has been used to select the sample from each of the five village administrations. The sample selected from each selected village administrations was proportional to the population in each village administration and the formula for this purpose was determined by the formula (2).

$$n_i = \frac{N_i\ (n)}{\sum N_i} ----------(2)$$

Where n_i – the sample to be selected from i`s village administration

Ni – the total population living in the selected i`s village administration

$\sum$ - the summation sign

$\sum Ni$ – the sum of the total population in the selected five village administrations

N– Total sample size

Table1. Distribution of sample selected from districts and their ten selected village administrations

Districts	Kebele name	Name of the selected fishery cooperative in the selected village	Current No. of members	HH total no	Sample selected	Proportion
A.T.J.K	Abay danaba	Abay burkitu	18	607	21	12.6%
	Batu 02 kebele	Ziway batu	60	437	15	8.98%
Dugda	Graba qorke adi	malima bari	52	407	14	8.38%
	Silase	Tube shati	20	511	17	10.18%
Lume	Darar dambal	Darar dambal	51	463	16	9.58%
	Qoqa	Koka Nagawo	47	476	16	9.58%
Adama	Bate Garmama	Biftu Garmama	41	42	19	11.37%
	Bate qalo	Malka qaloo	35	422	14	8.38%
Ziway D	Herera	Tulu Gudoo	88	531	18	10.77%
	Bashira cafa	Dhibayu cafa	33	513	17	10.18%
5	10	10		4909	167	100%

Source: Own survey data, 2019/20

Types of data and Method of Data Collection

Both primary and secondary data were used in this study. Secondary data sources were bureaus of District livestock and fishery resource development, Bureaus of District agricultural and natural resource development, Primary cooperatives, Zonal Bureaus of livestock and fishery resource development and Central Statistical Authority (CSA). Secondary data were collected from different sources and relevant published and unpublished reports and bulletins to generate relevant secondary data on the selected water bodies.

Primary data sources were selected fishermen and as well those farmers who were shifting their livelihood from fishing to others types of production systems from selected districts of surrounding Lake Dambal and Koka reservoir. Primary data were collected using informal and formal surveys. The informal survey was Rapid.

Market Appraisal (RMA) technique like Focus group discussion and key informants interviews using checklists. The formal survey was undertaken through formal interviews with randomly selected fishermen using a pre-tested semi-structured questionnaire on socio-economic characteristics of the respondents,
perception of fishers about climate changes, adaptation strategies to climate change and determinants of adaptation strategies. Before data collection, the questionnaire was pre-tested on ten fishermen to evaluate the appropriateness of the design, clarity and interpretation of the questions, relevance of the questions and time taken for an interview. Hence, appropriate modifications and corrections were made on the questionnaire. Focus group discussions and key informants were also held with 10 groups based on predetermined checklists.

Both qualitative and quantitative data was collected and used for the study. Data that was collected include fishery communities' perception of climate and any changes associated with climate occurring in their area, fish catches and any changes that had occurred and the reasons as to why such changes were happening. The respondents was also asked to cite how they were coping with such changes and others socio-economic characteristics variable.

Data analyzing technique

Descriptive Statistics

Descriptive statistics were used to explain the different characteristics of the households in the study area. The descriptive statistics such as minimum, maximum, standard deviation and mean were employed to analyse, describe and summarize respondents' socio-economic characteristics, perception of climate change and its adverse effects and choice of adaptation strategies. Statistical significance of the variables was used for both dummy and continuous variables using chi-square (x^2) and student t-test statistics, respectively by using Stata version 14 software to compare groups with respect to variables of interest.

Econometric analysis

Multivariate Probit Model was employed to investigate the factors that determine the choice of adaptation strategies. Farmers' adaptation activities to respond to climate change can be influenced by various factors, including household income, market, culture, and institutions. Identification of each factor that influences the behaviour of farmers is very important. Although the multinomial probit can be used to measure the set of adaptation choices being applied by fish producers, its limitation is difficult to make interpretations for the simultaneous influences of explanatory variables on each outcome variable (endogeneity problem cannot be addressed using multinomial probit). This is because the local adaptive choices practiced by the farmers are either substitutive or supplementary of one another. Multivariate probit model is appropriate to handle such measurement problems. It also allows the user to produce more than one equation with correlated disturbances, thereby enabling examination of the relationships among the outcome variables. During estimation, the adaptation choices of dependent variables in the multivariate model do not have negative values and hence, the error terms could be correlated to several predictors. Unlike in the ordinary least square method (OLS), the assumption of mean zero is senseless in the use of a multivariate model. By nature, farmers are more likely to adopt a mix of adaptation strategies to deal with a multitude of climate-induced risks and constrains than a single strategy. A shortcoming of most of the previous studies on modelling choice of climate change adaptation strategies is that they do not consider the possible inter-relationships between the various strategies (Yu *et al.*, 2008).

These studies mask the reality faced by decision-makers who are often faced with alternatives that may be adopted simultaneously and/or sequentially as complements, substitutes or supplements. Some recent empirical studies of technology adoption and climate adaptation decisions assume that farmers consider a set of possible practices and choose the particular practice bundle that maximizes expected utility (Marenya and Barrett, 2007; Nhemachena and Hassan, 2007; Yu *et al.*, 2008; Kassie *et al.*, 2009). Thus, the adoption decision is inherently multivariate and attempting univariate modelling excludes useful economic information contained in interdependent and simultaneous adoption decisions. Based on this argument, the study was adopted multivariate probit econometric technique to simultaneously model the influence of the set of explanatory variables on major adaptation strategies (Belderbos *et al.*, 2004; Lin *et al.*, 2005, Wondimagegn and Lemma, 2015).

The study was based on the premise that there were complementarily and/or substitutability between different strategies (Belderbos *et al.*, 2004). The dependent variable in the empirical estimation for this study was the choice of an adaptation options from the set of adaptation measures. Following Lin *et al.* (2005), the multivariate probit econometric approach for this study was characterized by a set of *n* binary dependent variables y_{hpj} such that:

$$y^{*}{}_{hpj} = x_{hpj}\beta_j + \upsilon_{hpj} \quad j = 1, 2, \ldots, m, and$$

$$y_{hpj} = \begin{cases} 1 & if\ y^{*}{}_{hpj} > 0 \\ 0 & otherwise \end{cases}$$

where j=1, 2,…,m denotes the climate change adaptation strategies available; x_{hpj} is a vector of explanatory variables; β_j denotes the vector of parameter to be estimated; and υ_{hpj} are random error terms distributed as multivariate normal distribution with zero means and unitary variance. It is assumed that a rational h^{th} farmer has a latent variable, $y^{*}{}_{hpj}$ which captures the unobserved preferences or demand associated with the jth choice of adaptation strategy. This latent variable was assumed to be a linear combination of observed household and other characteristics that affect the adoption of adaptation strategy, as well as unobserved characteristics captured by the stochastic error term.

Dependent and independent variables

Dependent variables

The dependent variables included in the analysis were the adaptation strategies adopted by fishers

Independent variables

Independent variables include in the analysis were socio-economic, institutional, and environmental factors. Specifically, desired variables was sex and age of the household head, household income, access to credit, educational status of the head, family size, farm size, climatic variables, access to extension service, access to information on climate change, farming experience and others relevant variables.

Table 2: Variable description and hypothesis for the impact of the independent variables on dependent variables

Explanatory variables	Description	Expected sign
Household head`s age	Continuous (Years)	+
Household head`s sex	Dummy, 1, if male, otherwise	+
Household head`s education level	Continuous (class year)	+
Household head`s annual income	continuous (ETB)	+
Household size	Continuous (number)	+ or -
Membership to fishery cooperative	1 if yes, 0 if otherwise	+
Household head`s fishing experience	continuous (years)	+
Access to weather information sources	1 if yes, 0 if no	+
Access to credit	1 if yes, 0 if no	+
Access to extension contact	1 if yes, 0 if no	+
Farm size	Continuous (Hectare)	+
Mean Annual temperature	Mean of annual temperature	+ or -
Mean Annual Precipitation	Mean of annual rainfall	+ or -

Results and Discussion

This chapter discusses the results obtained from the primary and secondary data. It consists the descriptive and econometric analysis of the sampled household characteristics in the study area.

Demographic and Socio-economic Characters for categorical variable of the sampled fishers

In this section descriptive analysis were used to describe characteristics of the sample households in the study area**.** Both continuous and discrete variables were used in order to describe the sample households included in this study. Table X shows, the percentage of the sample respondents based on household head sex in selected survey districts.

Table3. Sex of sample respondents in the study area

Zone	Districts		Sex of household head		Total
			Female	Male	
East Shoa	A.T.J.K	Count	5	31	36
		% within Survey district	13.88	86.12	100
	Dugda	Count	7	24	31
		% within Survey district	22.59	77.41	100
	Lume	Count	0	32	32
		% within Survey district	0	100	100
	Adama	Count	0	33	33
		% within Survey district	0	100	100
Arsi	Ziway Dugda	Count	4	31	35
		% within Survey district	11.42	88.58	100
	Total	Count	16	151	167
		% within Survey district	9.58	90.42	100
		% of total	9.58	90.42	100

Source: Own survey result of 2021

Sex of household head: The above table X indicted that, Out of 167 sample respondent, 9.58% were female household head where as 90.42% of them were male headed household. In A.T.J.K district out of 36 respondents 13.88% were female while 86.12% were found to be male headed household. In Lume district all of the respondents were male headed household. In Dugda district 22.59% were female while around 77.41% were male headed household head. In Adama district all of the sample respondents were male headed household. In the case of Ziway Dugda district, 11.42% were female headed while about 88.58% were male headed household in the study area.

Table 4 shows, the percentage of the sample respondents based on household head`s membership in the fishery cooperatives in the selected survey districts.

Zone	Districts		Fishery cooperative membership of household head		Total
			Yes	No	
East Shoa	Adama	Count	18	15	33
		% within Survey district	54.54	45.45	100
	A.T.J.K	Count	21	15	36
		% within Survey district	58.33	41.67	100
	Dugda	Count	19	12	31
		% within Survey district	61.3	38.7	100
	Lume	Count	23	9	32
		% within Survey district	71.87	28.13	100
Arsi	Ziway Dugda	Count	22	13	35
		% within Survey district	62.85	37.15	100
	Total	Count	103	64	167
		% within Survey district	61.67	38.33	100
		% of total	61.67	38.33	100

Source: Own survey result, 2021

Household head`s membership in the fishery cooperative (Yes/No Answer): In the study area, Out of 167 sample respondent, 61.67% of them have said yes whereas 38.33% of them have given No response whether they were a member of fishery cooperatives or not in the study area as a whole. In Adama district, out of 33 sampled respondents, 54.54% of them have said yes whereas 45.45% of them have given No response whether they were a member of fishery cooperatives or not in this district. In A.T.J.K district out of 36 respondents, 58.33.% of them have said yes whereas 41.67% of them have given No response whether they were a member of primary fishery cooperatives or not in this district. In Lume district out of 32 respondents 71.87% of them have said yes whereas 28.13% of them have given No response whether they were a member of fishery cooperatives or not in this district. In Dugda district 61.3% of the respondents have said yes whereas 38.7% of them have given No response whether they were a member of primary fishery cooperatives or not in this district. In the case of Ziway Dugda district out of 35 respondents, 62.85% of the respondents had given yes response whereas 37.15% have given No response whether they were a member of primary fishery cooperatives or not in this district.

Table 5 shows, the percentage of the sample respondents based on household head`s access to the credit services in the selected survey districts.

Zone	Districts		Access to credit services		Total
			Access	No access	
East shoa	Adama	Count	11	22	33
		% within Survey district	33.33	66.67	100
	A.T.J.K	Count	19	17	36
		% within Survey district	52.77	47.23	100
	Dugda	Count	13	18	31
		% within Survey district	41.93	58.07	100
	Lume	Count	11	21	32
		% within Survey district	34.37	65.63	100
Arsi	Ziway Dugda	Count	8	27	35
		% within Survey district	22.85	77,15	100
	Total	Count	62	105	167
		% within Survey district	37.12	62.88	100
		% of Total	37.12	62.88	100

Source: Own survey result, 2021

Household head`s access to the credit services: In the study area out of 167 sampled fishers, 37.12% of them have an access to the credit services for enhancing their fishing activities where as 62.88% of them had not access to the credit services for enhancing their fishing activities in the study area. In Adama District out of 33 sampled respondents, 33.33% of the respondents have got access to the credit services for enhancing their fishing activities where as 66.67% of them have not obtain access to credit services for enhancing their fishing activities in the district. In A.T.J.K district out of 36 respondents, 52.77% of the respondents have got access to the credit services whereas 47.23% of them had not obtained credit for enhancing their fishing activities in the district. In Lume district out of 32 respondents 34.37% of the respondents have got access to credit services whereas 65.63% of them have not obtain access to credit services for enhancing their fishing activities in the area. In Dugda district, 41.93% of the respondents have got access to the credit services whereas 58.07% of them have not obtain access to credit services for enhancing their fishing activities in the area. In the case of Ziway Dugda district out of 35 respondents, 22.85% of the respondents have got access to credit where as 77.15% of them have not obtain credit access for enhancing their fishing activities in the area.

Table 6 shows, the percentage of the sample respondents based on household head`s access to the extension services in the selected survey districts.

Zone	Districts		Household head`s access to the extension services		Total
			Accessed	Not accessed	
East Shoa	Adama	Count	13	20	33
		% within Survey district	39.39	60.61	100
	A.T.J.K	Count	14	22	36
		% within Survey district	38.88	61.12	100
	Dugda	Count	18	13	31
		% within Survey district	58.06	41.94	100
	Lume	Count	20	12	32
		% within Survey district	62.5	37.5	100
Arsi	Ziway Dugda	Count	15	2	35
		% within Survey district	42.85	57.15	100
	Total	Count	80	87	167
		% within Survey district	47.90	52.10	100
		% of Total	47.90	52.10	100

Source: Own survey result, 2021

Household head`s access to extension services: Out of 167 sample fishermen, 47.90% of them have got access to modern extension services on fishing activities where as 52.10% of them had not obtained access to extension services on fishing activities in the study area. In Adama District out of 33 sampled respondents, 39.39 % of the respondents have got access to extension services on fishing activities and 60.61% of them have not obtain access to extension services on the fishing activities in the area. In A.T.J. K district out of 36 respondents 38.88% of the respondents have got access to the extension services on fishing activities and 61.12% of them have not obtain access to it on the fishing activities in the area. In Lume district out of 32 respondents 62.5% of the respondents have got access extension services on the fishing activities and 37.5% of them had not obtain access to it on the fishing activities in the area. In Dugda district 58.06 % of the respondents have got access to extension services on fishing activities and 41.94 of them have not obtain access to it on the fishing activities in the study area. In the case of Ziway Dugda district out of 35 sampled fishermen, 42.85% of the respondents have got extension service access on fishing activities and 57.15% of them have not obtain access to it on the fishing activities in the study area.

Table 7 shows, the percentage of the sample respondents based on household head`s access to weather information sources in the selected survey districts.

Zone	Districts		Household head`s access to climate information		Total
			Yes	No	
East Shoa	Adama	Count	7	26	33
		% within Survey district	21.21	78.79	100
	A.T.J.K	Count	5	31	36
		% within Survey district	13.88	86.12	100
	Dugda	Count	12	19	31
		% within Survey district	38.79	61.21	100
	Lume	Count	13	19	32
		% within Survey district	40.625	59.375	100
Arsi	Ziway Dugda	Count	9	26	35
		% within Survey district	25.71	74.29	100
	Total	Count	46	121	167
		% within Survey district	27.54	72.46	100
		% of Total	27.54	72.46	100

Source: Own survey result, 2021

Access to climate information sources (Yes/No Answer): In the study area, Out of 167 sample respondent, 27.54% of them have said yes whereas 72.46% of them have given No response whether they have access to weather information sources or not in the study area as a whole. In Adama district, out of 33 sampled respondents, 21.21% of them have said yes whereas 78.79% of them have given No response whether they have access to weather information sources not in this district. In A.T.J.Kombolcha district out of 36 respondents, 13.88% of them have said yes whereas 86.12% of them have given No response whether they have access to weather information sources not in this district. In Lume district out of 32 respondents 40.625% of them have said yes whereas 59.375% of them have given No response whether they have access to weather information sources or not in this district. In Dugda district 38.79% of the respondents have said yes whereas 61.21% of them have given No response whether they have access to weather info sources or not in this district. In the case of Ziway Dugda district out of 35 respondents, 25.71% of the respondents had given yes response whereas 74.29% have given No response whether they have access to weather info sources or not in this district.

Table 8. Description & summary statistics of demographic characters for continuous variables

Variables	Adama	A.T.J.K	Dugda	Lume	Z.dugda	Overall	p-value
	(N=33)	(N=36)	(N=31)	(N=32)	(N=35)	(N=167)	
	Mean (SD)	mean (SD)	mean (SD)	Mean (SD)	mean (SD)	Mean (SD)	
Female in household size	3.0(1.6)	3.2(1.8)	3.1 (1.6)	3.4 (1.4)	3.8(1.1)	4.1(1.3)	0.613
Male in household size	4.4 (1.4)	3.8(1.5)	3.6(1.3)	3.4 (1.5)	5(1.6)	3.7(1.3)	0.037
Total household size	7.7 (2.3)	6.9 (2.7)	6.7(2.2)	6.6 (2.8)	8.4 (3.2)	7(2.1)	0.857
Female B/n 15-64 years in household	1.6(1.1)	1.3(1.6)	2.2(1.3)	1.2 (1.5)	2.1 (2.2)	1.7 (1.6)	0.642
Male B/n 15-64 years in household	1.8(1.3)	1.3(1.7)	1.5(1.8)	1.6 (1.8)	1.1 (2.0)	1.3(1.7)	0.731
Household size B/n 15-64 years	3.3(1.5)	2.2(1.9)	3.1(1.3)	2.9 (1.4)	3.0 (2.3)	2.5(1.6)	0.335

Source: Own survey result, 2021

Household size: The average family size of the sample respondents was found to be 7 person in the study area. The average male member in the sampled household was around 4 person. In Adama District it was 4 person, in A.T,J.K district 4 person, in Dugda district 4 person, in Lume district 3person and in Ziway dugda district was around 5 person. The significance value of the t-test shows rejection of hypothesis that the average number of male in household is equal across the districts. So the average number of male in household is significantly different across the study districts at 5% of significant level (Table 8 above).

Table 9. Description of demographic and socio-economic characters of sampled fishers

Variables	Adama	A.T.J.K	Dugda	Lume	Z.dugda	Overall	p-value
	(N=33)	(N=36)	(N=31)	(N=32)	(N=35)	(N= 167)	
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
Household head`s education level	4.4(2.3)	4.8(3.1)	4.2 (2.7)	4.3(3.0)	3.8(3.5)	4.3(1.6)	0.003
Household head age	40(10.17)	43(10.13)	41.2(10.15)	44 (10.1	45.1 (10.8)	42.66(10.12)	0.871
Fishing experience	12 (6.3)	15.2(7.8)	14(7.3)	16.3(7.5)	14.7(7.1)	14.44(8.4)	0.070
Farm size	0.6 (0.4)	0 .5(0.8)	1.0(0.7)	0.2(1.0)	0.4 (0.2)	0.5(1.0)	0.001
Monthly Fish income	2500.2(1350.1)	2708.1(1307.3)	2503.7(1333.2)	2642.5(1297.3)	2591.4(1428.7)	2589.18(12861.9)	0.039

Education of household head: Education equips individuals with the necessary knowledge of how to make living decision. Literate individuals are very ambitious to get information and use it**.** As agriculture is a dynamic occupation, the conservation practices and agricultural production technologies are always coming up with better knowledge. The average year of formal schooling of total sample respondent is grade 4.The average year of formal schooling is grade 4, grade 5,grade 4, grade 4 and grade 4 in Adama, A.T.J.K, Dugda, Lume and Ziway dugda districts respectively .The mean difference of the groups is statistically significant at 5 % of probability level. It shows that, on average sample respondents has significance mean difference across all districts at 5 percent of probability level.

Fishing Experience of Household head: In the study area, the average fishing experience of the respondents were found to be 14 years, while that of Adama, A.T.J. K, Dugda, Lume and Ziway Dugda districts were 12,15,14,16 and 15 years respectively. It showed that the average difference between the all groups is significant at 10% significance level. This showed that the average fishing experience of the respondents in all districts is not equal (see table 9 above).

Farm Size: On average total sample respondents have 0.5 ha of farm size for farm production in the study area. The average farm size of respondents is 0.6 ha, 0.5ha, 1, 0.2 and 0.4ha in Adama, A.T.J.K, Dugda, Lume and Ziway Dugda districts respectively. The mean difference between all groups was found to be significant at 1% probability level. This shows that the average land holding of sample households across all districts is not equal.

Income from fish per month in 2019/20 G.C (ETB): The average monthly income of the total sampled respondents in 2019 production year was 2589ETB in the study area. In Adama District it was 2500 ETB , in A.T.J.K district 2708 ETB , in Dugda district 2504 ETB , in Lume district 2643 ETB and in Ziway dugda district it was around 2591 ETB respectively. The mean difference between all groups was found to be significant at 5% probability level. This shows that the average monthly income from fish of sample households across all districts is not equal.

Livelihood activities of the sampled fish producers in the study area

Crop and vegetable production

It is clear that crop and vegetable production pattern of an area depends mainly on agro-ecology factors namely climate, soil types, crops types, community crop and vegetables production habit and also marketing factors. According to survey results, maize, tomato, onion, teff, wheat and sorghum were the major crops and vegetables farmers produce for consumption and source of cash in line with fishing activities (Table 10).

Table 10: Major crop and vegetables produced by selected fishermen in selected study area

Crop & vegetable type		A.T.J.K		Dugda		Lume		Adama		Ziway Dugda		Total	
		Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Maize	Yes	27	75	20	64.5	23	71.875	19	57.57	20	57.14	109	65.26
	No	9	25	11	5.5	9	28.125	14	42.43	15	42.86	96	34.74
Tomato	Yes	17	47.22	13	41.93	14	43.75	10	30.30	13	37.14	67	40.12
	No	19	52.78	18	58.07	18	56.25	23	69.70	22	62.86	100	59.88
Onion	Yes	13	36.11	17	54.84	10	31.25	9	27.27	11	31.42	60	35.92
	No	23	63.89	14	45.16	22	69.75	23	72.73	24	68.58	107	64.08
Teff	Yes	14	38.89	13	41.93	11	34.375	14	42.42	8	22.85	60	35.92
	No	22	61.11	18	58.07	21	65.625	19	57.58	27	77.15	107	64.08
Wheat	Yes	14	38.89	7	22.6	11	34.375	8	24.24	20	57.14	60	35.92
	No	12	61.11	24	77.4	21	65.625	25	75.76	15	42.86	107	64.08
Sorghum	Yes	11	30.56	7	22.6	5	15.625	10	30.30	3	8.57	36	21.56
	No	25	69.44	24	77.4	27	84.375	19	69.70	32	91.43	131	78.44

Source: own survey result of 2021

Livestock production of the fishers in the selected study area

Livestock plays significant role in the economy of the fishermen in the study area. In general they provide food (milk, meat, egg, hides and skin) as power for cultivation, serve as means of transportation, and manure production for soil fertility management. Farmers' kept livestock for food, cash, draught power and manure production and used as a source of income to purchase fishing equipment. In terms of population, livestock of fishermen organized at Koka reservoir is higher as compared to livestock of fishermen organized at Dambal Lake

Table 11. Livestock production of the fishers in the selected study area

Livestock type		A.T.J.K		Dugda		Lume		Adama		Ziway Dugda		Total	
		Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
oxen	Yes	15	41.67	14	45.16	16	50	9	27.27	15	42.86	69	41.31
	No	21	58.53	17	54.84	16	50	24	72.73	20	57.14	98	58.69
Cow	Yes	13	36.11	10	32.26	11	34.375	13	39.39	7	20	54	32.33
	No	23	63.89	21	67.74	21	65.625	20	60.61	28	80	113	67.67
Calf	Yes	7	19.44	6	19.35	8	25	5	15.15	5	14.29	31	18.56
	No	29	80.56	25	80.65	24	75	28	84.85	30	85.71	136	81.44
Heifer	Yes	11	30.56	9	29.03	8	25	3	9.09	7	20	38	22.75
	No	25	69.44	22	70.97	24	75	30	90.91	28	80	129	77.25
Goat	Yes	13	36.11	9	29.03	16	50	9	27.27	5	14.29	52	31.13
	No	23	63.89	22	70.97	16	50	24	72.73	30	85.71	115	68.87
Sheep	Yes	25	69.44	14	45.16	24	75	13	39.39	3	8.6	79	47.30
	No	11	30.56	17	54.84	8	25	20	60.61	32	91.4	88	52.70
Horse	Yes	5	13.89	4	12.9	3	9.375	5	15.15	7	20	24	14.37
	No	31	86.11	27	87.1	29	90.625	28	84.85	28	80	143	85.63
Donkey	Yes	7	19.44	9	29.03	21	65.625	20	60.61	27	77.14	84	50.29
	No	29	80.56	22	70.97	11	34.375	13	39.39	8	22.86	83	49.71
Poultry	Yes	23	63.89	21	67.74	24	75	28	84.85	30	85.71	126	75.45
	No	13	36.11	10	32.26	8	25	5	15.15	5	14.29	41	24.55

Source: own survey result of 2021

Fishing activities

Fish activities are a source of human diet and source of income for fishermen in the study area. The importance of fishing in terms of economics, food security and employment opportunity for people lives near lakes and reservoirs are enormous. Artisanal or non-motorized fishery is one of the most significant economic activities in the study area. Fishery is practiced in a traditional way and tools as past time activity.

Currently the majority of fishermen have been organized into fishermen cooperatives, in line with the policy of the Government. The Ministry of Agriculture has granted commercial fishing rights only to fishermen cooperatives, each of which has to pay in return for the privilege of exploiting t he lake resource).

Currently, fishers' cooperatives exist in most fisheries but they are generally weak. The cooperatives have bylaws and these could be developed to cover fisheries management issues considering that cooperatives have the potential to participate in co-management arrangements with government provided that they are strengthened (Fish II, 2013). Fishermen cooperative activities are coordinated by a governing board including a chairman, a vice-chairman, a secretary and a treasurer elected by the cooperative members, who manages the cooperative according to the annual plan approved by its general assembly.

Season of fishing activities

Fishing activity is seasonal and the supply of fish is mostly available during fasting time. As indicated in Table 12, about 57.5% of fishermen were involved in fishing activities year round. The primarily livelihood of those fishermen involved in fishing activity was catches fish year round. Besides, about 23.35 % of selected fishermen were involved on fishing activities during fasting time. Peak of fishing is during the fasting months (February, March, April and August) when meat markets are decreasing.

Table 12: season of fishermen involved in fishing activities in selected water bodies of rift valley area

Variables	A.T.J.K	Lume	Dugda	Adama	Z. Dugda	Total	Chi-square
	Freq (%)	Freq (%)	Freq (%)	Freq (%)	Freq (%)	Freq (%)	
Year round	18 (50)	16(50)	23 (74.19)	19(57.57)	20 (57.14)	96(57.5)	137.5***
During fasting time	9(25)	7 (21.875)	5 (16.12)	7(21.21)	11(31.43)	39 (23.35)	
September-April	6 (16.67)	5 (15.625)	3 (9.67)	5 (15.15)	4(11.42)	23 (13.77)	
January-May	3 (8.33)	4 (12.5)	0	2 (6.06)	0	9 (5.4)	
Total	36 (100)	32 (100)	31 (100)	33(100)	35 (100)	167(100)	

Source: Own survey results, 2021

Type of fishing equipment used for fishing activities in the study area

According to survey results motorized boat, wooden boat and yebela/bofofe were the major types of boats fishermen was used for fish catch at selected water bodies. Wooden boats are the major boats fishermen used for fishing purpose on selected water bodies. Motorized boat is found on Lake Zeway. Motorized boat in lake Zeway where there are mostly used for fish collection and transport purpose. Average purchase price of motorized boat was 91,571.5 Birr which is so expensive for fishermen to purchase. On average fishermen holds 1.44 wooden boat and purchase price or preparation cost was 8000 Birr averagely in 2020/21 Birr

Gears in use include gillnets, beach seines and hook/long-line on selected water bodies. The use of gillnets, Beach seines and hook gear is widespread in the selected water bodies. On average fishermen hold 1.375, 6.5 and 5 number of beach seines, gillnet and hook/long line, respectively. Averagely Purchase price or preparation cost of Beach scene was 53,375 Birr in 2020/21 Birr.

Table 13: Type of fishing equipment fishermen used in the study area

Type of boat/gear (No)	A.TJ.K		Dugda		Z. Dugda		Lume		Adama		Total		F-value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Motorized boat	1.5	0.77	1	0.81	-	-	-	-	-	-	1.25	0.33	3.57*
Wooden boat	1.7	0.28	1.25	0.34	1.25	0.4	2	0.6	1		1.44	0.28	7.5***
Yebela/Bofofe boat	1	-	1	-	1	-	2	-	1	-	1.2	-	-
Beach seine	2	1.5	1.5	0.48	1		1		-		1.375	1.53	8.70**
Gillnet(50m)	11	31.75	4		5	2.59	7		6		6.5	18	1.89
Hook/long line (by 100)	27	33.5	-	-	3.5	2.1	1	-	5.3	3.22	5	9.5	8.7***

Source: Own survey results, 2021

Current Fish species and their catch per day in the study area

As raised by sample respondents in the area, the main commercial fish species, which are found in Koka reservoir, was Nile Tilapia, African Catfish, Common Carp and Laebarbus intermdus (Bilcaa), while Nile Tilapia, African Catfish, Common Carp and Crucian carp were found in Lake ziway. Majority (85%) of fishermen in selected water bodies respond that average fish catch was less than 15 kg per day for all species in the selected water bodies (figure 1 below).

Fluctuations of fish yield are there in selected water bodies due to different internal and external factors. According to Focus Group Discussion the yield of fish was decreasing from time to time due to overfishing, expansion of illegal fishers, fish nets, and illegal traders which is not recommended, clima te change and etc.

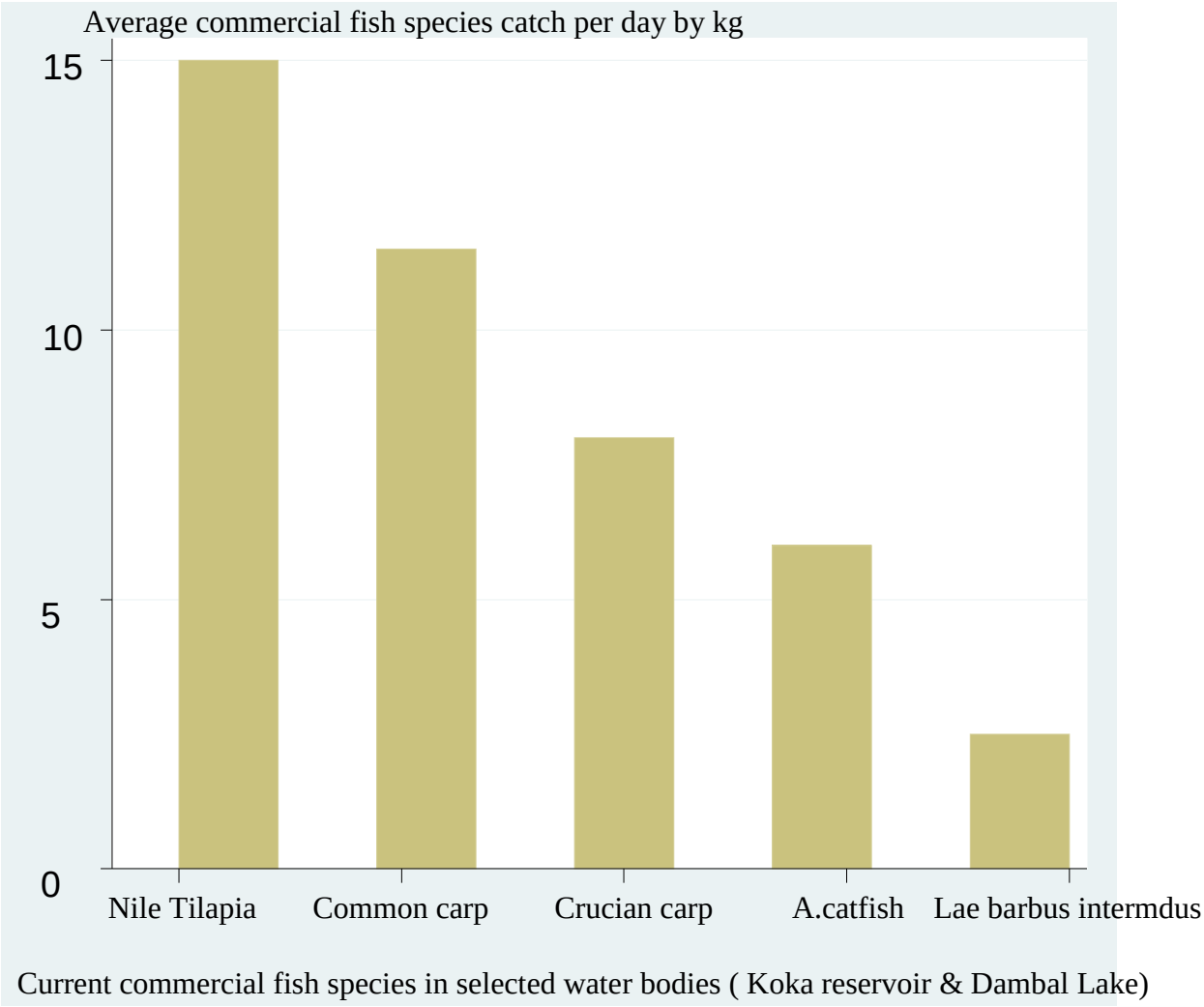

Figure 1. Average fish species catch per day by kg of Koka reservoir and Lake Dambal

Purpose of fishing in selected water bodies

All of the fishermen indicated that, fishermen involved in fishing activities for source of income by selling whole fish, filleted fish and gutted fish and for family consumption to fulfil their family balanced diet in all study districts. In terms of acceptance in the market Nile Tilapia species is the important species in the selected water bodies. According to Focus Group Discussion and KII catch of Nile Tilapia species was decreasing from time to time as compared to the other fish species due to overfishing, use of illegal fishermen, fish trader and fishing net (Monofilament net) which is imported from Dubai. As reported by the fishermen during the survey period this illegal fishing net (Monofilament net) is currently available in Koka reservoir and Dambal Lake.

Fishers` perception of climate change in the study area for the last 20 years (2002-2021 G.C)

The way the indigenous people think and behave in relation to the environment in which they live have a very important role in addressing climate change. In this study, Majority (96.4%) of fisher respondents responded that they are aware or heard about climate change in their surroundings. They associated climate change with increase in temperature, floods incidence, strong wind, drought occurrence, occurrence of water hyacinth and decreased in rainfall in the study area. In this study, the fishers reported that an increased drought incidence (34%), extremely hot temperature (25%), increased flood incidence (9.1%), erratic rainfall and late rains (18.9%), strong wind (10%) and presence of water hicintith and others in the selected water bodies. The higher proportion (59%) of the fish producers were reported that, there was extremely hot temperature and incidence of drought in 2005, 2009, 2013, 2020 and 2021 GC in the study area within the selected districts.

Most of the fishers revealed experiencing these extreme weather events in the 21st century. These events occurred frequently in the years between 2000 and 2021, as reported by 94.4% of the fishers. The respondents also reported that, wet season was started from June to September while dry season were start from December to March in the study area around the selected water bodies.
During the household survey, focus group discussion and key informant interviews, most (69%) of the participant suggested that the perceived exposures revolved around precipitation and temperature.
The key discussant of focus group discussion and key informant interviews also mentioned that climate change is defined differently between respondents and it is affected by time lived in the area and age of the respondents. The older people recollected past events over a long period through experiences and oral tradition, whereas the young fishers lacked the long-lived experiences but their recollections were also based on information passed down to them through oral tradition.

On the other hand, during a key informant interview, 55% of the discussant reported that, “by now 20 years ago, we should have planted crops and the rains would have been falling with good intensity. Currently, it is very hot and dry and people are not even sure as to when the rains will fall” in the study area.

Sources of information for weather forecasting in the study area

Table 7 below shows that the main source of information on the climate change were through personal experiences (19.76%), Farmer/fish producers` cooperative (17.36%), neighbour farmers (16.76%), Religious home (14.97%), Radio/mass media (11.37%), extension workers (8.38%), newspaper (7.18%), and Nearby metrology station (4.19%)respectively, were the top ranked sources of information on climate change in the study area.

Table 14: Sources of information on climate change to fishermen

No	Sources	Frequency (n=167)	Relative proportion (%)
1	Radio/Mass media	19	11.37
2	Extension workers	14	8.38
3	News paper	12	7.18
4	Personal experiences	33	19.76
5	Neighbour farmers	28	16.76
6	Farmer/fishery cooperative	29	17.36
7	Nearby Metrology station	7	4.19
8	Religious home	25	14.97

Source: Own survey data, 2021

The respondents` perception to the extreme weather events could be attributed to their levels of exposure and experience [14]; [15]; [16]. For this reason, 20 years (2002-2021 GC) recall period was employed and sufficient to validate the stated adverse climate events. Age and fishing experience could be responsible for increasing the probability of recalling major climate incidences [17]. However, what the fishers` perceive to be climate change is not straightforward [18]. For this reason, 20 years' time series metrological data were used to validate this study.

Trend analysis of metrological data (Temperature and rainfall) for 20 years

The climatic conditions are not uniform throughout the selected two watersheds. The mean annual rainfall of Dambal Lake and Koka reservoir and its surroundings varied from 800-921mm with high fluctuation. The mean annual evaporation varied from 1500mm-1635mm across the two selected water bodies, which is higher than the mean annual precipitation of the study area.

The minimum and maximum annual precipitation in the two selected watershed is 600 mm and 1227.7mm respectively. The mean annual maximum and minimum temperature varies from 29-23°C and 18-12°C respectively in the 2 selected water bodies. Temperature is higher from November to April & lower from June to October in the two selected water bodies of the study area. February and March are the hottest months of the year around the 2 selected water bodies. The wet season – June to September – accounts for about 55% of the annual precipitation, while the dry season contributes 45%. There is no clear trend (increase or decrease) in rainfall and temperature characteristics around the two selected water bodies during the last 20 years (2001-2021 G.C).

Impact of the Perceived Climatic Changes on Fish production in the selected water bodies of rift valley area

Majority (72%) of the fishers responded that the change in climate was the main driver of low fish production and species composition changes. However, some fishers (15%) attributed low fish harvesting to overfishing and presence of water hgcinith and chemical disposal to the water bodies (13%) in the selected water body. The specific extreme weather events cited by the respondents as being responsible for low fish production were increased incidences of drought (25%), erratic rainfall (20.5%), strong winds (13.5%), extreme hot temperatures (8%) and flooding incidence (5%) and others like over fishing and presence of illegal fishing net and water highcinith in the selected district.
Some respondents who had indigenous knowledge on the relationship between climate and fish catches explained how rainfall is related to fish catches, with more rainfall resulting into more fish catches.

Adaptation strategies used by the fishing communities in response to climate change and variability in the study area

Table 15 below shows that adaptation strategies used by the fisher respondents to mitigate against the effect of climate change in their respective district were diversification to the non-fishing activities (High value crops and livestock rearing)(27.54%), operating small businesses (23.95), increasing the fishing time on the water bodies (22.75%), changing the landing site (12.57%), changing the fishing gears and targeting fish species and boats(15.57%), planting trees (7.80%), staying on the water bodies until strong wind became stable (5.4), praying the crater(6.6%), not entering to the water bodies until the climate change events (strong wind) leave the water bodies (1.80%) and no adaptation. As indicated in table 15 below, majority of fisher's respondents had adjusted to climate change in order to supplement fishing. However, some fishers (4.2%) did not adjust to the perceived changes as they accepted the low fish production.

The choice of an adaptation options from the set of adaptation measures mentioned above by the fishers is the dependent variables in this study. Resource limitations coupled with household characteristics and poor infrastructure limit the ability of most fish producers to take up adaptation measures in response to changes in climate variables as mentioned by the respondents, Focus group discussion and key informants interview in the study districts.
Out of 10 adaptation strategies identified by the fish producers, the five main dentified adaptation strate gy options are used in the selected district for empirical estimation

Table 15: Distributions and relative proportion (%) of Adaptation Strategies of fishers in the selected water bodies

Adaptation Strategies option	Frequency	percentage
Diversification to the non-fishing activities	46	27.54
operating small businesses	31	23.95
Increasing the fishing time on the water bodies	38	22.75
Changing the landing site	21	12.57
Changing the fishing gears	26	15.57
Planting trees around the shoreline	13	7.80
Praying the crater	11	6.6
not entering to the lake when there is strong wind	3	1.80
Staying on the lake when there is strong wind	9	5.4
No adaptation	7	4.2

Source: From survey data, 2021

Table 16. Adaptation measures to the low fish production matched with their perceived climate exposure in the selected water bodies of the study area

Exposure	Diversification	Business	Increase fishing time	Change landing site	Change fishing gears	Tree planting	Praying the crater	Not entering to the lake	Staying on lake	No strategy
Drought incidence	11	5	4	0	5	4	5	0	0	1
Hot temperature	7	7	5	0	3	4	0	0		2
Strong wind	8	5	8	8	0	2	0	3	6	
Flood incidence	0	7	3	7	4		4	0	0	1
Rainfall decrease	10	6	10	0	7	3	0	0		1
Total no of fishers	36	31	30	15	19	13	9	3	6	5

Table 17: Correlation matrix of the choice of coping strategies from Multi variate probit model

	The main Dependent variables				
	Operating small businesses	Increasing fishing time on the water bodies	Changing the landing location	Diversification to the high value crop & livestock	Changing the fishing gears
operating small businesses		0.457(0.115)	0.437(0.069)*	0.637(0.078)*	0.944(0.073)*
Increasing fishing time on the water bodies			0.831(0.057)*	0.934(0.039)**	0.887(0.057)*
Changing the landing location				0.654(0.071)*	0.541(0.064)*
Diversification to the non-fishing (high value crop & livestock)					0.928(0.025)**
Changing the fishing gears					
Joint Probability (Success)		0.488			
Joint Probability (Failure)		0.187			
P-value		0.001			
Likelihood ratio test (Chi^2)		$chi^2(12) = 257.071$			
Linear Predictions					
Water shade management		0.77			
Increasing fishing time on the water bodies		0.74			
Changing the landing location		0.67			
Diversification to the non-fishing		0.81			
Changing the fishing gears		0.62			

Source: From own survey data, 2021

***** and** represent significance level at 10 & 5%

The above table 17 discusses the results from the multivariate probit model. The likelihood ratio test (chi^2 (12) =257.071, P > 0.001) of the independence of the error terms of the different adaptation equations is rejected (Table 10). Thus, this study assumes the alternative hypothesis of the mutual interdependence among the multiple adaptation approaches. The result therefore supports the use of multivariate probit model. All the pairwise coefficients are also positively correlated indicating complementarity among these strategies. The results show that the joint probability of adopting the choice of adaptation strategies is approximately 49% while not adopting the choice is 19%. It can also be inferred from the linear predictions of the result that the likelihood of adopting operating small businesses is 77%, while it is 74%, 67%, 81%, and 62% for increasing fishing time on the water bodies, Changing the landing location, Diversification to the non-fishing activities (to the high value crop production and livestock rearing) and Changing the fishing gears respectively.

The Determinants of Adaptation Strategies of fishers to Climate Change around selected water bodies

Variables	Operating small Businesses		Increasing fishing time		Changing the la nding location		Diversification to high value crop and livestock		Changing the f ishing gears	
	Coef	Std. Err	Coef	Std. Err	Coef	Std. Err	Coef	Std. Err	Coef	Std. Err
HH Age	0.007	0.128	0.039	0.257	0.012	0.909	-0.035	0.851	0.075	0.642
Household head`s sex	-18.760	27. 933	- 23.10 0	21.12 7	0.260	0.700	0.086	0.18	0.097	0.193
Education level	-0.0761	0.894	0.024	0.911	-0.015	0.079	0.029***	0.011	0.065	0.121
monthly fish income	0.035	0.952	0.568	0.690	0.087	0.090	0.180***	0.075	0.758 **	0.38
Fish cooperative member	-0.790	0.851	0.026 **	0.013	0.568	0.429	0.778	0.567	- 0.713	0.510
Credit access	0.095	0.172	0.547	0.871	0.476	0.452	0.0790	0.540	0.734 **	0.369
Farm size	0.065	0.590	- 0.257	0.927	0.072	0.080	1.215 **	0.598	- 0.165	0.435
Fishing experience	-0.009	0.025	0.110 *	0.065	2.174 **	0.774	0.009	0.021	0.022	-0.013
Household size	0.0002 **	0.000 08	0.045	0.088	0.087	0.090	10.10 ***	3.34	0.137	0.675
Access to extension contact	0.048	0.900	7.029 *	3.767	1.415*	0.566	0.012	0.157	0.780	0.880
Access to weather infor mation sources	-0.399	0.781	0.904 *	0.235	0.533**	0.246	0.0770	0.171	- 0.722	0.897
Mean annual ppt	0.667	0.890	0.028	0.034	0.0850	0.153	0.011	0.011	0.233	0.178
Mean annual temperature	2.872	3.008	- 2.075	2.351	-3.418	2.784	-3.651	2.542	-2.90	1.970
Constant	121.31	53.64	99.58	70.53	90.82	77.02	84.989	66.73	23.91	72.39

Table 18: Estimates of the MVP for the Determinants of Adaptation Strategies to Climate Change
Source: From own survey data, 2020/21

Household Characteristics

Among fishers` socio-economic characteristic variables, Family size has a significant and positive effect on climate change adaptation, increasing the probability of diversification to non-fishery activities (high value livestock rearing and crop production) adaptation strategies. The probable reason is that larger family size and a larger number of productive household members increase agricultural production because it is associated with labour-intensive agricultural practices. Thus, household size has a significant association with some of the adaptation categories.

The result in Table 18 shows that household head education level has a positive effect on farmers' adaptation strategies (high value crop and livestock adaptation option) and hence, it significantly increases adaptation options. This is because educated farmers are expected to adopt new technologies based on their awareness of the potential benefits from the proposed climate change adaptation measures.

Household size has a significant and positive effect on climate change adaptation, increasing the probability to adopt operation of small business adaptation strategies. This means that, relying on fishing alone is not enough to obtain more household income to support the life of large family size. Therefore, household head who has large family size should have to adapt ''small business 'Adaptation strategies to overcome the negative impact of climate change on the fishing communities in the study area.

Fishing experience: This variable has a positive effect on some climate change adaptation strategies (changing the fishing location & increasing the fishing time on the ground). This means, it helps to stimulate response to the negative effects of climate change (incidence of flood & strong wind during fishing) on fishing activities. This is because more experienced fishermen are assumed to have better knowledge about weather information and its implication on fishing practices. More experienced fishers can easily overcome the problem of strong wind and flood incidence created during the fishing time on the water bodies. It helped to stimulate response to the negative effects of climate change on agriculture. This is because more experienced farmers are assumed to have better knowledge about weather information and its implication on agricultural practices.

Household Assets

The coefficient of fisher`s monthly income is positively and statistically significant for the choices of ''changing to the efficient fishing gears'' adaptation strategies. Adaptation strategies can be expensive with some requiring the purchase of improved fishing gears. Thus, when there is a high fisher`s monthly income from fishing, fishers may find it possible to adopt any adaptation strategy even when provided with information on climate change, as they might not be able to purchase the expensive fishing equipment.

The study also observed that the magnitude of a fisher's monthly income increased the likelihood of adjusting to the climate change. High income levels build adaptive capacity [19] that could enable fishers to diversify into non-fishers` activities (high value crops and livestock enterprises). Families with high income levels are responsive to climate change [20]. High income from fishing promotes the willingness to invest into other initiatives that provide a cushion against household emergencies caused by future low fish catches [21].

Farm size has positive and significant association with diversification to non-fishing activities (crop and livestock production). Large farm sizes provide an opportunity for diversification of their crop and livestock enterprises, and it can help to distribute risks associated with unpredictable weather. Therefore if the fishers own a farm land, it can easily adopt diversification to crop and livestock enterprises to overcome the risk of unpredictable weather impacts on fishing activities

Access to services and social groups

The coefficient of **access to credit** is positively and statistically significant for the choices of ‘‘changing to the efficient fishing gears’’ adaptation strategies. Adaptation strategies can be expensive with some requiring the purchase of improved fishing gears. Thus, in the absence of credit, farmers may find it difficult to adopt any adaptation strategy even when provided with information on climate change, as they might not be able to purchase the expensive fishing equipment.

The coefficient of **membership of fishery cooperative** is positive and statistically significant in influencing “increasing the fishing time and stay on the water bodies for a long time” adaptation strategies. This could be attributed to the fact that members of cooperative ‟ groups can share experiences and exchange information about how to overcome the problem of strong wind created during the fishing time on the water bodies. Participating in fishers’ groups made the fishers more likely to apply the adaptation strategies. A fishers’ group is associated with comprehensive information about the fishing activities, including adaptation to climate change.

Access to climate related information is an important variable that affects adaptation options. The results in Table 18 show that, access to climate information had impacted adaptation to climate change. That is, a farmer who had better access to weather information (i.e., seasonal or mid-term forecasting) made better informed adaptation decision. Small scale fishers who had access to weather information had a higher probability of implementing climate change adaptation strategies such as changing the landing location and increasing the fishing time on the fishing ground.

Access to extension services: this variable has a positive effect on some climate change adaptation strategies (changing the fishing location & increasing the fishing time on the ground). This means, it helps to stimulate response to the negative effects of climate change (incidence of flood & strong wind during fishing) on fishing activities. This is because more experienced fishermen are assumed to have better knowledge about weather information and its implication on fishing practices. More experienced fishers can easily overcome the problem of strong wind and flood incidence created during the fishing time on the water bodies.

Conclusion and Recommendation

The study analysed the determinants of climate change adaptation strategies, using the multivariate probit model. The study rejected null hypothesis of the independence of the different adaptation strategies. Thus, the alternative hypothesis of inter-dependence among the different adaptation strategies which justifies the use of the multivariate probit for this analysis was adopted for the study. The findings from multivariate probit model revealed that the fishers` choice of adaptation strategies are statistically significantly affected by factors such household head education level, monthly fish income, being a member of fish cooperative, credit access, farm size, household head fishing experience, household size, access to extension services and access to weather related information of the fish producers. Various sources of extension information significantly inform adoption decisions. Key among these is government extension; awareness of climate change and measures to mitigate its effects is thus depicted as a key factor in the adaptation process. The study identifies many explanatory variables as a key factor to adaptation of climate change in the study area. Resource availability enables farmers to implement adaptation decisions, the lack of which presents the household with a significant challenge of adopting the adaptation measures. With the estimates of the multivariate model indicating complementarities among the adaptation strategies choices used by the rice fishers.

The complementarities among these strategies shows that farm level policies that affect a choice of adaptation strategies can have a trickle-down effect on others. It is therefore, recommended for the stakeholders in the fishing activities to ensure that decisions that support all the choices of adaptation strategies are put in place. Government policies and investment strategies must be geared towards the support of education, credit facilities and information about adaptation to climate change, including technological and institutional methods, particularly for smallholder fishers and farmers in the study area. The government could build the capacity of agricultural extension systems and make climate change education a priority through ICT innovations. There is a need also for new institutions, such as Public-Private-Partnerships organized, which can take research findings, into the field and help smallholder farmers and fish producers adapt to a changing and varying climate elements. Investment in education is critical for overall development and may thus also provide a policy instrument for increasing the use of climate risk coping strategies and reducing the vulnerability of farm households.

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Economic Valuation of Ecosystem Services of Lake Zeway and Selected Bishoftu Crater Lakes

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Abstract

Protecting Lake Ecosystem is crucial not only to protect this country's public and economic health, but also to preserve and to restore the natural environment for all aquatic and terrestrial living things. Even if the Dambal and Bishoftu crater lakes are known for its` multifuctionality and rich in its` lake resources, some of these lakes are now degraded. The study was initiated to estimate households' mean willingness to pay (WTP) for the protection of the lakes and to identify factors that affects the maximum willingness to pay for protection of wetlands of these lakes. To meet these objectives, data from 237 rural households were collected using multi stage random sampling procedures. In the study both descriptive and econometrics analysis are employed. Econometric models such as, seemingly unrelated bivariate probit and double hurdle models were used to estimate mean WTP and determinants of WTP, respectively. Factors such as age of household head, credit access, distance from home to the lake, frequency of extension contact and participation in lake conservation practices have significant effect on the households' WTP. Thus, critical consideration of such factors is pertinent to increase the level of public support towards the rehabilitation intervention. Econometric models such as, seemingly unrelated bivariate probit and double hurdle models were used to estimate mean WTP and determinants of WTP, respectively. The result shows that the mean WTP values from double bounded dichotomous choice ranges from 195.53 to 250.71 ETB per year per household. Therefore, the aggregated welfare gain expected from the protection intervention ranges from 5,540,733.6 to 6,352,40 5.1 per year.

Keywords: Willingness to pay, Double hurdle model, Lake Protection

Introduction

An ecosystem service is defined as "the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious, and other nonmaterial benefits"(CGIA, 2016). The people of less developing countries more depend on ecosystem goods and services such as economic dependences, social well beings and livelihoods of the peoples those found around the particular ecosystem like forest ecosystem, wetland ecosystem and among these ecosystems lake ecosystem is one of them and it has great role to support the livelihoods of the people found around lakes (EFTEC, 2005). The livelihoods of people living in, or near to the wetlands depend on ecosystem services in deferent levels. Loss or degradation of the water balance harms them directly and indirectly as ecosystems play a critical role in their daily life and in maintaining the quality of the environment by absorbing and processing waste products (Petra et al., 2008).

Lakes (and more generally freshwater resources) provide many services. Some of them are directly valued by humans (increased water quantity, reduced damage due to flooding) whereas others benefit mainly to environment (reduced erosion, improved habitat for species). Since most of these services are not traded on markets, their economic valuation is not straightforward. As a result a wide non-market valuation literature has developed in the last decades and numerous lake valuation studies have been performed. Due to the wide range of valuation methods, characteristics of lakes and value estimates, it is very difficult to assess whether any systematic trends can be extracted from this literature and to shed light on what factors determine a lake's value (Reynaud, 2015).

Diversion of lakes water for use in irrigation, industry, invasion of plants and exotic species are threatening facts on lake ecosystems. In addition, contamination by toxics and nutrients from industry, farm, sewage, and urban runoff are threatens on lakes. Almost, in all of the continents except Antarctica, all the above listed threatens are a common threatens on lake ecosystem (Ayres et al.1996, Lemly et al.2000, Revenga et al.2000). In most parts of the world, anthropogenic impacts on lakes are spreading geographically due to human population increment and the globalization of trade (Ayres et al. 1996, French 2000). Conservation of natural and water resources based on amounts that people are willing to pay to protect or increase the resources' services. A typical approach to explain why individuals place values on a natural resource is based on distinguishing between those who use the resource and those who do not (Freeman 1993). As a result, total economic value is not only use value, but the sum of both use and non-use. Economists developed several techniques for placing monetary values of non-market goods and services. There are various non-market valuation techniques used to estimate the values of environmental resources (Mitchell and Carson, 1989). One of these techniques is a contingent valuation technique which is applied for this study.

The wetland ecosystem of Ethiopia includes twelve drainage systems/basins, over fifteen natural lakes, many swamps, marshes, floodplains, and man-made reservoirs. As a land locked country, Ethiopia lacks wetlands that are associated with coastal areas; otherwise, all wetland types (Ramsar convention 1971) that exist in different parts of the globe also available in the country. Most of the wetlands in the country can be considered as freshwater wetlands. There are abundant lacustrine type of wetlands that include lakes of the Rift Valley (Lakes Ziway, Langano, Awassa, Shalla, etc), Lake Tana, Lake Bishoftu and many other crater lakes and their associated wetlands (Forum for environment, 2007).

When we come to the study area, lake is a freshwater lake supporting multitude uses, including irrigation, fishing, water supply and recreation. However, the lake is being degraded primarily because of various land- and water-use activities in its watershed. The other lakes this study focus will be Bishoftu crater lakes. Namely: Bishoftu, Hora-arsedi, Chelleleka, Kuriftu, Kilole, Green, Babogaya and Balbala. Even if the town is rich in its lake resources, some of the lakes are degraded. In order to minimize some threats lake conservation or protection programs are required. To achieving better management of these resources require understanding of the function of the ecosystem. And also it needs sufficient planning, financial resource and community participation. Trying to identify if there exists an unobserved valuation function that determines a lake's value given its physical, economic and geographic characteristics will be the main objective of our paper. Information regarding economic valuation of ecosystems services of these lakes is not available or very limited. Therefore, this study will be conducted in order to value the use value of ecosystem services of Zeway and selected Bishoftu crater lakes. Such studies will be important and lead to improved understanding of the main ecosystems services of these lakes and their values and examines the major reasons for their losses.

Objectives of the study

The broad objective of the study will be to investigate the economic value of ecosystems services of Lake Dambal and selected Bishoftu crater lakes and the possibility of its conservation.

Specific Objective

- ☞ To examine whether respondent are willing to pay (WTP) for protection of wetlands of these lakes
- ☞ To estimate farmers' mean willingness to pay for the conservation of wetlands these lakes.
- ☞ To identify factors that affects the maximum willingness to pay for protection of wetlands of these lakes

Research Methodology

Description of the Study Area

Lake Dambal: is one of the freshwater Rift Valley lakes of Ethiopia. It is located about 160 km South of Addis Ababa. The districts holding the lake's shoreline are A.T. J K, Dugda, and Ziway Dugda. It`s watershed encompasses an area of 7032 km^2, falling between gradients 7° 22′36″N and 8°18′21"N latitude and 37°53′40″E and 39°28′9″E longitude. On average, the lake is located at an elevation of 1650 masl and it is shallow and has an open water area of 434 km^2 and shoreline length of 137 km, a maximum depth of 8.9 m and an average depth of 2.5 m (Von Damm and Edmond, 1984). The maximum length and width of the lake is 32 km and 20 km, respectively (LFDP, 1997). The climatic conditions are not uniform throughout the watershed. The minimum and maximum annual precipitation in the watershed is 729.8 mm and 1227.7 mm respectively. The mean annual temperature of 18.5 °C. The wet season – June to September – accounts for about 55% of the annual precipitation, while the dry season contributes 45% (Billi and Caparrini, 2006). There are two main feeder rivers to Lake Dambal; namely, Meki originating from Gurage Mountains in the Northwest and Ketar from the Arsi Mountains in the East; and it has one out flow in the south through Bulbula River, draining into Lake Abijata. Lake Dambal contains five main Islands: Tullu Guddo (4.8 km^2), Tsedecha (2.1 km^2), Debresina (0.3 km^2), Funduro (0.4 km^2) and Gelila (0.2 km^2). Debresina and Gelila have only a few inhabitants, the other three are inhabited by several hundreds of people (Yared Tigabu, 2003).Technologies such as fish smoking technology was demonstrated at Tullu Gudo under Lake Ziway condition. The lake has high economic importance for its natural resources (such as water, fish, wildlife, etc.), bio-diversity, recreational value and horticultural crops production as it is easily accessible and situated near the main asphalted highway, which is extended from the southern part of the country to Addis Ababa market outlets. The lake exhibits fresh water quality and is an important element of the Ethiopian Central Rift Valley region because it currently serves as the water source for closed and open farm irrigation, and as the only potable water supply for the Town of Batu. It also supports the livelihoods of the fishing community. It is a habitat for biological diversity, such as fish, birds, and mammals like hippopotamuses, among others. The marshes around it also support several bird species and provide roosts for several thousand cranes, herons, ducks, geese, etc. (Spliethoff et al., 2009).

Lake Dambal fishery was the most fishery contributor lake having a maximum contribution of all lakes in Oromia Region. This is because of the support it received from phase I (1981 – 1984) and phase II (1991 –1998) fishery development projects of the EDF (Yohannes 2003). Lake Dambal harbors the indigenous African catfish, *Clarias gariepinus*, and other commercially important fish species (*Oreochromis niloticus*, exotic *Carassius carassius*, *Cyprinus carpio* and *Labeobarbus intermedius*), in which some are native and others exotic that were introduced into the lake by the Ministry of Agriculture with the aim of fishery development (Abera et al. 2014). The potential yield of all species of Lake Ziway is estimated between 3,000 - 4500 tons per year (Mitike, 2013). The total production in 1987 was estimated at 2070 tons in which 1944 tons of the landing were composed of Tilapia.

Hora-Arsedi crater lake is one of the Bishoftu crater lakes, which was believed to be created around 7000 years ago by volcanic collapse above zone of fractured rocks. The lake is a double crater with a maximum depth of 38 m (North crater) and 31m (South crater, which is called Hora ilmo) and a mean depth of 17.5 m, located at 47 km away from Addis Ababa in the south eastern direction at 8° 50' and 39°E at an altitude of 1850 m (Mohr, 1961; Prosser, *et al.*, 1968; Wood, *et al.*, 1984). The surface area and volume of this lake is 1.03 km^2 and 0.018km^3 respectively, while the PH value of this lake is 9.2. The region has two rainy periods, the minor one extending roughly from February to April and the major one beginning in June and ending in September. The region around the lake is characterized by moderate rainfall, varying around about 850 mm per annum (Rippey and Wood, 1985), high incident solar radiation and low relative humidity. The mean temperature of its surface water was frequently found to be about 22^0C with a maximum of 24.5^0C and minimum of 19.2^0C. This lake has a great value especially for Oromo people to celebrate Irrecha festival yearly and a lot of domestic and abroad tourists have been celebrating this irrecha festival in each year and hence it has a great economic value for the country.

The vertical distance from the crater rim to the lake surface is about 80 m. Lake Hora-Arsedi receives 43% of its total inflow from groundwater, but almost all water lose (97%) is by evaporation. The annual variation in depth of this lake is less than a meter, which suggests the maintenance of water level by seepage to and from the water table (Baxter and Wood, 1965). Like all the other volcanic crater lakes in this area, Lake Hora-Arsedi is a closed system, surrounded by very steep and rocky hills and cliffs. The catchment of the lake is formed from volcanic rocks of basalt, rhyolite and tuff (Mohr, 1961). It is affected by the community around the lake area for different reasons (for example washing clothes, boat parking, livestock drinking, Irecha festival celebration, fishing, swimming , recreational purpose and others).

Balbala reservoir is established in Adaa district of Qoftu kebele in East Showa zone of the Oromia region by damming Belbela river in 1980 by Cuban civil Mission in collaboration with Ethiopian water resources and it is a cascade reservoir created by damming along the course of Belbela river. The protection works, canals, and on-farm structures for the dam were later constructed by the Ethiopian Water Works Construction Authority (EWWCA) with an objective of irrigating land area to be used by State Farms. The reservoir is supplemented (recharged) by the other storage dam (Wadecha) through hydrological catchments transfer.

It is located at 15 km East of Bishoftu town and about 55 km southeast of Addis Ababa along the road to chafe Donsa. It is found between 38 ^{0} 01'- 40° 04'E longitude and 08$\circ$ 47'- 09$\circ$ 00' N latitude. The reservoir is situated on a highland with an average elevation of 2,300 m a.s.l. The surface area and mean depth of this reservoir is 150Ha and 12m respectively.

Arround this reservoir, agriculture is the major source of employment, revenue, export earnings and a means for ensuring food security. As a result, there has been an ever-increasing expansion of irrigation-agricultural development practices and fishing activities in the area although workable management and exploitation strategies are not yet in place (Wakena Totoba, 2006).

The brown soil of the study area is dominated by clay, soils or black cotton soil, which is the type of clay mineral believed to have greater importance with respect to soil water storage (Wakena Totoba, 2006). The sloppy part of the land is degraded and exposed to high surface runoff. The poor natural vegetation cover, which is largely constituted by scattered bushes and small shrubs, afford little protection for the land from erosion and degradation. As a consequence, rill and gully erosion are not uncommon in the reservoir area (Wakena Totoba, 2006). This has important implications for the underwater light climate and water quality, which determine the trophic status of the water body under consideration. The climate in the reservoir area is wet to sub-humid according to the Thonthwaite's system of defining climate or moisture regions (NMSA, 1996, cited in Wakena Totoba, 2006).

The Belbela reservoir region has an extended period of wet season (March-September) with mean monthly rainfall varying from 50 to 223 mm. The rainfall of the study region is unimodal with the

highest amount of rainfall occurring between June and September and accounting for about 74% of the mean annual precipitation in the catchment areas of the reservoir. The mean annual rainfall for this reservoir is 866mm (Wakena Totoba, 2006).

The reservoir is known to support flourishing commercial fishery, which is based on introduced fish species primarily Oreochromis niloticus (Lemma Abera and fishermen, Pers. Comm.). The reservoir serves as the primary source of drinking water for both local inhabitants and livestock. The reservoir water at the shores is also used for swimming and washing clothes by people living in the vicinity of the reservoir.

Kilole Crater Lake: Kilole Crater Lake is member of string volcanic explosion crater lakes that are found in Middle Rift Valley of Ethiopia. It is located at South East of Addis Ababa in Ada'a distinct of East Shoa Zone near Bishoftu town. Kilole Crater Lake is located at 12 km distance from Bishoftu town. It situated at South East of Bishoftu in Hiddi 'kebele' at latitude 8° 48' 350''N, longitude of 39 ^{o} 05' 152'' E and an altitude of 2000 masl. The surface area and volume of this lake is 0.771 km^2 and $2x10^6m^3$ respectively, while the maximum and average depth of this lake is 6.4m and 2.6m respectively.

Arround this lake, agriculture is the major source of employment, revenue, export earnings and a means for ensuring food security. As a result, there has been an ever-increasing expansion of irrigation-agricultural development practices and fishing activities in the area although workable management and exploitation strategies are not yet in place. The lake is known to support flourishing commercial fishery, which is based on introduced fish species primarily Oreochromis niloticus (Lemma Abera and fishermen, Pers. Comm.). The lake serves as the primary source of drinking water for both local inhabitants and livestock. The lake at the shores is also used for swimming and washing clothes by people living in the vicinity of the Crater Lake.

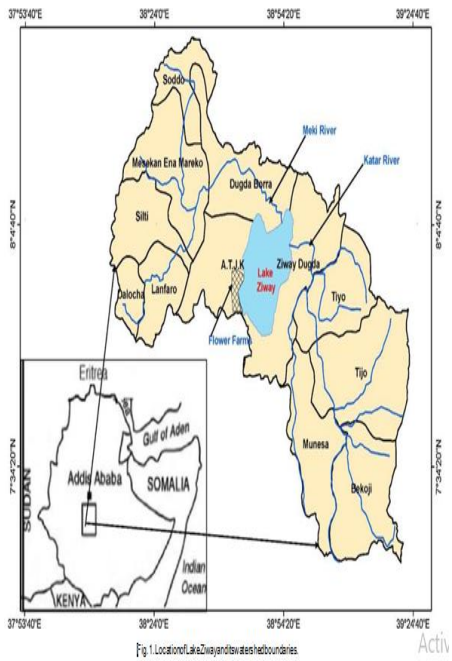

Figure 1: Map of Ziway Lake

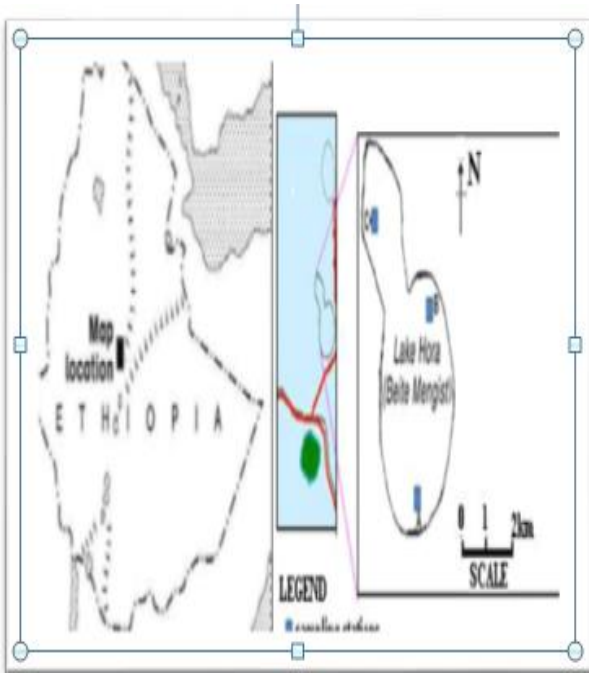

Figure 2: Map of Harsadi Crater Lake

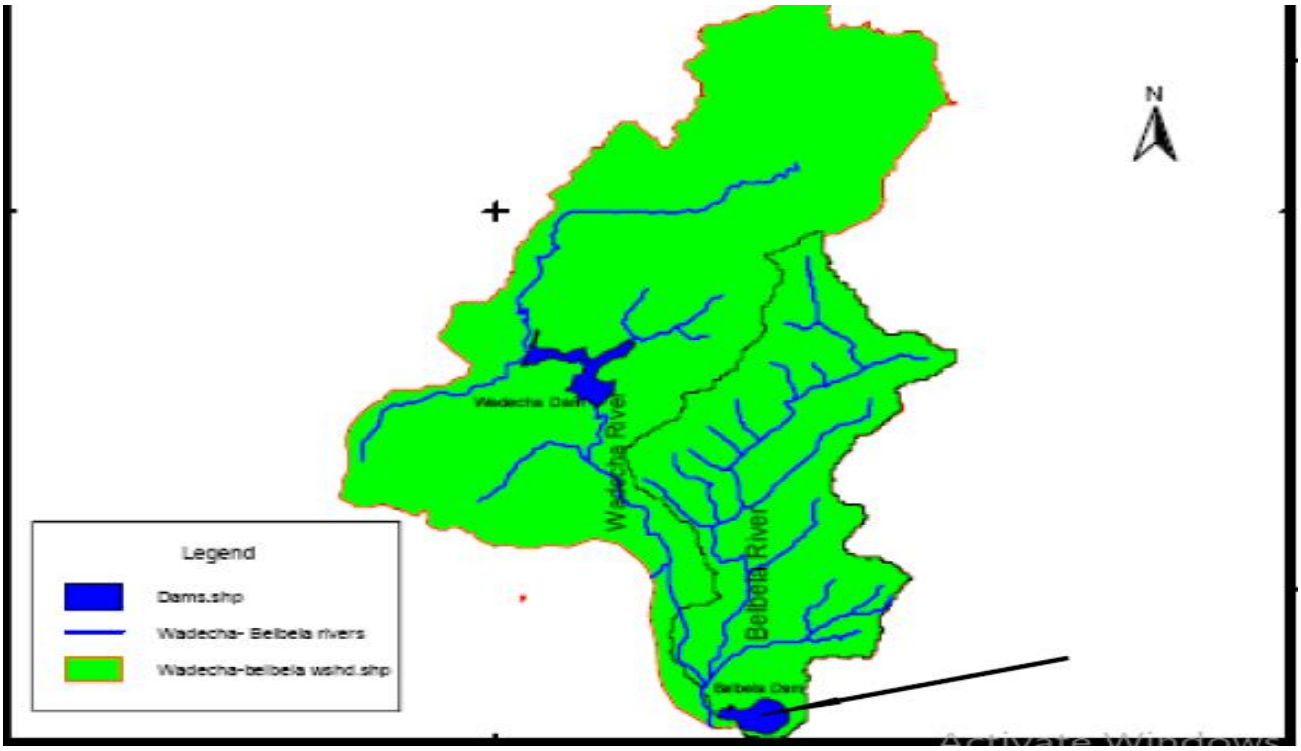

Figure 3: Map of Belbela reservoir

Sample size and Sampling Technique

For this study, a multiple stage random sampling technique were used for the selection of representative respondents. In the first stage, Dambal lake and Bishoftu crater lakes was selected through purposive sampling technique. At the second stage strata sampling were used to select 9 kebeles from each selected water bodies depending on livelihood activities of households of surrounding lakes. In third stage, based on lists of households in each strata random sampling of respondent were employed to select sample households.

Simple random sampling was used to select respondents from Lake Dambal and Bishoftu craters lakes. Respondents for this study were residents around lakes these lakes.

A representative sample size were estimated using formula of yemane (1967)

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

Where: n = Sample size, N = Population size, e = Level of precision or the error in which the researcher was tolerate.

As the population in the study area is homogenous in many characteristics such as livelihood strategy, cultural and other socioeconomic and institutional setups, the precision level used was 6.45%. Therefore, the sample size was determined to be 237 rural households.

$$n = \frac{30151}{1+30151\ (0.0645)^2} = 237$$

Data type, sources and method of collecting data

Both primary and secondary data were employed for this study. Both qualitative and quantitative data were collected from secondary and primary data sources. Secondary data sources are bureaus of District livestock and fishery resource development, Bureaus of District agricultural and natural resource development, Metrology agency, Primary cooperatives, Zonal Bureaus of livestock and

fishery resource development, Central Statistical Authority (CSA), and Bishoftu town agriculture office and cultural and tourism office. Secondary data were also collected from different and relevant published and unpublished reports, bulletins, and websites.

Primary data was collected from selected households from selected woredas of surrounding Lake Dambal and selected Bishoftu crater lakes. Primary data was collected using informal and formal surveys. The informal survey employed for this study was PRA technique like Focus group discussion and key informants interviews by using checklists. The formal survey was undertaken through formal interviews with randomly selected households around the selected water bodies using a pre-tested semi-structured questionnaire. Before data collection, the questionnaire was pre-tested on 20 respondents selected form each lake to evaluate the appropriateness of the design, clarity and interpretation of the questions, relevance of the questions and time taken for an interview. Hence, appropriate modifications and corrections was made on the questionnaire.

Method of Data Analysis

Both descriptive and econometric analysis was employed to infer the data. Descriptive statistics such as mean, standard deviation, percentage, ratios and frequency were used to compare and contrast different categories of sample units with respect to the desired characteristics and contingency valuation method was employed for measuring the total value households head give for lakes management. Ecosystem services which are not traded in markets remain un-priced. The relative economic worth of the functions was estimated using non-market valuation techniques. In order to value the provisioning ecosystem goods and services of Lake Dambal and Bishoftu crater lakes, the study were used estimating Willingness to Pay (WTP) which is part of Contingent Valuation Method (CVM) (Freeman, 2003). CVM is one of the methods which used for valuing ecosystem and CVM is hypothetical market by preparing survey which includes close and open ended questions (Bishop and Heberlein, 1990). The study were used close ended questions by putting bid value or different price for ecosystem services for Lake Dambal and Bishoftu crater lakes. The bid values obtained from pretested questionnaire survey by using open ended questions with giving their prices from household heads and small scale irrigation respondents.

Constructed hypothetical market scenario

In the first part of the CV scenario, detail information about wetland degradation and its consequence were presented by relating with some evidences from Ethiopia and abroad. In addition, information that describes how the wetland would look like if intervention measures could not be undertaken was also presented in detail. After this, as Ndebele *et al*. (2014) applied, three contingent valuation scenarios were presented with color photo. The first scenario was presents how the lakes currently looks like based on photos taken at the site. The second scenario was the ‘future scenario, which tried to show how the wetland would look like if the conservation program is not implemented. The final ‘future scenario’ was about how the wetland could potentially look like if the protection program implemented.

To avoid over or underestimation of WTP, households were reminded to critically consider their income level, the benefits they expect from the program, availability of substitute and other socioeconomic and institutional factors to answer the WTP questions (Arrow et al. 1993). In addition, to avoid protest and free-riding behaviour of the households, as Ndebele et al. (2014) suggested, households were requested to assume that the conservation program would only implemented if all the surrounding people are willing to contribute based on their ability.

Elicitation method and initial bid sets

Using a series of questions in the DB-DC elicitation method can progressively narrow down households stated amount to their true WTP amount. For this reason, DB-DC elicitation method with follow up question was adopted to estimate mean WTP amount. The initial bids offered can be determined by using information obtained from the pretesting questionnaire using 20 randomly selected households. Therefore, initial bids that give maximum efficiency in estimating mean WTP was obtained by offering an initial bid amount closer to the true mean WTP value (Haab and McConnell 2002) using mean, median and mode of the WTP
amount from the open-ended pre-test question. Hence, the initial bids that were equally and randomly allotted to each sampled households were 150, 180, 200 and 245 ETB per year per household.

Econometric Model Specification

Mean Willingness to Pay (WTP) Estimation method

With two binary responses (WTP1 and WTP2), it is impossible to use the conventional probit or logit model to estimate these two equations simultaneously. Thus, seemingly unrelated bivariate probit model, which simultaneously estimate the initial and follow-up bid equations, becomes appropriate. Estimation of mean WTP using such model could lead to a more statistically efficient WTP estimation (Malama 2015). A study by Signorello (1998) also confirms that, when there is interdependence between the two responses, which is manifested by the significant correlation coefficient ($\mathfrak{x}$ <0.85), seemingly unrelated bivariate probit could be appropriate econometric model to estimate the mean WTP. Therefore, seemingly unrelated bivariate probit was employed to estimate households' mean WTP for the protection of the selected lakes of the study area. There are four possible outcomes in the double bounded dichotomous choice elicitation method with their probability (Hanemann *et al* 1991).

$$\mathbf{B1 < WTP < B2: (Yes, No) = Pr\ (\mu 1 + \mathfrak{x}\ B1, \mu 2 + \mathfrak{x}\ B2)} \quad (2)$$
$$\mathbf{B_1 > WTP > B_2: (No, Yes) = Pr\ (\mu_1 + \varepsilon_{1j} < B_1, \mu_2 + \mathfrak{x}\ B_2)} \quad (3)$$
$$\mathbf{WTP > B2: (Yes, Yes) = Pr\ (\mu 1 + \varepsilon 1j > B1, \mu 2 + \mathfrak{x}\ B2)} \quad (4)$$
$$\mathbf{WTP < B2: (No, No) = Pr\ (\mu 1 + \mathfrak{x}\ B1, \mu 2 + \varepsilon 2j\ \mathfrak{x}\ B2)} \quad (5)$$

Where, B1, B2 and WTP are initial bid, second bid amount and WTP amount for the follow up question respectively.
According to Lemi (2015), seemingly unrelated bivariate probit model can be specified as follows:

$$\boldsymbol{Y1 * = \alpha 1 + \beta 1 B1 + \varepsilon 1} \quad (6)$$
$$\boldsymbol{Y_2 * = \alpha_2 + \beta_2 B_2 + \varepsilon_2} \quad (7)$$

$$Y1 = \begin{cases} 1 \text{ if } Y^*1\ \mathfrak{x}\ B1 \\ 0 \text{ if } Y^*1\ \mathfrak{x}\ B1 \end{cases}$$

$$Y2 = \begin{cases} 1 \text{ if } Y^*_2\ \mathfrak{x}\ B_2 \\ 0 \text{ if } Y^*_2\ \mathfrak{x}\ B_2 \end{cases}$$

Corr ($\mathfrak{x}$1, $\mathfrak{x}$2/B1, B2) = $\mathfrak{x}$

Where, Y1 and Y2 are WTP responses for the first and second equations respectively, B1

and B2 are the bid in the first and second bid questions, α's and β's are parameters to be estimated and $\mathfrak{x}$ 1 and $\mathfrak{x}$ 2 are unobservable random components and correlation coefficient ρ, is the covariance between the errors for the two WTP function.

Therefore, the mean WTP was calculated by using the coefficients from the constant term and the bids offered. These coefficients were obtained by regressing the dependent variables (WTP1 and WTP2) on the initial and follow up bid amount holding other explanatory variables constant (Haab and McConnell 2002). Thus, mean WTP was calculated by using the formula:

$$\mathbf{MWTP} = -\boldsymbol{\alpha} / \boldsymbol{\beta}$$

Where, α is a coefficient for the constant term, β is a coefficient offered bids to the respondents.

Determinants of households' WTP

WTP amount is the final amount that households are willing and able to pay for the proposed conservation/protection intervention. This variable has continuous value for those who are willing to pay and zero for those who are not. To identify the model that best fit, different methods were implemented.

Based on the Likelihood ratio statistics at 11degree of freedom, double hurdle model was selected than Tobit model. Hence, factors that influence the probability of households' WTP and its amount can be determined separately in the double hurdle model.

Therefore, the first decision (first hurdle) was specified using probit model as follows:

$$WTP_i^* = \mathfrak{x} + \beta`X_i + u_i$$

$$\mathbf{WTPi} = \begin{cases} 1 \text{ if } WTP^* > 0 \\ 0 \text{ otherwise} \end{cases}$$

Where WTP_i is a dummy variable that takes the value 1 if the household head is willing to pay for the rehabilitation intervention and zero otherwise; X_i is a vector of household characteristics and $\mathfrak{x}$ is a vector of parameters.

In the second hurdle, the decision on maximum amount of WTP were specified as follows:

$$\mathbf{MaxWTP^*_i} = \mathfrak{x}_\mathbf{o} + \mathfrak{x}\mathbf{X_i} + \mathfrak{x}_\mathbf{i}$$

$$MaxWTP_i = \begin{cases} 1 \text{ If } WTP^* > 0 \\ 0 \text{ Otherwise} \end{cases}$$

Where, $MaxWTP_i$ represents the maximum amount that the household are willing to contribute; X_i is a vector of the individual's characteristics and $\mathfrak{x}_o$, $\mathfrak{x}$ is a vector of parameters

The total aggregate WTP estimates depend on both the benefits per person or household and the number of beneficiaries. The populations that accrue benefits from the proposed program were those residential that live in near lake Dambal and Bishoftu town.

Total revenue=RxM

Where; *R* is the mean/median amount of WTP and *M* is the total number of residential or housing units.

Description of Variables and Expected Sign

List of variables	Description of variables	Nature and measurement unit of v ariables	Hypothesized direction of signif icance
BID	Initial bid amount	Continuous (Birr)	
WTP	Willingness to pay	Dummy (1 if yes , 0 otherwise	
MWTP	Maximum willingness to pay	Continuous (Birr)	
Credit	Credit access (Credit)	Dummy (1 if used, 0 if not)	-
Education	Educational status of respondent (Education)	Continuous (Class year)	+
Dist	respondents home distance from the lake	Continuous (Kilometer)	Negative
Age	Age of household head	Continuous (Number of years)	-
Ext contact	Frequency of extension contact (Extension)	Number of visit in a year	Positive
HHsize	Household size	Continuous (Man equivalent)	Positive
Land size	Irrigable Landholding size of househ old head (Land size)	Continuous (Hectare)	-
TLU	Total livestock owned by household head (Livestock)	Continuous (TLU)	Positive
Sex	Sex of household head (Sex)	Dummy (1 if male, 0 if female)	_+
Conservati on	Participation in environmental conservation practice	Dummy (1 participated, 0 if not)	Positive

Results and Discussion

This chapter deals with the result and discussions of the data which is obtained from the contingent survey. It has two parts. The first part discuses about the descriptive analyses while the second part talks about econometric analysis.

Descriptive statistics

From the surveyed households 87.76% of them were willing to contribute in favour of the protection intervention, whereas 12.24% of them were not willing for the proposed protection program for various reasons. In this regard, the household's decision to accept or reject the offered bid amount is found to be a function of many demographic, socioeconomic and institutional factors. Hence, the relationship be tween these factors and households' WTP are presented below.

Demographic and socioeconomic characteristics of sampled respondents

On the other hand, livestock rearing contributes to the rural livelihood next to crop production. In this regard, For protection of Harsadi crater lake, households who are willing to pay have an average of 2.54 TLU whereas; non-willing households have 3.7 TLU on average. For protection of Belbela reservoir households who are willing to pay have an average of 3.5 TLU whereas; non-willing households have 4.7 TLU on average. This mean difference in TLU possession between willing and non-willing households is found to be statistically significant (Table 1 and 2).

The average distance from households' home to the lake Dambal, harsadi lake, Belbela reservoir and Kilole lake were found to be 10.25, 15, 14.7, and 22.11 minutes of walk respectively for the households who are willing to pay for the lake conservation. This distance from home to the wetland also varies across willing and non-willing households. As presented in Table 1 and 2, households who were not willing to contribute to the lake conservation are situated at a distance of 15.51, 19.03, 20.4 and 24 minutes of walk on average respectively.

The mean age of households, who are willing to pay (WTP) for the Harsadi and Kilole crater lake conservation was found to be 40.8 and 38.5 years respectively; whereas for non-willing households it was 48.6 and 41.35 years. This mean difference in age of household head between willing and unwilling household head was found to be significant (table 1 and 2).

Households ,who are WTP for the protection of Dambal lake has less irrigable land around the lake as compared to the un-willing household heads this mean difference in ownership of irrigable land is also statistically significant. It is consistent with the finding of zhu *et al*. (2016) households who have more land around the buffer zone of the wetland might discern the intervention negatively due to fear of lose in their irrigable land.
In terms of frequency of extension visit, willing households have the chance of frequent extension visit compared to the non-willing households in the study area.

Table 1. The relationship between continuous independent variables and WTP of lake Dambal and Harsadi crater Lake

	Dambal lake (n=90)					Harsadi crater lake (n=55)				
	Willing (n= 79)		Unwilling (n=11)		t-value	Willing (n=51)		Unwilling (n=4)		t-value
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Age	42.7	14.33	44.71	11.25	0.27	40.80	12.9	48.60	16.6	3.31***
Educ	8.94	3.11	6.89	3.56	3.92***	9.10	4.76	5.00	2.74	2.94***
HHsize	5.36	3.08	8.21	4.97	0.12	3.67	2.08	4.50	2.91	0.83
IRland size	0.45	0.66	0.5	0.87	2.13**	0.125	0.79	0.30	0.53	3.67
Total land	2.9	2.13	3.55	2.70	0.15	2.00	3.13	3.00	2.96	0.98
Extcontact	9.18	6.3	3.81	5.97	3.57***	3.50	5.65	6.44	8.90	0.86
TLU	3.52	1.95	2.80	2.28	0.96	2.54	1.35	3.7	2.08	2.35***
Dist	10.25	8.60	14.51	9.30	2.99***	15.00	9.01	19.03	13.23	2.07**

Source: Own survey of 2021

Table 2. The relationship between continuous independent variables and WTP of Belbela reservoir and Kilole Crater Lake

	Belbela reservoir (n= 50)					Kilole crater lake (n=42)				
	Willing (n= 45)		Unwilling (n=5)		t-value	Willing (n=33)		Unwilling (n=9)		t-value
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Age	40.5	13.00	44.70	12.12	1.40	38.50	11.500	41.35	14.78	2.25**
Educ										
HHsize	4.50	3.20	6.00	4.45	5.00***	5.25	2.85	6.00	3.05	11.95***
land	2.00	1.50	2.5	1.67	2.25**	2.41	1.7	3.00	2.2	5.45***
Extcontact	8.00	5.10	4.50	2.5	3.03***	11.5	6.20	7.00	3.05	7.04***
TLU	3.50	1.92	4.7	2.00	7.07***	4.75	2.07	5.00	2.01	0.90
Dist	14.70	10.55	20.40	12.00	8.70***	22.11	14.15	24.00	11.40	1.90**

Source: Own survey result, 2021

Institutional characteristics of sampled respondents

As indicated in the table 3 and 4 below, there was a significant variation in the participation for the all selecte3d lake conservation among willing (89.9%) and non-willing (10.1%) households. This implies that willing households have better exposure for environmental conservation participation than their non-willing do.

Table 3. Association between demographic and institutional variables with WTP of Lake dambal and Harsadi Crater Lake

Variables	Category	Lake Dambal (n=90)					Harsadi crater lake (n=55)				
		Willing	%	unwilling	%	χ 2 value	Willing	%	unwilling	%	χ 2 value
Credit	Yes	45	56.96	7	63.63	1.49	35	68.62	0	0	1.05
	No	34	43.04	4	36.37		16	31.38	4	100	
Sex	Male	65	82.27	6	54.54	1.25	46	90.19	3	75	1.62
	Female	14	17.73	5	45.46		5	9.81	1	25	
Conserv	Yes	70	88.60	8	72.72	8.45***	48	94.11	3	75	5.75***
	No	9	11.40	3	27.28		3	5.99	1	25	

Source: Own survey result, 2021

Table 4. Association between demographic and institutional variables with WTP of Belbela reservoir and and Kilole Crater Lake

Variables	Category	Belbela reservoir (n=50)					Kilole crater lake (n=42)				
		Willing	%	unwilling	%	χ 2 value	Willing	%	unwilling	%	χ 2 value
Credit	Yes	20	44.44	2	40	1.52	17	51.51	3	33.33	1.63
	No	25	45.56	3	60		26	48.49	6	66.67	
Sex	Male	38	84.44	4	80	1.37	29	87.87	7	77.77	1.07
	Female	7	15.56	1	20		4	12.13	2	22.23	
Conserv	Yes	39	86.66	5	100	2.27**	30	90.90	9	100	4.78***
	No	6	13.34	0	0		3	9.10	0	O	

Source: Own survey result, 2021

Response patterns for the Double bounded-Dichotomous choice

In the double-bounded dichotomous choice elicitation method, the response patterns tending towards the two extremes of "Yes -Yes" and "No – No". As Table 5 shows, majority (31.64%) of the sampled households accept both the initial and follow-up bids. On the other hand, 29.11%) of them reject both bids offered. In between these two extremes, 22.78% and 16.45% of the responses in the DB-DC elicitation method were "Yes- No" and"No-Yes" respectively.

Table 5: Patterns of response for the two offered bids

Possible outcome	Frequency	%
Yes-Yes	75	31.64
No-No	69	29.11
Yes-No	54	22.78
No-yes	39	16.45

Source: Own survey result, 2021

Reasons for rejecting or accepting the offered bids

Respondents' decision to accept or reject the offered bids is dependent on many demographic, environmental, socioeconomic, biophysical and institutional factors. However, households might reject the offered bids either from their disapproval or from genuine behaviour. In this regard, the genuine and protest behaviours were identified by using a well-designed interview questions. Accordingly, 27.7% of the non-willing households were protest zero bidders and the remaining were genuine zero. For the genuine zero responses, the main reasons for rejecting the offered bids were financial problem and it should be the NGO`s and government concern. On the other hand, some households protest the payment for protection intervention with the reasons of they are not obtaining benefits. From 237 valid responses, 87.76% of the sampled households were willing to contribute in favour of the proposed protection of the selected lake. These willing households had different motivations to pay for the program. In case of Lake Dambal respondents, FGD and key informants' interview indicates that most part of this lake is covered by **Aware** grass and it is a good

source of cash income for landless youth and surrounding communities. Those individuals sold *this grass* two times per week with an average of 300ETB per trip.

Table 6: Reasons for accepting the offered bids

Reasons for accepting maximum WTP	Frequency	%
It is a tourist recreational place and destination	25	12.01
It`s conservation is just our culture	20	9.61
It is the source of my income	63	30.28
It is better if we kept it for future generation	26	12.5
The benefits I derived is greater than the payment	73	35.09

Source: Own survey result, 2021

Table 7: Reasons for the rejection of the offered bids

Reasons for rejection	frequency	%
It is the government's and NGOs concern	7	24.13
I do not have enough income to pay	13	44.82
I am not obtaining benefit from it	5	17.24
I donot have a confidence on the future protection of the lake	4	13.8

Source: Own survey result, 2021

Estimation of mean willingness to pay (WTP)

Table 8: Seemingly unrelated bivariate probit parameter estimates

Variable	Coefficient	Std. Err.	T-value
Initial bids	0.025	0.003	8.33***
Constant	1.472	0.357	4.12***
Second bids	0.035	0.010	3.5
Constant	0.752	0.275	2.72***
Rho (ρ)	0.953	0.174	5.47***
No. of obs		237	
Log likelihood		-251.41	
Wald $chi^2(2)$		41.00	
Prob > chi^2		0.0000	
Likelihood-ratio test of rho=0: chi2(1) = 5.355 Prob>chi^2=0.0087***			
Mean WTP = 195.53 ETB (At 95% CI, 195.53 to 250.71 ETB)			
y = Pr(WTP1=1,WTP2=1) (predict, p11) = 0.5672			

Note: *** shows significant variables at 1% probability levels

Source: Own survey result, 2021

Factors affecting households WTP Decision

Age of the respondent has a negative sign in Harsadi, Belbele reservoir and Kilole crater lakes at 5,1 and 10 % significance level respectively. The result shows that remaining other thing constant if age of respondent increases says by 1 year the probability of respondent WTP for the protection of Lake Harsadi, Belbela reservoir and Kilole lake decrease by 0.36,4.5 and 5 % respectively. As expected age has negative relation with WTP. This might to be as age increases respondent attention for environmental resource conservation is decrees related to carelessness for remaining few year.

Credit access: The exceptional result of this study was the negative relationship between credit utilization and WTP decision. This can be interpreted as: being a credit service user decreases the probability of WTP by -34.65% compared to nonusers. In addition to this, the FGD and KII result confirms that due to its higher interest rate and misallocation of the borrowed money, once the

households enter into the credit system they could not repay their loan in most cases. Hence, credit user households have lower probability of WTP compared to the non-users.

Distance from home to the wetland (DIST): As the distance from home to the lake increase by one minute of walk, the probability of willingness to pay in favour of the protection intervention decreases by 0.6% 0.9%,7.5% and 3.1% for lake Dambal, Harsadi lake, Belbela and Kilole crater lake respectively. Thus, households who are situated far from the wetland are less likely to pay for the rehabilitation of the wetland. This attributes to the fact that those households who are situated at a distance from the wetland might perceived as they are less beneficiary from the wetland compared to the nearest. This result is also in consistent with the findings of Shang *et al*. (2012).

Frequency of Extension contact (Ext contact): Extension contact found to have a significant and positive effect on the probability of households' WTP. This can be interpreted as; each additional extension contact by extension agent increases the probability of household's WTP by 5.7,8,12 and 0.4% for protection of lake Dambal, lake Harsadi,Belbela reservoir and kilole lake at 5,10,5 and 10 significance level respectively. The possible reason is that having more extension contact always associated with enhancement in households' awareness regarding the degradation level of the wetland and its consequence. This inspires households to conceive as rehabilitation of the wetland is pertinent to enhance the benefits obtained from it.

Participation in environmental conservation practice (CONSERV): Households who participate in environmental conservation practices have 15%, 7.5%, 9.5% and 0.3% at 5%, 10%, 10% and 1% probability level for protection of Danbal lake, Harsadi lake, Belbele reservoiR and Kilole crate lake respectively more probability to be willing to pay compared to those who do not participate. The rationality is that households, who participate in natural resources conservation, become well informed about the advantages of lake conservation. This finding is also consistent with the findings of Lamsal *et al*. (2015), which affirms that participation in environmental conservation practice determines WTP decision positively.

Irrigable land size around the lake (Land): the results in the table below shows that households with more land around the wetland are less likely to accept the payment for the consrvation of the of the Dambal lake. Hence, as households' land size around the Dambal lake increased by one hectare, the probability of WTP in favor of the protection intervention decreases by 5.2%. This finding indicate that households plough up to the edge of the Lake Dambal illegally when the water retreats every year. However, the perceived risk of loss in their irrigable land during protection program intervention could negatively affect their WTP decision.

Table 9:Probit estimation results of respondents WTP decision for the selected lakes

Variables	Dambal Lake (N=90)			Harsadi Crater lake (N=55)			Belbela Reservoir (N=50)			Kilole Crater Lake (N = 420		
	Coff	Std. Err	mfx	Coff	Std. Err	mfx	Coff	Std. Err	Mfx	Coff	Std. Err	mfx
Age	0.008	0.013	0.001	-0.06**	0.0304	-0.003	0.300***	0.081	0.045	-0.120*	0.070	0.050
Educ	-0.036	0.012	0.049	0.0231	0.705	0.13	0.905	1.050	0.070	1.0870	2.950	0.023
HHsize	0.150*	0.080	0.047	0.473***	0.085	0.075	-0.2705	0.570	-0.350	2.056	3.907	0.030
Distance	-0.0798***	0.0271	-0.006	-0.90***	0.075	-0.009	-0.257***	0.0172	-0.075	-0.585***	0.055	-0.031
Land	-0.324***	0.124	0.052	1.035	2.09	0.034	3.070	3.760	0.087	0.095	1.078	2.890
Extcontact	0.7695**	0.3497	0.057	0.110*	0.065	0.080	0.215**	0.099	0.120	0.379**	0.715	0.004
Conserv	0.585**	0.090	0.150	0.125*	0.073	0.075	0.150**	0.0872	0.009	0.222***	0.0760	0.003
TLU	-0.8513	0.6328	-0.450	0.127	0.481	-0.135	0.6328	0.780	0.905	0.091	0.6328	0.037
Credit	-1.4504***	0.4246	-0.3465	1.450	2.657	0.570	-0.124*	0.065	2.750	-0.135**	0.059	-0.215
_Const	-2.1056	1.0767		0.062	0.850		0.047	0.635		0.056	0.950	
Obs. No=90				Obs. No=55			Obs. No=50			Obs. No=42		
Loglikelihood=-80.705				Loglikelihood=-55.071			Loglikelihood=- 53.015			Loglikelihood=- 50.009		
Pseudo R2= 0.457				Pseudo R2= 0.560			Pseudo R2=0.445			Pseudo R2=0.370		
Prob > chi2 =0.0000				Prob > chi2 =0.0000			Prob > chi2 =0.0000			Prob > chi2 =0.0000		
LR chi2 (10)= 51.85				LR chi2 (10)= 87.00			LR chi2 (10)=60.47			LR chi2 (10)=64.072		
y = Pr(WTP) (predict) = 0.7005				y = Pr(WTP) (predict) = 0.60			y = Pr(WTP) (predict) = 0.500			y = Pr(WTP) (predict) = 0.900		

Source: own survey result of 2021

** and *** shows significant at 5% and 1% level of significance respectively

Determinants of Households`MWTP

Total Livestock Unit (TLU): livestock holding measured in tropical livestock unit found to have a significant and positive influence on the households' willingness to pay amount for Dambal, Harsadi, kilole crater lake and Belbela reservoir protection. Thus, holding other factors constant, a one-unit increase in livestock holding in TLU increases the amount that the household could pay by 12, 11.75, 16.57 and 7.4ETB for Harsadi, Kilole and Belbela reservoir protection respectively at 1% significance level. The possible reason is that livestock holding is a proxy for household's wealth and serves as a main source of income next to crop production.

Education level of household head: Education level of respondent has expected positively and significantly affect the maximum willingness to pay (MWTP) since highly educated respondents have high understanding and knowledge about environmental conservation and since they have high income than that of lower educated respondents, they are highly willing to pay for the proposed project. The result shows that education level of household head is positively associated to the protection of all selected lakes. It has positive and significant effect on the WTP amount for the protection of Dambal, Harsadi, Belbela and Kilole crater lake at 10%, 5%, 5% and 1% significance level respectively holding all other factors constant. The positive sign indicates that as people get more educated their awareness for resource conservation are improved would also increase amount of WTP for protecting Lake.

Distance: it has a negative and significant effect on the MWTP for the protection of Dambal lake and Kilole crater lake at 5% and 1% significance level respectively by keeping all other factors constant. the result shows that remaining other thing constant if the distance of the respondent increases let us say by one kilometres, the probability of the respondent willingness to pay amount for protection of lake Dambal and Kilole crater lake reduces by 12.35 ETB and 23.00ETB respectively.

Age of the household head (AGE): It has a negative influence on the WTP amount that the households could contribute to the protection of Lake Dambal. Thus, holding the effect of other factors constant, an increase in the age of the household head by one year decreases the amount that the household could pay by 1.25 ETB. Such negative and significant relationship between age of the household head and WTP amount might be associated with lower financial capability of the old aged households compared to the young and the middle-aged households.

Frequency of Extension contact (Extcontact): Extension visit, which is the primary source of information related to new technologies, innovations and natural resource management, found to have a positive and significant effect on the WTP amount for the conservation of the the Belbela reservoir. Therefore, an increase in frequency of extension contact by one more visit increases the household's WTP amount by 2.52 ETB. Previous studies by Senayet Lamesgin (2017) also emphasized that a frequent extension visit by extension agent increases the households' awareness on the roles of the lake conservation and this positively affects the WTP amount.

Participation in environmental conservation practice (CONSERV):: Holding other factors constant, participation in environmental conservation practices related to natural resource (Lake Harsadi and Belbela reservoir) conservation increases the household's WTP amount by 17.50 and 21.75 ETB compared to those who do not participate in environmental conservation practices at 5% and 1% significance level respectively.

Table 10: Truncated regression result of respondent's maximum WTP for the selected lakes in the study area

Variables	Dambal lake			Harsadi crater lake			Balbala reservoir			Kilole crater lake		
	Coff	Std. Err	mfx	Coff	Std. Err	mfx	Coff	Std. Err	mfx	Coff	Std. Err	mfx
Age	-2.035**	0.957	1.25	2.580	2.900	0.452	3.390	7.070	3.03	_0.607	0.425	1.070
Educ	0.118*	0.072	0.049	0.180**	0.085	0.13	0.165**	0.081	0.070	0.257***	0.024	0.230
Distance	-0.205**	0.095	-12.35	3.680	5.047	1.450	0.099	0.088	0.451	-1.057***	0.400	-23.00
Land	1.075	2.911	0.235	0.0575	0.067	3.050	0.075	0.080	3.070	3.005	5.073	1.909
Extcontact	1.990	2.890	0.780	0.023	0.047	2.500	3.690	5.875	2.520	0.009	0.009	3.005
Conserv	3.007	7.080	1.007	1.056**	0.500	17.50	2.365***	0.917	21.75	0.379	0.450	0.200
TLU	0.231***	0.095	12.000	0.751***	0.045	11.75	0.352***	0.095	16.57	0.1054***	0.0367	7.4
BID1	-0.588	0.487	-0.455	-0.675	0.890	-0.45	-0.345	0.680	-0.75	2.705	3.450	0.139
_Const	50.610	49.090		57.020	64.030		61.050	68.072		66.571	54.190	
2 Obs. No=79				Obs. No=51			Obs. No=45			Obs. No=33		
Loglikelihood=-857.072				Loglikelihood= -740.17			Loglikelihood=-67.005			Loglikelihood=-57.920		
Wald chi^2 (11)= 67.15				Wald chi^2 (11)=55.00			Wald chi^2 (11)= 43.47			Wald chi^2 (11)= 43.75		
Prob > chi2 =0.0002				Prob > chi2 =0.0001			Prob > chi2 =0.0003			Prob > chi2 =0.0001		
y = Linear prediction = 74.32				y = Linear prediction =74.3			Y= Linear prediction = 63.4			y= Linear prediction = 52.14		

Source: own survey result of 2021

Estimating Aggregate Willingness to Pay and Total Revenue

As indicated in in Table 11, the mean willingness to pay (WTP) estimated from Seemingly unrelated bivariate probit model ranges from 195.53 to 250.71 Birr for the initial and follow-up bids respectively. After excluding expected protest bidders, about 416, 499, 339, 372, 368, 523,325,290,507 and 28337 households are expected to pay for the protection of the selected lakes in , Abay danaba, Walin bula, Herera, Bashira chafa, Giraba qorke adi, Girisa Baqale, Hidi, Qoftu and 09kebeles and ion the study area respectively. Therefore, by using mean WTP amount from the initial bid, the expected aggregate welfare gain from the conservation of the selected crater lake is about 81340.5, 97569.5, 66284.6, 72737.1, 71955, 102262.1, 63547.2, 56703.7, 99133.7, and 5540733.6 ETB per year for the households in Abay danaba, Walin bula, Herera, Bashira chafa, Giraba qorke adi, Girisa Baqale, Hidi, Qoftu and 09 kebeles and in the study area respectively. Therefore, the aggregated benefit expected from the proposed protection ranges from 5,540,733.6 to 6,352,405.1 per year.

Table 11. aggregate welfare gain

Kebele	Total HH	Sampled HH	Valid Response	%Protest Zero	Expected protest bidders	Expected valid Response	Mean WTP	Aggregate WTP
Abay danaba	427	16	16	0	11	416	195.53	81340.5
Walin bula	520	13	13	0	21	499	195.53	97569.5
Herera	379	12	12	0	40	339	195.53	66284.6
Bashira chafa	407	11	11	0	35	372	195.53	72737.1
Giraba qorke adi	385	17	17	0	17	368	195.53	71955
Girisa baqale	542	21	21	0	19	523	195.53	102262.1
Hidi	350	42	42	0	25	325	195.53	63547.2
Qooftu u	327	50	50	0	37	290	195.53	56703.7
09kebele	535	55	55	0	28	507	195.53	99133.7
Sampled kebeles	3872	237	237	0	233	3639		711533.4
The study area HH	30,151	-	30,151	0	1814	28,337	195.53	5540733.6

Source: Own Survey result, 202

Conclusion and Recommendation

Majority of the respondents indicated their support towards the conservation of lakes by paying their cash based on their interests. The mean WTP amount that each respondents could pay for the protection of the selected lakes is about 195.53 and 250.71 ETB per year for the initial and follow up bids respectively. In conclusion, the probability and amount of WTP are mainly determined by the socio-economic and institutional factors than the demographic factors. Thus, for successful conservation of selected lakes, policymakers and other concerned parties should consider the following determinants critically.

Based on the findings of this study, the following policy implications are suggested.

- As the result of the study shows, there are different socio-economic variable that affect the proposed lake protection plan. So, the project planners and any other stakeholders should take in to consideration those significant variables that affect respondents WTP and MWTP responses separately for lake Dambal and selected Bishoftu crater lakes.
- Frequency of extension contact & Participation of household head in lake conservation practices were affects the WTP_positively and significantly. Therefore provision of frequent extension services and awareness creation should be needed to fulfill the gap of perception of the respondents about problem of the selected lake management.
- Probability of WTP is negatively & significantly affected by the age of household heads around the selected Bishoftu Crater Lake. Thus, developing a strategy that can improve the old aged households' annual income directly solves their budget constraint and at the same time, it increases their probability of WTP for the selected lake protection significantly.

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Factor Affecting Agricultural Drought Adaptation Strategies in the Moisture Stress Areas of Eastern Hararghe Zone

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Abstract

Drought is an extreme and frequent event in the Lowland areas of East Hararghe Zone and it adversely affects the livelihood of the farming community. Identifying the adaptation strategies that farmers use in the face of agricultural drought is crucial to understand how farmers minimize the effects of drought on their production, especially in the face of climatic changes that may impact the occurrence of extreme weather events (drought). The study was conducted in Babile, Gursum and Midhaga Tola districts of East Hararghe Zone to analyze adaptation strategies employed by smallholder farmers to the adverse effects of agriculture and factors that determine their adaptation decisions. The study was based on three-stage sampling techniques to select the study kebeles and sampled respondents. Both primary and secondary data sources were used. Data were collected through a household survey. The collected data were analyzed by using descriptive statistics and the multivariate probit (MVP) econometric model. The results revealed that in response to the effects of agricultural drought, the adaptation strategies used by smallholder farmers included terracing as soil and water conservation strategy, changing planting date, crop diversification, using improved crop varieties, using small-scale irrigation and agro-forestry practices. The results of the MVP econometric model showed that gender, family size, farm size, educational level, income, livestock holding, access to extension services, access to credit services and access to climate information affected smallholder farmers' choice of adaptation strategies to agricultural drought in the study districts. Therefore, policies and programs aimed at enhancing and strengthening the agricultural drought adaptation strategies of the smallholder farmers need to consider these factors well.

Key words: Drought, Adaptation, Multivariate probit, East Hararghe

Introduction

Drought is one of the most disastrous climate-related threats in the world, and affects agriculture, the environment, infrastructure, and socioeconomic activities (Moeletsi and Walker, 2011). Drought is defined as an insufficiency of rainfall over an extended period of time, usually a period of a month or more, resulting in a shortage of water and giving rise to adverse effects on vegetation, animals, and people (Msangi, 2004). Drought is a periods of increased dryness due to precipitation falling far short of expected of that expected for a region (Pickering & Owen, 1994). Meteorologists define drought solely based on the degree of dryness and the duration of the dry period whilst agriculturalists link drought to agricultural impacts focusing on precipitation shortages. Agricultural drought is a reduction in soil moisture availability below the optimal level required by a crop during each different growth stage, resulting in impaired growth and reduced yields; and socio-economic drought is when human activities are affected by reduced precipitation and related water availability. Socioeconomic drought associates human activities with elements of meteorological, agricultural, and hydrological drought.

Generally, droughts are classified as either a meteorological drought (lack of precipitation over a region for a period of time), hydrological drought (a period with inadequate surface and sub-surface water resources), agricultural drought (a period with declining soil moisture and consequent crop failure due to lack of surface water resources) or socio-economic drought (failure of water resources systems to meet water demands, which impacts human activities both directly and indirectly) (Senbeta,2009) and (Serigne, and T.Kandji, 2006).

Ethiopia is a country located in the Horn of Africa that is experiencing a warming trend of annual temperature and increasing drought severity (Burnett 2013; ISET 2013). The annual temperature of the country has been increasing by 0.37 °C every 10 years during the past 55 years (McSweeney et al., 2010). Ethiopia is one of the most vulnerable countries to climate change and variability in Africa and is frequently confronted with climate-related hazards that affect the lives and livelihoods of people (Burnett, 2013; ISET, 2013; World Bank, 2010). Climate related shocks and stresses with drought and flood being the major one has affected agricultural sector in Ethiopia (Deressa et al. 2011; ISET 2013). Although agriculture contributes to about 46% of gross domestic product (GDP), approximately 85% of exports and approximately 77% of total employment in Ethiopia, it is one of the most vulnerable sectors to the current and projected drought, potentially exposing millions of people to recurrent food shortages (ATA, 2017).

East Hararghe Zone is one of the drought prone areas of Ethiopia. Drought is a recurrent phenomenon occurring at different intensities in East Hararghe Zone. The lowlands of east Hararghe zone are particularly known by food shortage due to prolonged drought and the variability of rainfall from year to year and it's often uneven distribution during the growing seasons give place to a wide range of climatic hazards which farmers have to deal with (EHZAO, 2021). The farming communities in the north-west region experience frequent droughts affecting their livelihoods through reduced crop harvests, and livestock and fisheries production, resulting in food and nutrition insecurity. Reduced and uneven rainfall leads to the drying up of surface water.

When farmers are faced with adverse effect climatic changes specifically drought, they may opt to adopt a mix of drought copping strategies as a way of mitigation rather than relying on a single strategy to exploit complementarities or substitutability among alternatives. Thus, in addition to adopting a particular drought coping strategy, a farmer may choose other strategies. Adoption could be partly dependent on earlier adopted strategies informing decisions on subsequent practices in the future (Kassie et al., 2013; Lin et al., 2005). Significant investigations have been carried out on climate change adaptations and their determinants in certain regions of the country (Belay et al. 2017; Deressa et al. 2011; Di Falco 2009; Tazeze et al. 2012; Tessema et al. 2013). They are focused on the holistic adaptation strategies to climate change and variability, but no studies were conducted to draw out farmers' adaptation responses to drought and influential factors to adaptation strategies in the study areas. Hence, there is a great need to understand the specific coping strategies that farmers' employed in the face of increased drought at the household level, as well as the factors affecting the farmers' choice of coping strategies. The purpose of the study was to assess the farmers' coping strategies to drought and the factors influencing their strategic measures. Specifically, the study sought to understand how the farmers perceived the effect of drought on their agricultural production, to identify the coping strategies

that the famers' employed in times of drought, and the factors that influenced the farmers' use of drought coping strategies.

Objectives

1. Analysis of farmers' perceptions on agricultural drought and adaptation strategies in the study areas;
2. To identify the factors affecting drought adaptation strategies used by the farmers in the study areas.

Research Methodology

Description of the Study Areas

The study was conducted in lowland districts of the East Hararghe Zone. The lowlands of the East Hararghe zone are known for Striga infestation and drought-prone, and to offset the effect of Striga and drought, improved lowland sorghum varieties are being promoted and disseminated to the farmers through different organizations such as the Research Center, Office of agriculture, cooperative farmers University, and NGOs the study area.

The agro climatic range of the Zone includes lowland (*kolla*, 30-40%), midland (*weyna dega*, 35-45%) and highland areas (*dega*, 15-20%). Annual rainfall averages range from below 700 mm for the lower *kolla* to nearly 1,200 mm for the highland. The variability of rainfall from year to year and it often uneven distribution during the growing seasons give place to a wide range of climatic hazards that farmers have to deal with (EHZAO, 2021).

Based on the 2007 Census conducted by the Central Statistical Agency of Ethiopia (CSA), the Zone had a total population of 2,723,850, which is increased by 48.79% over the 1994 census, of whom 1,383,198 are male and 1,340,652 are female. The main socio-economic activity in the area is mixed farming (crop production and animal husbandry). Moreover, the main crops grown in the area include maize, sorghum, groundnut, *khat*, coffee, haricot bean, and different vegetables. Livestock husbandry includes cattle, sheep, goat, chicken camel and donkey are common.

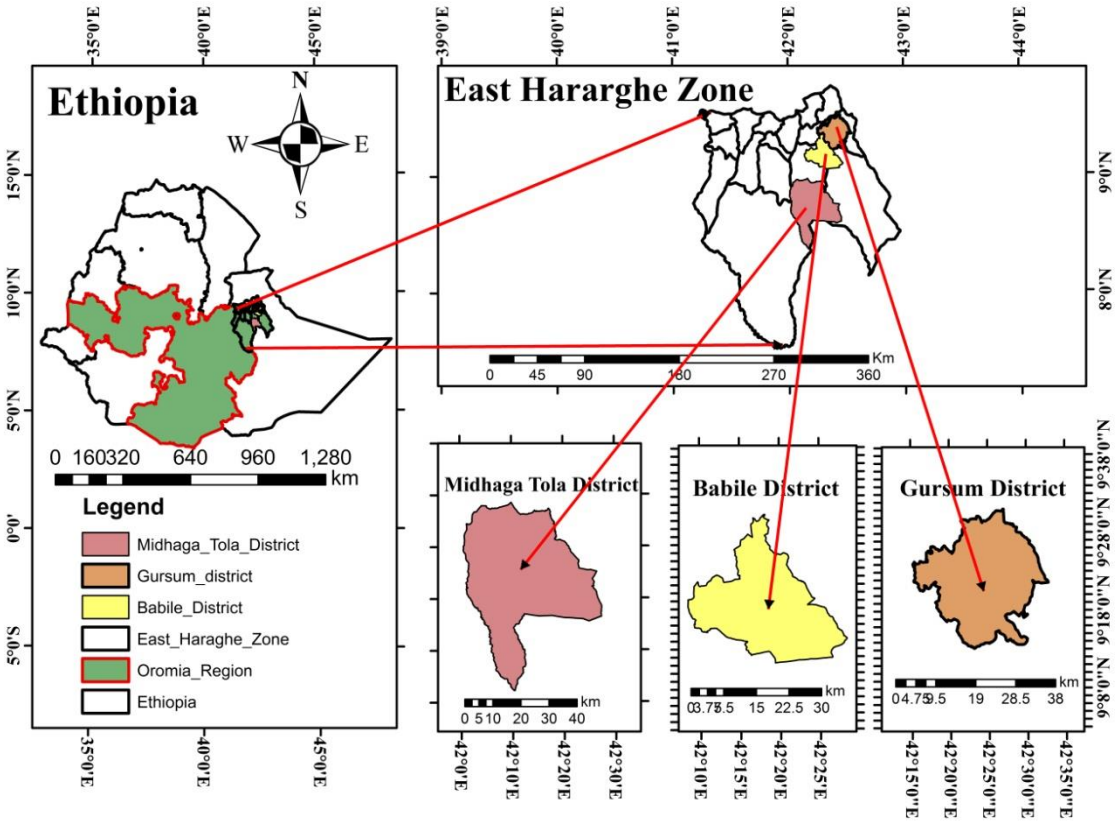

Figure 1. Administrative map of the study areas

Sampling Technique and Sample Size Determination

Three-stage sampling method was employed for selecting the sample units for the study. In the first stage, three districts of drought-prone or lowland areas from the East Hararghe Zone (Babile, Gursum and Midhaga Tola) were selected purposively. Secondly, two peasant associations (*kebeles*) were selected randomly from each district. The selected *kebeles* were Oda Oromia and Qabso from Gursum district, Awusharif and Ifa from Babile District, and Roba and Urji from Midhaga district. Finally, a total of 123 sample respondents were randomly selected based on probability proportional to size. For the drawn sample respondents, the simplified formula provided by Yamane, (1967) was employed to determine the required sample size at 95% confidence level with a degree of variability = 0.5 and a level of precision (e) = 9%.

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

Types and Methods of Data collection

Both primary and secondary sources of data were used. Primary data were collected directly from sample households through an interview schedule. Whereas, relevant secondary data were collected from different sources such as published and unpublished books and districts' agriculture and development office.

Method of Data Analysis

Both descriptive statistics (mean, standard deviation, frequency and percentage) and econometric model (multi-variate probit model) were employed to meet the specific objectives of the study. Data were analyzed with STATA version 14.

Specification of Econometric Model

When farmers have faced with adverse effects of climatic changes specifically drought, they may opt to adopt a mix of drought coping strategies as a way of mitigation rather than relying on a single strategy to exploit complementarities or substitutability among alternatives. This study used a multivariate probit (MVP) econometric technique, which simultaneously models the influence of the set of explanatory variables on each adaptation of coping strategies, while allowing the unobserved factors (error terms) to be freely correlated (Belderbos et al. 2004; Lin et al. 2005).

Since the drought coping strategy adoption decision is inherently multivariate, attempting univariate modeling excludes useful economic information contained in interdependent and simultaneous choice decisions (Dorfman, 1996). Therefore, this study will be analyzed by multivariate probit model (MVP). The MVP technique simultaneously models the influence of the set of explanatory variables on each of the different drought coping strategy alternatives while allowing for the potential correlation between unobserved disturbances, as well as the relationship between the drought coping strategy of different practices based on the study of (Belderbos *et al.*,2004; Yu *et al.*,2008; Kassie *etal.*,2009). One source of correlation may be complementarily (positive correlation) or substitutability (negative correlation) between different choice (Belderbos *et al.,* 2004). A positive correlation also occurs if there are unobservable farmer-specific characteristics that affect several decisions but that are not easily captured by measurable proxies. Failure to capture unobserved factors and inter relationships among choice decisions regarding different practices will lead to bias and inefficient estimates (Greene, 2008).

The observed outcome of drought coping strategy choice can be modeled following random utility formulation. Consider the jth household (j = 1... *N*) Which is confronting a decision on whether or not to adopt the available coping strategy on place *p* (*p* =1... *P*) over a specified time horizon. Let U_i represent the benefits to the farmer from fixed farm area or place, and let U_k represent the benefit of coping strategy adoption practice the kth coping strategy choice: (*k = all strategy as dependent*) representing coping strategy choice .The farmer can chooses to adopt strategy at the kth *location* of place *p* if the benefit that the farmer gains from k^{th} strategy at location of the place *p from coping strategy* if $Y^*_{ipk} = U^*_k - U_i > 0$. The benefit Y^*_{ipk} that the farmers can gain from K^{th} coping strategy on place *P* is a latent variable determined by observed and unobserved characteristics:

$$Y^*_{jpk} = X'_{jpk}\beta + U_{jp} \quad (k = \textit{All coping strategy as dependent}) \qquad \textbf{(2)}$$

Where X_{jp} represents observed household Socioeconomic, institutional and demographic characteristics; U_{jp} represents unobserved characteristics; *K* denotes the types of coping strategy and $ß_k$ denotes the vector of parameters to be estimated. Using the indicator function, the unobserved preferences in equation (1) translate in to the observed binary outcome equation for each choice as follows:

$$Y_k = \begin{cases} 1 \text{ if } Y^*_{jpk} > 0 \\ 0 \text{ otherwise} \end{cases} \quad (k = S_1, S_2, S_3\ S_4, \textit{ all coping strategy}) \qquad \textbf{(3)}$$

In the MVP model, the error terms jointly follow a multivariate normal distribution (MVN) with zero conditional mean and variance normalized to unity where $(U_{S1}, U_{S2}, U_{S3}, U_{s4}) \sim MVN(0,\Omega)$ and the symmetric covariance matrix Ω is given by:

$$\Omega = \begin{pmatrix} 1 & \rho_{s1s2} & \rho_{s1s3} & \rho_{s1s4} \\ \rho_{s2s1} & 1 & \rho_{s2s3} & \rho_{s2s4} \\ \rho_{s3s1} & \rho_{s3s2} & 1 & \rho_{s3s4} \\ \rho_{s4s1} & \rho_{s4s2} & \rho_{s4s3} & 1 \end{pmatrix} \qquad \textbf{(4)}$$

Hypothesized dependent and independent variables

The dependent variables, adaptation measures employed by farmers in the study area included crop diversification, improved varieties, soil and water conservation, changing planting dates, using irrigation and agro-forestry applications. The independent variables and their hypothesized effects are presented in (Table 1).

Table 1. Description of independent variables and hypothesis for its effect on dependent variables

Explanatory variables	Description	Expected sign
Gender	Dummy (1=Male,0=Female)	±
Age	Continuous	+
Education status	Categorical	+
Farm Experience	Continuous	+
Household size	Continuous	±
Livestock holding	Continuous	±
Land holding	Continuous	±
Crop Income	Continuous	±
Livestock Income	Continuous	±
Access to extension service	Dummy (1=Yes,0=No)	±
Access to credit	Dummy (1=Yes,0=No)	±
Access to climate information	Dummy (1=Yes,0=No)	±

Results and Discussion

Socio-economic Characteristics of Respondents

Table 2 and 3 presents the descriptive characteristics of the respondents. The respondents mean age was 34.95 years, with about 16 years of farming experience. This means that, on average, smallholder farmers in the study areas were relatively middle-aged, having many years of farm experience and relatively higher household sizes (average of six members per household) than the national household average size of 4.93 members per household. The average land holding size of households in the study areas was 0.812 ± 0.700 hector. The average livestock holding of the households was 2.89 TLU. Crop production and livestock rearing are the main sources of farm income in the study areas. The survey results showed that on average the households in the study areas earned 5504 Birr per annual from the farm income (selling crop produce, and livestock and livestock products).

Table 2. Descriptive statistics of socio-economic characteristics of respondents

Continuous Variables	Mean	Standard Deviation	Min	Max
Age	34.95	9.93	18	60
Farming experience	16.67	9.60	3	45
Household size	6.95	2.48	1	13
Land holding	0.812	0.700	0.125	4
Livestock holding	2.891	2.501	0	10.031
Farm Income ('000' Birr)	5.5043	10.1724	0	76

Source: Survey Result, 2020/21

The result of the study indicated that out of the total respondents, 105 (85%) of them were male while the rest 18 (15%) of them were female. The survey results show that 54.47% of the respondents had no formal education (illiterate), 39.03% had completed primary education, and 6.5% had obtained secondary education. With regards to the marital status of the respondents, 95.93% of the respondents were married, 2.5% were single, and the remaining was widowed (Table 3).

The respondents were asked if they received early warning system information and climatic advisories about drought. We found that 58.54% of the respondents had access to climate information in the study areas. The survey results show that 13% and 71.54% of the respondents had access to credit and extension services in the study areas respectively (Table 3).

Table 3. Descriptive statistics of socio-economic characteristics of respondents

Categorical Variables		Frequency	Percentage
Gender	Female	18	14.63
	Male	105	85.37
Education Status	Illiterate	67	54.47
	Primary education	48	39.03
	Secondary education	8	6.5
Marital Status	Married	118	95.93
	Single	3	2.44
	Widowed	2	1.63
Access to extension services	No	35	28.46
	Yes	88	71.54
Access to climate information	No	51	41.46
	Yes	72	58.54
Access to credit services	No	107	86.99
	Yes	16	13.01

Source: Survey Result, 2020/21

Farming Practices of the Respondents

The survey results indicated that 87% of the respondents are depends on the rain fed for their crop production practices in the study areas. The remaining, 13% of the respondents were used both rain-fed and small irrigation practices for their crop production practices in the study areas. The respondents were asked about the soil fertility status of their land. Accordingly, 17.89%, 62.60% and 19.51% of the respondents replied that their soil fertility status was fertile, medium fertile and poor fertile respectively in the study areas. Analysis indicated that sorghum and maize are the major crops grown during the main season in the study areas (Table 4). Apart from these two major crops recorded across all the study areas, groundnut and *khat* are ranked as third and fourth respectively. Potato, onion and common bean are produced in small amounts in the study areas.

Table 4: Farming practices of the respondents

Variables		Frequency	Percentage
Farming Practices	Rain fed	107	86.99
	Irrigation	-	-
	Both	16	13.01
Soil fertility status	Fertile	22	17.89
	Medium	77	62.60
	Poor	24	19.51
Major crops grown	Sorghum	107	86.99
	Maize	88	71.54
	Groundnut	64	52.03
	Khat	30	24.39

Source: Survey Result, 2020/21

Perceived Effects of Drought on Agriculture

All the respondents had experienced the occurrence of drought on their farms in the study areas. The survey results revealed that 92.68% of the respondents had faced severe crop failure problems due to drought in the study areas. About 89% of the respondents replied that this crop failure particularly occurred during *meher* season. 76.42% of the respondents were responded that there was an insufficient amount and distributions of rainfall exist in the study areas which causes crop failures. The survey results revealed that 94. 31% of the respondents had faced food shortage problems due to drought in the study areas. About 86% of the farmers perceive high in crop pest prevalence while about 11% and 3% perceive moderate seasonality of some crop pests and fewer crop pest species respectively. 100% of the respondents had faced the problem of livestock death due to severe drought in the study areas. 96.75% of the respondents responded that water scarcity was the core problem in the study areas due to drought in the study areas (Table 5).

Table 5. Respondents' perceived effects of drought on agriculture

Drought Effects	Frequency	Percent
Crop failure	114	92.68
Decrease of crop production	97	78.86
High Crop pest prevalence	106	86
Livestock death	123	100
Food shortage	116	94. 31
Water scarcity	119	96.75
Lower income	113	91.06

Source: Survey Result, 2020/21

Farmer Adaptation Strategies in Response to Drought

In the study areas, the respondents have adopted different strategies to reduce the consequences of drought thus far and to manage future patterns in climate change. Farming is the primary occupation for all of the sample households although they combine some level of non-farming income sources. According to the survey result, significant proportions of farmers have observed drought over the past 15 years. Small holder farmers are using major different adaptation strategies in response to drought. These includes:- the use of improved crop varieties, use of irrigation, soil and water conservation practices, crop diversification, adjusting planting dates and agro-forestry practices. These strategies, however, are mostly used in combination with other strategies.

In the study areas, 51.91% of farmers used improved crop varieties as a coping strategy to reduce the adverse effect of drought. Using drought-tolerant, early maturing and high-yielding varieties of major crops such as sorghum, maize, and haricot bean are predominant drought adaptation practices in the study areas. One of the most adaptation options used to cope with the adverse effect of drought in the study area was adjusting the planting date that is from early planting to late planting and vice versa. In the study area, 75.61% of sample households used adjusting planting date as a drought coping strategy on their farm.

Crop diversification (intercropping, double cropping and multiple cropping) are the common practices in the study areas. The most intercropped crops are cereals (maize, sorghum); with pulse crops (haricot beans, ground nuts) while sometimes horticultural crops (hot pepper and sweet potato) are also intercropped with other crops. From the total sample households, about 76.42% use crop diversification as a coping strategy for drought.

Soil conservation practices are widely used by farmers as an adaptation strategy for drought in the study areas. The study result showed that, out of the total sampled households, 92.68% used soil conservation as a coping strategy to reduce the effect of drought. Soil/stone bunds, tied ridging, ridging, mulching and manure application are among soil conservation techniques that are commonly used by farmers in the study areas.

Table 6. Summary of adaptation strategies used by smallholder farmers in the study areas

Coping strategies	Category	Frequency	Percentage (%)
Use of improved crop varieties	No	53	43.09
	Yes	70	51.91
Adjusting planting date	No	30	24.39
	Yes	93	75.61
Crop diversification	No	29	23.58
	Yes	94	76.42
Soil and water conservation (SWC)	No	9	7.32
	Yes	114	92.68
Use of Irrigation	No	97	78.86
	Yes	26	21.14
Agro-forestry practices	No	67	54.47
	Yes	56	45.53

Source: Survey Result, 2020/21

Irrigation was also used by some farmers as a coping strategy for drought. However, its availability, accessibility, and scarcity of irrigation were a great problem. About 21.14% of sample respondents have used irrigation as a coping strategy to drought in the study areas. Agro-forestry practices such as planting different trees (mango, coffee, etc.) have existed on the farm in the study areas. About 45.53% of sample respondents have used agro-forestry as a coping strategy to drought in the study areas.

Econometric Estimation of the Factors Affecting Farmers' Drought Coping Strategies

The multivariate probit model was used to examine the factors that influenced the respondents' Choice of adaptation measures during the agricultural drought in the study districts. In order to cope with the effects of drought, the respondents adopted different measures on the basis of their limited household and external resources. Table 7 present model estimates of the factors influencing the respondents' choice of drought copping strategies. The coefficients are explained at the 1%, 5%, and 10% levels of significance.

Gender is an important variable affecting adoption decisions at the farm level. The variable gender was significant and positively influenced farmers' choice of crop diversification as a coping strategy to drought. This implies that female respondents were less likely to adopt crop diversification as a coping/adaptation strategy. This finding was consistent with Dakalo et al., (2019) who found that male-headed households adapted more readily to drought coping strategy.

The result of the study indicated that the education level of the respondents had a positive association with using of irrigation practices in the study districts. This implies that as education level of the respondents were increased they were more likely to use irrigation practices as a coping/adaptation strategy drought in the study districts. The variable of farmers' education indicated that the practice of drought coping strategies increases with a higher educational level (Iheke et al., 2016). This result is in line with that of Deressa et al. (2009) and Tesso et al. (2012) who reported positive and significant effect of education on adopting climate change adaptation measures in Ethiopia.

Household size of the households had significant impact on the adaptation options to climate change. The model result shows that household size had negative and significant impact on use of improved crop varieties as strategy to reduce the negative impact of extreme climate change (drought) in the study districts. This indicates that as the household size increased by one household member the respondents were less likely to adopt improved crop varieties as adaptation/coping strategy to drought in the study districts. This could be because households with large families may be forced to divert part of the labor force to off/non-farm activities in an attempt to earn income in order to ease the consumption pressure imposed by a large family rather than adopting improved crop varieties and others (Belaineh et al., (2013) and Tazeze et al., (2012)).

Livestock holding is an important variable affecting adaptation strategy to climate change at the farm level. The ownership of livestock of the households had positive and significant impact on using improved crop varieties, adjusting various cropping calendar/plating date and using irrigation practices as adaptation strategies to cope up to drought in the study districts. The possible reason could be livestock plays a very important role by providing traction (especially oxen) and manure required for soil fertility maintenance. Those farmers with large livestock holding have better chance to earn more money to invest on the agricultural inputs which is also support to adjusting plating date. This result is consistent with the findings of Kibebew *et al.* (2016) and Temesgen *et al.* (2008).

Land holding has negatively and significantly affected use of improved crop varieties and irrigation use as drought adaptation/coping strategies in the study districts. This result is consistent with the findings of Solomon et al., (2014). In contrasts to this study, farmers with large land holding size may have an easier access to new improved crop technologies introduced in to the area. This showed that farmers with large land holding size have adopted one or a combination of climate change adaptation options as compared to the farmers with small land holdings (Taddesse (2011) and Tessema et al., (2013)). But, the land holding of the households has a negative impact on use of irrigation as adaptation strategy. The possible reason could be if the farmers have more land holding they can benefit from the economic scale of it as compared with those who have small land holding (Temesgen et al. (2008).

Annual income obtained from selling of crops produce has negatively and significantly affected irrigation use as drought adaptation/coping strategy in the study districts. This indicate that as annual income obtained from the crop increased the respondents were less likely use irrigation practices as adaptation/coping strategy to drought in the study districts. This may due to that the study districts are mostly produce the crops depends on the rain fed or meher season for consumption purpose. In line with this finding the respondents who earned a monthly income of

R10000 to R20000 were less likely to adopt water-use efficiency as coping strategy drought in South Africa (Dakalo et al., (2019). Annual income obtained from selling of livestock and livestock products was positively and significantly affected crop diversification as drought coping strategy in the study districts.

Access to extension services had positive and significant associations with all coping strategies to drought except crop diversification and using irrigation in the study districts. This implies that information on weather helps to plant at the optimum time, selecting varieties that are suitable for the environment, and soil and water conservation being done in the study area as a common practice to reduce land degradation then soil fertility improvement. In addition the respondents are practicing agro-forestry in the study districts. In line with this result, the extension services related to forecasting climate change, adaptation options, and other agricultural production activities is a vital factor influencing the use of different adaptation measures for most farmers (Ayalew, W. (2016) and Teshome et al., (2021)).

Access to credit services had negative and significant associations soil and water conservation practices as strategy to drought coping option in the study districts. This indicates that the respondents were less likely use soil and water conservation as adaptation/coping strategy to drought in the study districts because access to credit services was very low. May be those who accessed credit services were use as the financial sources to invest on the agricultural inputs than to invest on the soil and water conservation practices. So, access to credit service is an important factor to narrow the financial gaps of farmers so that they could purchase the required farm inputs and technologies useful for improving agricultural production and reduce climate change impact. In contrast to this result, access to credit services had positive and significant associations soil and water conservation practices as strategy to climate change and variability adaptation strategies in the West Hararghe Zone (Gosa et al., 2020).

Access to climate information had positive and significant impact on the use of improved crop varieties, crop diversification, using irrigation and agro-forestry practice as coping strategies to drought in the study districts. This revealed that as the respondents accessed to climate information they were more likelihood to adopt/use improved crop varieties as coping strategy to drought in the study districts. In line with this result, Vaughan and Hansen (2019) also stated that meteorological information is very important for farmers that depended on rain-fed agriculture to improve agricultural productivity and increase income, thereby reducing the impacts of climate change and minimizing risks.

Table 7. Estimates of the multivariate probit model on the choices of farmers' drought copping strategies

Explanatory Variables	Improve crop varieties		Adjusting planting date		Crop diversification		SWC		Irrigation use		Agro-forestry Practices	
	Coeff.	**P>|z|**	**Coeff.**	**P>|z|**	**Coeff.**	**P>|z|**	**Coeff.**	**P>|z|**	**Coeff.**	**P>|z|**	**Coeff.**	**P>|z|**
Gender	0.1034	0.804	0.009	0.983	6.402***	0.000	-0.398	0.434	-0.480	0.266	0.147	0.767
Age	0.011	0.658	0.034	0.142	-0.035	0.176	0.008	0.829	0.033	0.162	-0.006	0.839
Education status	0.047	0.255	0.043	0.335	0.044	0.301	-0.056	0.350	0.088*	0.061	0.019	0.695
Farm Experience	0.367	0.368	-0.318	0.405	0.703	0.108	-0.046	0.932	-0.424	0.295	-0.131	0.764
Household size	-0.965***	0.003	0.259	0.295	-0.378	0.199	-0.020	0.946	0.102	0.745	0.153	0.576
Livestock holding	0.563***	0.007	0.517*	0.012	0.189	0.416	0.388	0.242	0.471**	0.041	0.149	0.516
Land holding	-0.394**	0.032	0.176	0.342	-0.088	0.662	0.255	0.189	-0.74***	0.000	0.123	0.508
Crop Income	0.006	0.102	-0.005	0.117	-0.004	0.329	-0.003	0.543	-0.012**	0.01	-0.004	0.188
Livestock Income	-0.001	0.691	0.005	0.169	0.024**	0.013	0.005	0.349	0.001	0.833	-0.001	0.712
Access to extension service	0.641*	0.052	0.565*	0.076	0.585	0.107	0.501***	0.000	-0.124	0.718	2.452***	0.000
Access to credit	0.217	0.616	-0.550	0.192	0.921	0.109	-0.963*	0.053	-0.667	0.279	-0.243	0.564
Access to climate information	0.537*	0.053	-0.029	0.917	1.123***	0.001	-0.008	0.986	0.663**	0.02	0.88***	0.008
Constant	-0.270	0.779	-0.407	0.673	7.162***	0.000	6.038***	0.000	-1.332	0.232	-1.544	0.112

Number of obs = 123
Wald chi2 (36) = 469.50
Log pseudolikelihood = -144.96261 Prob > chi2 = 0.0000

Note: *** p<0.01, ** p<0.05, * p<0.1, Source: Survey Result, 2020/21

Conclusion and Recommendations

This study examined factor affecting smallholder farmers' agricultural drought adaptation strategies in the moisture stress areas of Eastern Hararghe Zone. The results indicated that majority of the smallholder farmers employed different adaptation strategies to adapt to adverse the effects of drought, including soil and water conservation strategy, changing planting date, crop diversification, improved variety, irrigation practices and agro-forestry practices in the study districts. The majority of the respondents used soil and water conservation strategy to cope up to drought in the study districts. The results of MVP econometric model showed that gender, family size, farm size, educational level, income, livestock holding, access to extension services, access to credit services and access climate information affected farmers' choice of coping strategies to drought in the study districts. Thus, this study underscored the importance of considering socio-economic and institutional variables are the main adaptation strategies to agricultural drought in the study districts.

Finally, the study recommended the policies and programs aimed at enhancing and strengthening the drought coping strategies used by the farmers like soil and water conservation, use of improved crop varieties, crop diversification and adjusting planting dates is crucial. Increasing the knowledge level of farmers regarding agricultural drought and drought coping strategies, as well as making extension services, credit services and climate information services easily accessible to the farmers could improve drought coping strategies within the study districts. Small holder farmers' access to media should have to be strengthened in order to create awareness. Future studies should examine the climate change variability and adaptation strategies in the other agro-ecologies of East Hararghe Zone because this study was limited lowland agro-ecology and focused only on the drought.

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Assessment of Wheat Production and Marketing Systems in East Hararghe Zone of Oromia Region, Ethiopia

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Abstract

The study was undertaken in selected districts of East Hararghe Zone of Oromia Region, with objectives to assess and describe wheat production and marketing systems in the area. As sampling procedures, three stage sampling procedures were employed to select a total of 253 sample farmers. Primary data were collected from sampled households through a household survey, and the collected data were analyzed using descriptive statistics. On average about 0.48 hectares of land was allocated to wheat, and the average productivity of wheat was 20.87 quintals per hectare in the study area. The survey result also indicated that about 63.7%) of the farmers have used improved wheat seeds. Moreover, the survey result indicated that six major wheat-marketing channels were identified to deliver the product from producer to consumers in the study area. Diseases, shortage of improved seeds, timely unavailability of inputs, and lack of access to pesticides were found as the main constraints in the area. To address these constraints and to enhance wheat production and productivity in the area, recently released improved wheat varieties (rust resistant, adaptation and good yield potential) should be introduced and delivered to farmers to ensure increased wheat productivity, and research centers and Universities has been striving toward releasing improved wheat varieties. The extension system, Research centers and other stakeholders need to place a greater emphasis on improving availability of improved seeds, and dissemination of knowledge that will help the farmers in the access and use of inputs. The government gives emphasises to improving access to tractors and combine harvesters, and promotion of wheat row planters and small scale wheat threshers in the area.

Key words: Wheat production, marketing system, market channels, East Hararghe

Introduction

Wheat (Triticum aestivum L.) is an important industrial and food grain which ranks second among the most important cereal crops in the world after rice and traded internationally (Asadallah, 2014; Falola *et al*., 2017). Wheat is one of the most important cereal crops grown in several African countries including Ethiopia, and demand for wheat is increasing in Africa and sub-Saharan countries because of income growth, urbanization and dietary diversification (Jayne *et al*., 2010; Negassa *et al*., 2013).). In sub-Saharan African countries, wheat is also a strategic commodity which generates farm income and improves food security status (Amentae *et al*., 2017; Minot *et al*., 2015). But in sub-Saharan countries including Ethiopia produce wheat only about 30% of their domestic requirements, and the heavy dependence on imports and making the region highly vulnerable to a global market and wheat supply shocks (Negassa *et al*., 2013,).

In Ethiopia, wheat is one of the strategic cereal crops for the majority of Ethiopian's population, and it plays an important role in the development of the agricultural sector and improvement in the income levels and livelihood situations of the smallholder farmers of the country. In addition, wheat production and its marketing are increasingly becoming the means of livelihood for a million smallholder farm households in in the country and. the smallholder farmers are improving their way of life by growing and selling wheat produce so that the government promotes them to produce more for alleviating poverty (CCSA, 2017; Berhanu, 2012). Moreover, in Ethiopia, wheat has been selected as one of the target crops in the strategic goal of attaining national food self-sufficiency by producing it using rain fed and irrigation (Aleminew, *et al.,* 2015). Even though the crop has a huge potential, only 20% of the total wheat production is sold, while 80% of its total production is used for consumption (Abafita, 2016).

In sub-Saharan Africa, Ethiopia is the largest producer of wheat, ranking fourth next to teff, maize and sorghum in area coverage, and in 2019/20 production year about 1.78 million hectares of land was under wheat and the volume produced (53 million quintals) with average productivity of 29.70 quintals per hectare (Bergh, *et al*., 2019, CSA, 2020). Similarly, in East Hararghe Zone, wheat is among the most important cereal crops grown by smallholder farmers next to sorghum and maize, and it ranks third in area coverage after sorghum and maize, and it is a major source of livelihood for farm households in the Zone. In 2020 production year, about 1970,517.66 hectares of land was under wheat and the volume produced (31 million quintals) in Oromia Region whereas in East Hararghe Zone the total area of land under wheat was 24,143.35 hectares and the volume produced was 527,273.95 quintals with average productivity of 21.84 quintals per hectare which is less than regional and national yield (CSA, 2020). In Ethiopia in general and in the study area in particular, smallholder farmers are the dominantly wheat producer and accounts for more than 92% of the country. These farmers are characterized as subsistence oriented, low productivity, entirely dependent on the weather with little investment in irrigation and characterized by the traditional production and market systems. In addition, lack of adequate improved seed supply, lack of sufficient mechanization services, and impracticality of research outcomes to growers are still remaining challenges to wheat farmers in the country (Bart, *et al.,* 2016).

East Hararghe Zone has favorable climate conditions for wheat production, and market opportunities, the farmers constrained by biophysical and socio-economic constraints, and there is also inadequate information on wheat production systems, varieties grown and management practices used by smallholder farmers in the Zone (Kibret, *et at.,* 2020). In addition, despite the increasing importance, and opportunities for increasing wheat production and productivity, there was an information gap on existing wheat production and marketing systems in the study area. Hence, this study was designed with the objectives to assess and describe wheat production, marketing systems, farmers' varieties preferences and identifying existing wheat production and marketing constraints and opportunities in the study area.

Methodology

Description of the Study Area

The study was undertaken in wheat production potential districts of East Hararghe Zone of Oromia Region. The East Hararghe Zone is located at the eastern part of Oromia regional state and it is found about 525 km away from Finfine capital of the country. The zone lies between $7^0 32^{'}$N to $9^0 44^1$Nand 41^0 $10^{'}$E to $43^0 16^{'}$E and is demarcated by West Hararge Zone from the west, Bale Zone from the south, Somali regional state from the East and Southeast, and Dire Dawa administrative council from the North. East Hararge Zone has three major agro-ecologies namely lowland, midland and high land. The lowland accounts (67.76%) followed by midland (24.57%) and highland (7.67%) agro-ecologies. East Hararghe zone lies within an altitude of 500 to 3405 meters above sea level.

The annual rainfall of the zone ranges between 400 to 1010 mm, and the annual temperature also ranges between 14 ^{o}c to 25°c. The Zone has a total of 26,308.60 km^2 of land. Agricultural production is the main means of livelihood of the residents of the zone, and it is characterized by a smallholder mixed farming system where crop production and livestock rearing are simultaneously practiced. The main crops produced in the area include sorghum, maize, wheat, barley, haricot bean, faba-bean, vegetables such as potato, onion, cabbage, carrot, pepper; fruits, coffee and chat are produced in the zone. Livestock husbandry is also dominated by cattle, sheep, goats, camels and donkeys (EHZFEC, 2018).

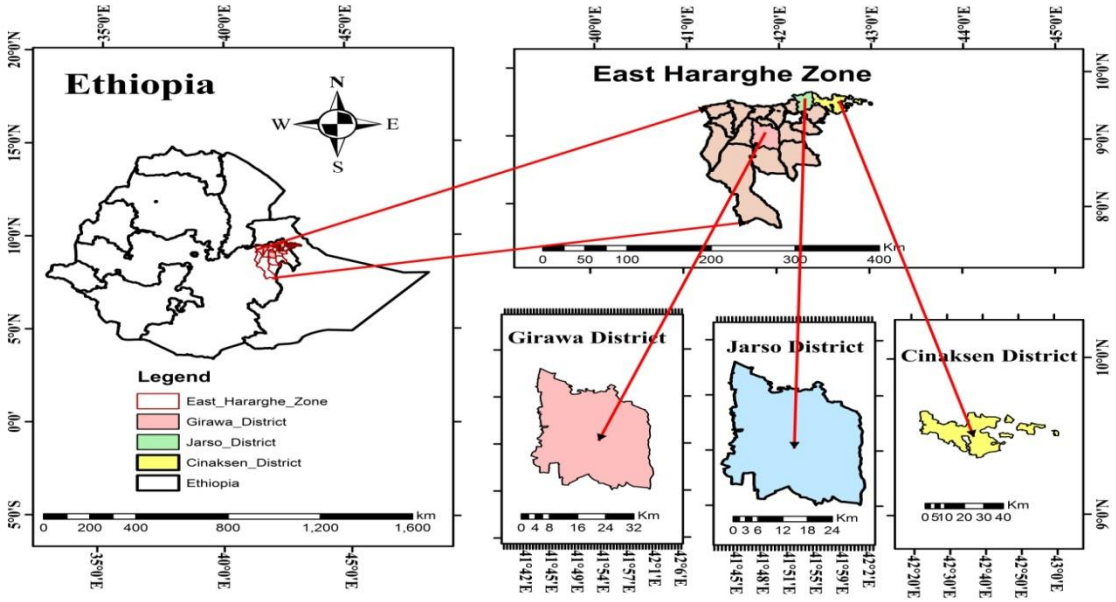


Figure 1. Location Map of study areas

Sampling Method and Sample Size

Three-stage sampling techniques were used to select representative districts, Kebeles and sample farm households. In the first stage, three districts (Gurawa, Chinaksen and Jarso) were purposively selected based on wheat production potential and accessibility from East Hararghe zone in with collaboration of Zonal experts. In the second stage, wheat-growing kebeles in each district were listed and identified. Once wheat-growing kebeles were identified, six kebeles from Gurawa and Jarso districts (three kebeles from each), and four kebeles from Chinaksen district were selected. This resulted in a total of ten wheat-growing kebeles being selected randomly from three districts. In the third stage, a total of 253 wheat producer farmers were selected randomly using probability proportional to the population size sampling technique. In addition, about 90 wheat producer farmers, experts, Development Agents and leaders of farmers' cooperatives were purposely selected also participated in this study through Key informant interviews (KII) and focus group discussions (FGDs) in the study area.

Sources of Data and Methods of Collection

The study used primary and secondary data sources to collect data. Primary data were collected through individual interviews using semi-structured questionnaires from selected wheat grower farmers. The primary data collected from farmers include demographic and socio-economic characteristics, an area under wheat production, nature of the production system, quantities produced and sold, sales price, sources of inputs, type of varieties used and their preferences and constraints and opportunities in 2019/20 production year. In addition, key informant interviews and focus group discussions were held with wheat farmers, development agents and experts by using checklists to support primary data collected through individual interviews. Secondary data required for the study were taken from Central Statistical Agency's website, and district agricultural and natural resource offices.

Method of Data Analysis

Descriptive statistics such as frequencies, percentages, means and standard deviations were used to examine the socioeconomic characteristics of wheat grower farmers, and wheat production and marketing systems of the study area. In addition, trend analysis, ranking and preferences were used to analyze wheat production status, farmers' varieties preferences, and wheat production and marketing constraints in the study area. The collected data were analyzed by using SPSS statistical software package version 20.

Results and Discussion

Socioeconomics Characteristics of Wheat Grower Farmers

The socioeconomic characteristics of wheat farmers in the study areas are presented in Tables 1 and 2. The survey result presented in Table 1 showed that the minimum and maximum age of the wheat grower farmers was 23 and 72 years respectively with a mean age of 39.24 years in the study area. There is also a significant difference among the sample wheat grower farmers in age at 1% significant level. The average wheat farming experience was 19.88 years and there is a significant difference among the households in wheat farming experience at 5% significant level (Table 1). This shows that farmers in the study area have good experience in wheat production and this further indicates that wheat is largely produced by elder farmers in the study area; hence this calls for the need to disseminate improved wheat production technologies. As to family size, the survey result indicated that the average family size of sample wheat farmers was 7.10 persons with 86% of farmers having family sizes greater than 5 persons, and about 58 % of total family members having an age of greater than 16 years. This shows that family size with age composition is important to wheat production activities which require more family labor. Concerning landholding of wheat grower farmers, the maximum and minimum size of landholding of the farmers was 0.125 and 6 hectares respectively with a mean of 0.693 hectares in the study area (Table 1).

Table 13. Summary of socioeconomic characteristics of sampled wheat grower farmers

Variables	N = 253				
	Min.	Max.	Mean	Std. Dev.	t-test
Age of household head	23	72	39.24	10.99	6.50***
Experience in wheat farming	4	50	19.88	12.23	3.22**
Family size	2	12	7.10	3.29	8.49***
Total land holding	0.125	6	0.69	0.94	2.32**

Source: Own survey result, 2020, **, and *** indicates significance at 5% and 1% respectively

Moreover, the survey result indicated that 60.57% and 39.43% of the wheat producer farmer were literate and illiterate, respectively. The results indicate that about 60.57% of the farmers were literate and they have attended formal education (Table 2). This is in line with the finding of Degefu, *et al*. (2016) that stated about 62.5% of the sampled household heads were literate. The chi-square test result revealed that educational status and wheat production had a statistically significant association at less than 1% significance level. The survey result indicated that about 90.9% of wheat farmers were male-headed households, whereas 9.1% were female-headed households. The chi-square test result revealed that the sex of the household head and wheat production had a statistically significant association at less than 1% significance level (Table 2).

Table 2. Summary of socioeconomic characteristics of sampled wheat grower farmers

Characteristics	Category	N=253		
		Frequency	%	X^2-test
Education level	Illiterate	100	39.53	10.36***
	Literate	153	60.57	
Sex of household head	Male	230	90.9	13.24***
	Female	23	9.1	

Source: Own survey result, 2020, **, and *** indicates significance at 5% and 1% respectively

Access to Services for Wheat Production

Access to agricultural extension services is believed to be an important instrument to deliver agricultural services to farmers and helping them to increase production and productivity. The survey result showed that about 88.5% of wheat farmers received extension services during 2019 production year. The farmers also noted that the extension service is seasonal/yearly base which is during land preparation, seed/fertilizer collection, sowing and disease occurs. Extension agents provide advice and support services to improve the production potentials of smallholder farmers. The association between extension service and wheat production was statistically significant at less than 1% significance level in the study area (Table 3). The survey result also showed that that about 45.8% of the farmers received training on wheat production in the area (Table 3).

The result of this study also indicated that about 79.1% of farmers have access to information on wheat production and marketing from different sources such as Agriculture and Natural Resource office, Research Center, Cooperatives, other farmers and Radio. As to access to credit, it is found that about 7.1% of the wheat grower farmers received credit to expand their wheat production, but the majority of the farmers, 92.9% did not receive any credit from any organization/institution for wheat production in the study area (Table 3). As to membership in cooperatives, the survey result shows that about 68.4% of the farmers were members of cooperatives, while 31.6% of the farmers have not been a member of any cooperatives in the study area (Table 3). The result is in line with prior study conducted by Degefu, *et al*. (2017); Mengistu, *et al.* (2016) in the study area.

Table 3. Proportion of wheat farmers on access to services in the study area

Services		N= 253		
		Frequency	%	χ^2 - test
Accessed to extension services to wheat production:	Yes	224	88.5	6.17***
	No	29	11.5	
Accessed to training on wheat management:	Yes	116	45.8	3.74**
	No	137	54.2	
Access to information on wheat production:	Yes	200	79.1	5.45**
	No	53	20.9	
Accessed to credit:	Yes	235	92.9	9.40***
	No	18	7.1	
Membership to cooperative:	Yes	173	68.4	8.12***
	No	80	31.6	

Source: Own survey result, 2020, **, and *** indicates significance at 5% and 1% respectively

Wheat Production System

Area allocated and productivity

Wheat production in the study area is mainly for home consumption. The survey result in Table 4 indicated that on average about 0.48 hectares of land was allocated by sample grower farmers to wheat crop which is about 69.57% of their total landholding under wheat production in the study area (Table 4). This indicates that most farmers were operating by allocating more area to wheat to meet their wheat product requirements from their products and to ensure food security in the study area. The result also indicates a significant mean difference among the sample households in land allocated to wheat production (Table 4). The average productivity of wheat was 20.87 quintals per hectare with a standard deviation of 10.39 in the study area. On the other hand, the report of CSA (2020) indicates that the average productivity of wheat was 21.84 quintals per hectare in the country. The average quantity of wheat produced per household was 13.40 quintals with a standard deviation of 6.40 in the study area (Table 4).

Table 4. Area allocated, production and productivity of wheat in 2019

Variables	Min	Max	Mean	Std.D	t-test
Land allocated for wheat(ha)	0.13	6.0	0.48	0.22	3.6**
Average productivity (qt/ha)	10.0	36.0	20.87	10.39	6.4***
Wheat volume produced(qt/hh)	2.5	60	13.40	6.40	8.2***

Source: own survey result, 2020

Dynamics of wheat production

As indicated in figure 2 about 58.9% of the wheat grower farmers perceived that the trend of wheat production in terms of area coverage and volume of production was decreased in the last 5 years in the study areas. The decrease in wheat production may be attributed to the type of variety farmers are growing which is usually supply shortage of seed, disease and drought. About 31.6% of the wheat grower farmers perceived that the trend of wheat production in terms of area coverage and volume of production was increased in the last 5 years in the study areas.

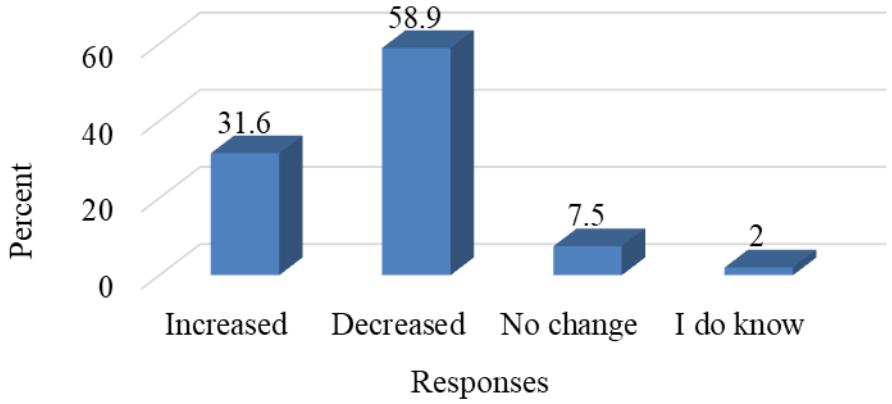


Figure 2. Farmers' perception to trend of wheat production

Wheat production and utilization

Analysis of wheat production in the study area shows that the farmers produced an average of about 13 quintals, and the total wheat production in the study area was estimated to be 2183 quintals during 2019 production year. The largest proportion of the wheat produced was consumed at home in the study area. The study has shown that the majority (63.77%) of the wheat produce was consumed at home in 2019 production year in the study area (Figure 3). This indicates that wheat is mainly produced for home consumption purposes as part of the diet of the household to ensure household-level food security. About 30% of the wheat produced was sold to generate income during the same year. In addition, the wheat produces also stored/retained about 6.32% of the wheat produced stored for seed in the study areas.

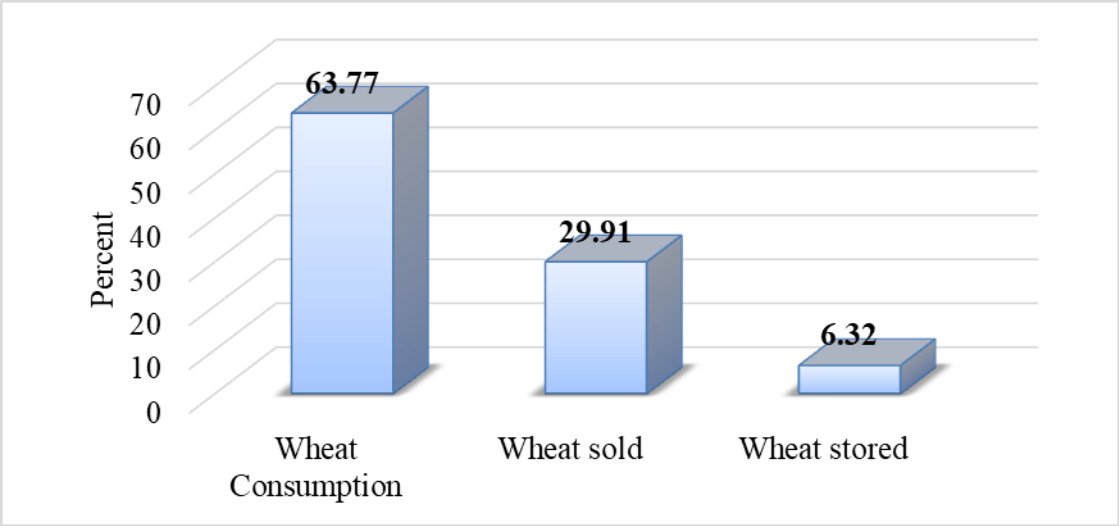


Figure 3. Wheat production and utilization in percent

Production calendar of wheat production

The activities of wheat production start with clearing which mainly includes clearing potato residues, and then, the farmers continue with land preparation (tillage by hand, oxen and tractor). The survey result in table 5 indicated that the activities of wheat production start with input preparation which is mainly seed and fertilizer between April and June. The largest proportion of the wheat-growers stated that land is cleared which mainly crop residues and prepared between March and June, and planting is started at end of June to July for the wheat. Fertilizer applications on the wheat field are also important activities performed starting from June to August. Weeding management practices are done starting from mid of July to August for the rain-fed wheat production.

Harvesting of wheat is started from the end of November to December, and threshing is also done starting from the end of December to January in the study area. Selling wheat grain is not a common activity in the study area, but some farmers are stored and sold wheat grain started from the end of January to May in the study area.

Table 5. Seasonal calendar for wheat production activities in the study area

Activities	**Months**											
	Sep	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**
Input preparation												
Land clearing and preparation												
Planting												
Fertilizer application												
Weeding												
Harvesting												
Threshing												
Storing and marketing												

Source: own survey result, 2020

Wheat cropping system

In the study area, growth of potato followed by wheat is a common practice, particularly in mid-highland areas. The farmers practiced double-cropping where potato is grown following the rainfall in the spring and then wheat is grown during the main season. As to cropping pattern, wheat sole cropping is the most popularly practiced wheat production system and about 98.7% of wheat growers reported that they practiced sole cropping, and only 1.3% of them reported that they use both the sole and intercropping/mixed (wheat intercropping with some pulse crops such as haricot bean, faba-bean and maize in mid-highland areas due to land shortage in the study area.

Wheat management practices

Land ploughing method: the survey result further indicated that about 50.20%, 26.48% and 23.32% of wheat producer farmers were used hand tillage, tractor and oxen plough methods for Wheat land preparation, respectively as indicated in figure 4. Land preparation using hand tillage is common in mid-highland areas. In these areas topography of the land was ragged, and the farmers owned a small plot of land and sowing of wheat is done after potato was harvested.

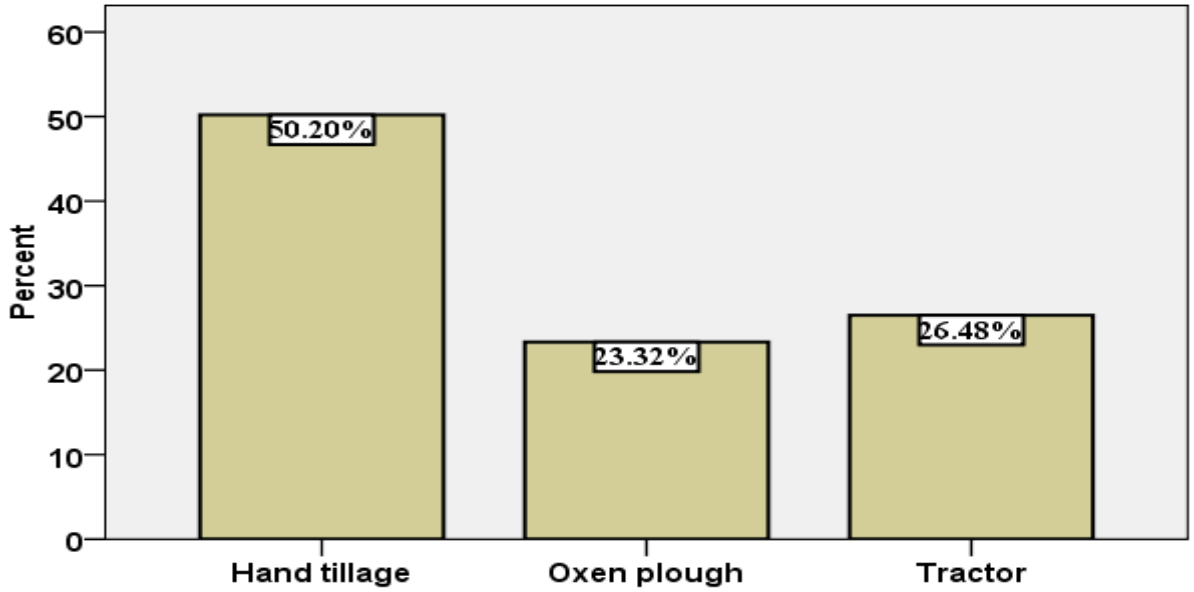
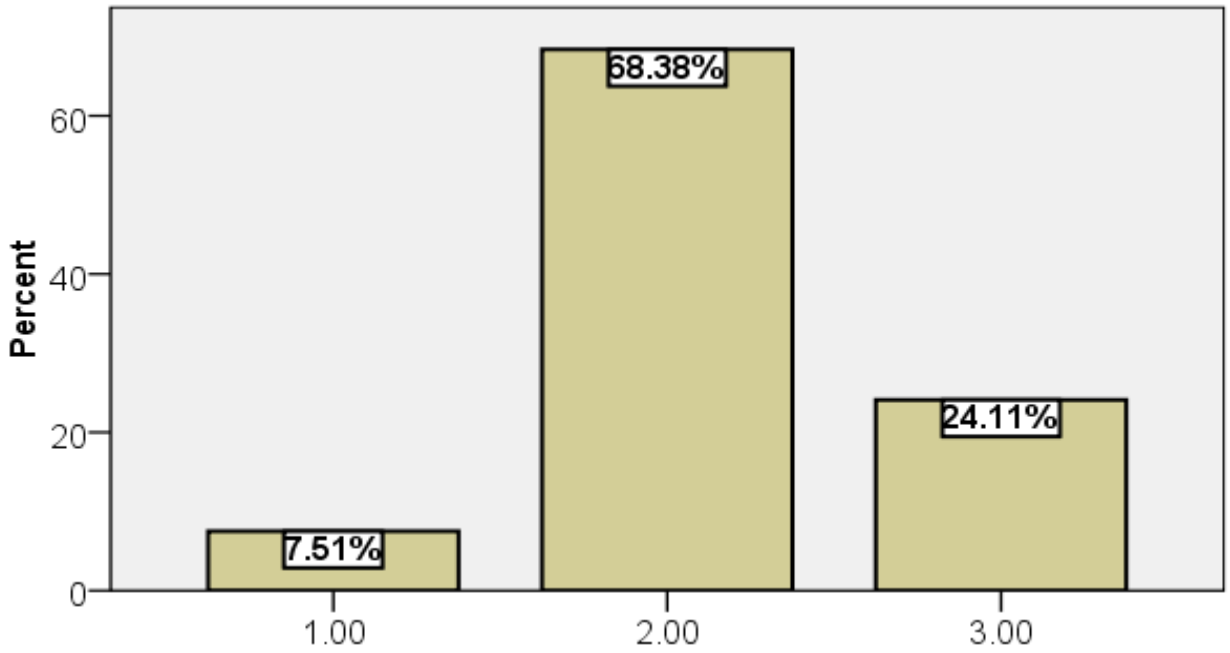


Figure 4. Land ploughing method for wheat

Frequency of land ploughing: the survey result indicated that about 68.38% of the sampled wheat producer farmers on average ploughed their wheat land 2 times (ploughing 1 time before sowing and ploughing once for wheat seed covering whereas about 24.11% of wheat producer farmers on an average ploughed their wheat land 3 times (ploughing 2 times before sowing and ploughing once for wheat seed covering, and only 7.51% of wheat farmers on an average ploughed their land once for sowing and covering of wheat seed in the study area (Figure 5). The result of the survey showed that the majority of the farmers have used recommended frequency of land ploughing for wheat in the study area.



Method of wheat sowing: The survey result indicated that about 63.6% of the wheat farmers used row planting using the seed drill method, while 36.4% used the broadcast method for sowing wheat in the study area (Table 6). This indicated that row planting using the seed drilling method of sowing was found widely practiced among wheat producer farmers in the study area. Focus group farmers reported that the farmers used the broadcast method for sowing wheat crop previously, but nowadays, the majority of the farmers are adopting row planting for wheat in the area, and they also reported that broadcast and hand seed drill is common planting methods for wheat crop due to lack of row planter for wheat crop in the study areas.

Table 6. Method of wheat sowing in the study area

Method of sowing	Frequency	%
Broadcast	92	36.4
Row planting using seed drill	161	63.6
Total	253	100

Source: own survey result, 2020

Weeding/cultivation method and frequency: the farmers reported that different grass and broad-leafed species of weeds were established in wheat fields, and reducing wheat yield. Weed control using hand weeding in wheat fields is a common practice performed in the study area, and it is usually performed 2 to 3 times by hand in wheat fields. The result of the survey as shown in figure 6, about 64.82% of the farmers have performed 2 times weeding and inter-cultivation practices by hand and hand hoe for weed control, and fertilizer application, and 18.58% of wheat farmers have performed 3 times weeding and inter-cultivation in wheat fields whereas only 16.60% of wheat farmers have performed hand weeding and inter-cultivation once for controlling weeds and inter-cultivation in wheat fields in the study area (Figure 6). The report of Ministry of Agriculture (2011) indicated that two or three hand weeding has shown to be the most economic practice and gives the best results in most areas of the country.

Input Utilization

Labor sources and use: Wheat farm activities include land preparation, ploughing, sowing, weeding, harvesting and threshing are among wheat production activities demanding more labor as reported by the farmers in the study area. The sources of labor for wheat production activities are presented in Table 7. Family labor was the main source of labor for 75.5% of the farmers in the area, where 13% of wheat grower farmers used both families and hired, 10.7% and 7% of the farmers used hired labor and labor in exchange for wheat farm activities, respectively in the area.

Table 7. Source of labor for wheat production in the study area

Labor source	Frequency	%
Family labor	191	75.5
Hired labor	27	10.7
Labor exchange	18	7
Cooperation	17	6.5
Both family and hired	33	13

Source: own survey result, 2020

Improved seed use: wheat producer farmers in the study area use both improved and local wheat seeds. The result of the survey as shown in table 8 the majority of the farmers (63.7%) who produced wheat in the 2019 production season were used improved wheat seeds, while, the remaining 36.3% of the wheat producers in the area, used local wheat seed(Table 8).

Fertilizer use: the survey result indicated that the majority of wheat producer farmers in the study areas use inorganic fertilizer for the wheat crop. Out of sample wheat producer farmers, about 81% and 68.4% of them applied NPS and Urea fertilizers to their wheat fields, respectively (Table 8). However, the farmers in the study area apply varying fertilizer rates to wheat. The finding of Endale (2011) indicated that the use of inorganic fertilizers has shown an increase in Ethiopia recently despite having one of the lowest levels of application, even compared to sub-Saharan countries standards.

Pesticides/herbicides: the survey result further showed that only 23.8% of sample wheat farmers used pesticides in their wheat fields for controlling wheat diseases and weeds, while the majorities (76.2%) of the farmers have not used any pesticides on their wheat fields but they reported wheat diseases as main challenging them in the area. The farmers in focus group discussions were reported that lack of access to pesticides, high prices and the problem of knowhow of pesticide use in wheat production are the main limiting factors in the area.

Table 8. Input use (% respondents) for wheat in the 2019/20

N=253				
Response	Improved seed	Fertilizer (NPS)	Fertilizer (Urea)	Pesticides/herbicides
Yes	63.7	81.0	68.4	23.8
No	36.3	19.0	31.6	76.2

Source: own survey result, 2020

Amount of seed and fertilizers used

The survey result showed that on average, wheat producer farmers used the wheat seed of 160.92 kg/ha in the study area (Table 9). This is almost higher than the recommended rate (blanket) of seed per hectare which is 125 kg/ha for the area. The survey further indicated that the average amount of NPS and Urea fertilizer application rate for the wheat was 95.87 kg and 45.27 kg/ha, respectively in the study area (Table 9). The result shows that the farmers used a low rate of

fertilizers particularly use of UREA less than recommended rate due to their financial affordability and access to fertilizers in the study area.

Table 9 Amount of seed and fertilizers used kg/ha in the study area

Type of inputs	Minimum	Maximum	Mean	Std. Dev
Improved seed	100	250	160.92	45.48
Fertilizer (NPS)	50	100	95.87	34.25
Fertilizer (Urea)	20	50	45.27	29.04

Source: own survey result, 2020

Wheat varieties grown

Bread wheat type varieties were commonly grown by farmers in the study area. Table 10 shows the different wheat varieties grown by farmers in the study area. As shown in Table 10 the dominant wheat varieties grown by the majority of the farmers in the study area were Danda'a, Pavon 76, Kekeba, Hidase and Kubsa, and based on the proportion of farmers growing these varieties Danda'a and Pavon 76 varieties were ranked as first and second whereas Kekeba, Hidase and Kubsa varieties were ranked as third, fourth and fifth, respectively in the study area. The survey result further indicated that based on the proportion of the farmers grown the varieties in the study area, Ogolcho and Kingbird varieties were ranked sixth and seventh followed by Senate, Digalu and Madawalabu varieties, respectively in the area (Table 10).

Table 10. Wheat varieties grown and proportion of farmers in the study area

Wheat varieties	Frequency	%	Rank
Ogolcho	20	12.19	6
Digalu	9	5.49	9
Danda'a	41	25	1
Madawalabu	6	3.66	10
Senate	10	6.10	8
Kingbird	14	8.54	7
Kubsa	26	15.85	5
Kekeba	34	20.73	3
Pavon 76	40	24.39	2
Hidase	30	18.29	4

Source: own survey result, 2020

Farmers' wheat varieties preferences

Wheat varieties grown, along with their preferred traits and preferences ranking are summarized in Table 11. High grain yield, disease resistance, stand vigor and early maturity were used by the farmers as the key criteria for selecting wheat varieties in the study area. The survey result indicated that the wheat varieties such as Kekeba, Pavon 76, King-bird, Danda'a, Senate and Ogolcho varieties were selected by the farmers because of for their high grain yield, disease resistance, stand vigor, adaptability to the environment and early matured. Based on these criteria Kekeba, Pavon 76 and Kingbird varieties were ranked as first, second and third preferred varieties by the farmers followed by Danda'a, Senate and Ogolcho preferred varieties by the farmers in the study area (Table 11).

Table 11. Wheat varieties grown, farmers' preferred traits and preference ranking in the area

Varieties	Farmers' preferred traits	Preference (Rank)
Ogolcho	High yielder, stand vigour, early maturity, adaptability to environment, susceptible to disease	6
Digelu	High yield, stand vigour but is susceptible to disease and late matured	9
Danda'a	High yielder, disease resistant, stand vigour, adaptability to environment, but is late maturing	4
M/Walabu	High yield, susceptible to disease, and early maturity	8
Senate	High yield, disease resistant, stand vigour, adaptability to environment, early maturity	5
Kekeba	High grain yielder, disease resistant, stand vigour, adaptability to environment, early maturity	1
Kubsa	High yielder, stand vigour, adaptable to environment, but susceptible to disease	7
Kingbird	High grain yield, disease resistant, stand vigour, adaptability to environment, early maturity	3
Pavon 76	High yield, disease tolerant, stand vigour, adaptability to environment, early maturity	2
Hidasie	High yield, disease tolerant, high tiller capacity, late matured and it is highly susceptible to disease	10

Source: own survey result, 2020

Year of wheat varieties use

The survey result indicated that on average, the farmers used improved wheat seeds for 7.5 years with a minimum and maximum of 1 and 10 years respectively (Table 12). This shows that the farmers were used saved seeds or accessed from other farmers in the study area.

Table 12. Wheat improved varieties grown by farmers in and their outstanding criteria

Variable	Minimum	Maximum	Mean	Std. Deviation
Year of whet varieties use	1.00	10.00	7.5	3.34

Source: own survey result, 2020

Wheat seed source

Sources of wheat seeds are presented in Table 13. The result indicated that the majority of the farmers (45.06%) wheat producers' farmers used seeds obtained from producers' cooperatives obtained wheat seeds from producers' cooperatives, and about 10.28%, 5.53%, 4.74% and 3.16% of wheat producer farmers used seeds from the Office of Agricultural and Natural Resource, NGOs, Research Center and University, respectively in the study area. In addition, the survey result indicates that about 17.79 % of the wheat producer farmers used seeds retained from the previous harvest in the area, whereas about 11.07% and 2.37% of the farmers used seeds from other farmers and local markets, respectively in the study area (Table 13).

Table 13. Sources of wheat seed (% of respondents) in the study area

Sources of inputs	Frequency	%
Agricultural Offices	26	10.28
Producers cooperatives	114	45.06
Research center	12	4.74
University	8	3.16
NGOs	14	5.53
Own stock/saved	45	17.79
Other farmers	28	11.07
Local market	6	2.37

Source: own survey result, 2020

Farm Machineries, Storage and other Services

The survey result indicated that only 26.5% of wheat farmers accessed and used tractor service during 2019 production year in the area (Table 14). The key informant discussions and FGD farmers pointed out that the shortage of tractor service access and the high rent cost of tractor service is the major limiting factors to using a tractor for wheat production in the area. Table 14 bellow shows that the farmers did not access and use wheat row planter and thresher in the study area. Regarding access to combine harvester and improved storage, the survey result shows that about 22.5% of wheat farmers used combine harvester, and 77.5% of the farmers used manual methods of harvesting and threshing in the study area. The survey famers and FGD farmers reported that the high rent cost of combiner harvester is the major limiting factor to using the service in the area. As to storage**,** about 91.7% of the farmers did not access and used improved storage structures for wheat grain, and only 8.3% of the farmers used improved storage in the area.

Table 14. Proportion of wheat farmers' access to machinery and other services

Access to farm machineries	Frequency	%
Accessed to tractor service (yes)	67	26.5
Accessed to row planter (no)	253	100
Accessed to combine harvester (yes)	57	22.5
Accessed to small wheat thresher (no)	253	100
Accessed to improved storage (no)	232	91.70

Source: own survey result, 2020

Wheat Marketing System

Marketing channels for wheat

Wheat market channels for this study were designed based on the volume of flow of wheat products passing through different routes during the 2019/20 cropping season. The survey result indicated that seven major wheat-marketing channels were identified to deliver the product from producer to consumers in the area. A total of 2183 quintals of wheat was produced by the farmers in the area, and the identified channels from the survey were shown in Figure 7 bellow.

In the study areas, wheat marketing was taking place at village and district markets: about 83% of sample wheat farmers sold their produce at village markets and 17% of them sold at district markets. The result of the survey also shows that about 50.79% and 21% of sample farmers sold their wheat products to collectors and cooperatives at village markets, 20% and 8.21% of the farmers sold to wholesalers and consumers at village and district markets in the study area. During the survey, the producers noted that low prices, brokers' interference and fixing prices by traders were reported as a problem.

Production cost and benefit of wheat producers

The result of the net benefits analysis indicates that wheat production was profitable with 699.15 birrs per quintal and on average much higher than the average unit cost of production (450.85 Birr/qt) in the study area (Table 15).

Table 15. Cost and benefit of wheat production in the study area

Variables	Mean	Std. Dev
Produce(qt)	20.87	6.40
Average selling price (Birr/qt)	1150	1500
Production cost(Birr/qt)	450.85	1580
Revenue (Birr)	28174.5	23500
Net benefit (Birr/qt)	699.15	-

Source: own survey result, 2020

Wheat Production and Marketing Constraints

Farmers' perceptions of wheat production constraints and their ranks are summarized in Table 16. Diseases, insects, weeds, shortage of improved seeds, poor quality of seeds, lack of pesticides, timely unavailability of inputs, lack of access to pesticides and drought were found as the main wheat production constraint in the study area. Out of the total of sample wheat producers, about 77.17% of them reported that wheat diseases as the major constraint faced by farmers and it ranked first in the study area. This is related to the continued use of rust susceptible wheat varieties, lack of use of recently released rust resistant wheat varieties, and lack of access to pesticides were aggravated the problem of diseases in the study area.
The farmers who participated in the focus group discussion reported that lack of access to seeds of diseases resistant wheat varieties, lack of access to chemicals and farmers' lack of awareness of the use of chemicals also aggravated the infestation of diseases to wheat production in the study area.

The result of the survey also shows that shortage of access to seeds of improved wheat varieties with (73.64%) was identified as the second most important constraint to wheat production followed by quality insects (57%) and erratic rainfall distribution (55.91%) in the study area (Table 16). The farmers who participated in the focus group discussion reported that the limited availability and affordability of improved wheat seeds that are tolerant to diseases and resilient to climate changes were mentioned as the most important reasons for the farmers not using improved seeds in the study area. Furthermore, the results of the survey revealed that weeds infestation and lack of timely availability inputs were also regarded as major constraints of wheat production by 53.36% and 41.34% of the farmers respectively in the study area (Table 16). The result of the survey further showed that land shortage and soil fertility problems were perceived by the farmers as important constraints to wheat production while they ranked at a lower level in the study area (Table 16).

Table 16. Proportion of farmers indicating wheat production and marketing constraints

Main wheat production constraints (N=253)	Frequency	%	Rank
Diseases	196	77.17	1
Insects	143	56.52	3
Weeds	135	53.36	5
Shortage of improved seeds	187	73.64	2
Lack of timely availability of inputs (seed, fertilizers)	105	41.34	6
Drought/erratic rainfall distribution	142	55.91	4
Land shortage	85	33.68	7
Soil fertility problem	80	31.50	8
Main marketing constraints	**Frequency**	**%**	**Rank**
High input price (seeds, fertilizers and pesticides)	152	59.84	1
Low price of wheat grain	78	30.71	2
Brokers interference	69	27.17	3

Source: own survey result, 2020

Regarding wheat marketing constraints, about 59.84% of sampled farmers in the study area had high prices of agricultural inputs such as seeds, fertilizers, pesticides and herbicides considered the most important constraint to the wheat marketing system followed by the low price of wheat production in the surveyed area. Interference of brokers in the wheat produce market (27.17%) was identified as the third most important constraint to the wheat marketing system in the surveyed area (Table 16). The participant farmers reported that the farmers sold the wheat production in the village markets at a low price which is determined by brokers in the study area.

Other wheat production constraints include supplying of wheat seed out of agro-climatic conditions**,** availability of poor quality wheat seeds, limited availability and affordability of tractors and combines (high rent cost), lack of access to equipment and machinery such as wheat row planter and threshers, and lack of proper use of improved agronomic practices were also reported by the farmers as constraints to wheat production in the study area.

Wheat production opportunities: government policy-encourage wheat to ensure food security**,** availability of high demand, Suitable agro-ecology to wheat production-main and off-seasons, availability of fertile land and irrigation water, availability of research organizations and Universities and availability of market are some of the major opportunities available for expansion of wheat production in the study area.

Conclusion and recommendations

The study was undertaken in wheat production potential districts of East Hararghe Zone of Oromia Region, with objectives to assess and describe wheat production and marketing systems, farmers' varieties preferences and identify wheat production and marketing constraints and opportunities in the study area. As a sampling procedure, three-stage sampling procedures were employed to select a total of 253 sample farmers. Primary data were collected from sampled households through a household survey using questionnaires, and the collected data were analyzed using descriptive statistics. The mean age and wheat farming experience of the farmers were 39.24 and 19.88 years respectively and there is a significant difference among the households in wheat farming experience in the study area.

The average family size of sample wheat farmers was 7.10 persons with 86% of farmers having family sizes greater than 5 persons, and about 58 % of total family members having ages greater than 16 years. The survey result showed that about 88.5% and 45.8% of wheat farmers received extension services and training on wheat production respectively in the study area. The survey result shows that about 92.9% of the farmers did not receive any credit from any organization/institution for wheat production, and about 68.4% of the farmers were members of cooperatives in the study area.

On average about 0.48 hectares of land was allocated by sample grower farmers to wheat crop which is about 69.57% of their total landholding under wheat production in the study area. The average productivity of wheat was 20.87 quintals per hectare, and the average quantity of wheat produced per household was 13.40 quintals in the study area. The survey result also indicated that about 63.6% of the wheat farmers used row planting using the seed drill method, while 36.4% used the broadcast method for sowing wheat in the study area. The majority of the

farmers (63.7%) of wheat producers' farmers have used improved wheat seeds, and about 81% and 68.4% applied NPS and Urea fertilizers, respectively, while the majority (76.2%) of the farmers did not use any pesticides on their wheat in the area. The major wheat varieties growing by the farmers in the study area are Danda'a, Pavon 76, Kekeba, Ogolcho and Kingbird. Moreover, the survey result indicated that six major wheat-marketing channels were identified to deliver the product from producer to consumers in the study area. The result of the net benefits analysis indicates that wheat production was profitable with 799.15 birr/qt, in the study area.

Diseases, insects, weeds, shortage of improved seeds, poor quality of seeds, lack of pesticides, timely unavailability of inputs, lack of access to pesticides and drought were found as the main wheat production constraint in the study area. Out of the total sample of wheat producers, about 77.17% of them reported that wheat diseases as the major constraint faced by farmers and it ranked first in the study area. Shortage of access to seeds of improved wheat varieties (73.64%) was identified as the second most important constraint to wheat production followed by insects (57%) and drought/erratic rainfall distribution (55.91%) in the study area. Furthermore, the results of the survey revealed that weeds infestation and lack of timely availability inputs were also regarded as major constraints of wheat production by 53.36% and 41.34% of the farmers respectively in the study area. Regarding wheat marketing constraints, about 59.84% of sampled farmers in the study area had high input prices considered the most important constraint to the wheat marketing system followed by low prices in the study area.

Based on the finding of this study the following recommendations are given: Diseases are the most severe problem facing the farmers in the production of wheat. To address this, recently released improved wheat varieties (rust-resistant, adaptation and good yield potential) should be introduced and delivered to farmers to ensure increased wheat productivity. Research centers should be devoted to agronomic research on wheat, particularly, the development and release of disease-resistant high yielding wheat varieties, and build up agronomic research. The government has been striving toward releasing improved wheat varieties to respond to wheat disease and increase production. Research centers and other relevant stakeholders need to place a greater emphasis on improving the availability and use of improved seeds. Introduction and promotion of recommended fertilizer rates and agronomic recommendations can improve the production and productivity of wheat in the study area

Lack of access to pesticides is a serious problem facing the farmers in the study areas. This is needed to emphasize strengthening farmers' cooperatives to supply pesticides, and training should be given to farmers on the usage of pesticides. Introducing and promoting integrated pest management to wheat, and awareness of the use of agrochemicals. The shortage of improved seeds is the most important problem facing the farmers in the study areas. To address this, strengthening farmers' cooperatives in quality seed production through capacity building and facility support, improving cooperatives farmers' knowledge in quality seed production through training that engages in wheat seed production, and increasing farmers bargaining power through cooperatives. Extension service will need to be strengthened to facilitate the dissemination of knowledge and improved agronomic practices that will help farmers in the production, and deliver improved wheat agronomic practices, disease management and input use such as fertilizer recommendations to recommendations. The government gives emphasis to improving

access to tractors and combine harvesters, and the development and promoting of wheat row planters and threshers in the study area.

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Assessment of Coffee Production and Marketing System in East Hararghe zone of Oromia Region, Ethiopia

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Abstract

The study was conducted in coffee production potential districts of East Hararghe Zone of Oromia Region, with objectives to assess and describe coffee production and marketing systems, coffee market performance and identify coffee production and marketing constraints and opportunities in the study area, and three-stage sampling procedures were used to select a total of 164 sample coffee producers and 32 traders. Primary data were collected from the farmers and traders through household survey, and the collected data analyzed using descriptive statistics. The result of the survey indicates that on average, 0.26 hectares of land were allocated to coffee farm in the area. The result also indicated that the average productivity of coffee was 4.68 quintals per hectare, and about 97.52% of the farmers were growing local varieties in the study area. The survey result indicated that the main receivers of coffee from producers are primary cooperatives and assemblers/collectors and they take 40.6% and 30.5% from the producers, respectively. The most important constraints identified by coffee producers in the study area are coffee diseases, lack of access to improved coffee varieties and limited coffee extension services, lack of transparency in the coffee market and illegal traders hindering fair price were the main market constraints in the area. Based on the findings, the following recommendations are given as introducing high yielding and disease resistant improved coffee varieties, promoting improved coffee agronomic practices, supporting multiplication and distribution of coffee planting materials, Strengthening coffee research extension linkage, efforts should be need to aware and train coffee farmers and extension agents about coffee diseases management through practical training, enhancing extension services to improve farmers' skill and knowledge on coffee production and marketing system, improving market information delivery to the farmers and traders, and improving transportation facilities and road infrastructures can increase the accessibility of producers and traders market coffee outlet in the area.

Key words: Coffee production system, coffee marketing, market channels, East Hararghe

Introduction

Coffee is one of the most important export commodities in the international agricultural trade, representing a primary source of income and livelihood for many farmers of several countries including Ethiopia. Coffee is one of the leading traded commodities on the global market in both volume and value (Zewdu, 2016). 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 contributes about 4.2% of total world coffee production (Dugum, 2017). Coffee remains a valuable export commodity in Ethiopia as it is means of foreign exchange earning sector for the

country. Thus, coffee is a strategic commodity to Ethiopia that covers 24-26% of the total income of its earning and it is a source of livelihood for 25 % of the population (ECX, 2016).

Ethiopia is known for producing premium quality Arabica coffee in Africa and is the third-largest producer in the world. The country has suitable environmental conditions for coffee production which is first-rate opportunity for the producers as well as traders. In addition, Ethiopia is endowed with enormous genetic diversity and different coffee types with unique tastes and flavors (USDA, 2014). In a global market, the change in consumer behavior and the increasing consumption of high-quality coffee is an opportunity for Ethiopia. Improving coffee quality is a key prospect for increasing coffee exports and maybe a good strategy to get better prices for the coffee producers, and the government is continuing in supporting the coffee sector (Kassaye, 2017).

Regionally, the national production of coffee comes from Oromia region. The region is one of the largest coffee producers in terms of totalcoffee area cultivated and total production (CSA, 2019). Coffee production comes from the Oromia region shared about 64% (Birhanu, 2017). The report of CSA (2019) indicates that the in the region, about 3,435,447.12 quintals of coffee were produced from 531,702.73 hectares of land and creating means of livelihood for more than 2,047360 households in 2018/19 production year. East Hararghe Zone is one of the major coffee-growing areas from the From the region,. The Zone has favorable agro-ecological and it is endowed with vast genetic diversity and different coffee types with unique taste and flavor and the area is also accessible to the export outlet, that is, Djibouti port.
As a result, in the area coffee production is a major source of cash income and livelihood for a large number of farm households in the area. The type of coffee grown in this area is popularly known as “Harar coffee”. In 2016/17 production year, a total of 37,224.94 quintals of coffee was produced on 7584.32 hectares in the Zone (CSA, 2017). Having all the importance of coffee, and the opportunity for the coffee in the country, coffee production and marketing system continues to face multiple challenges such as low productivity, disease and low price (Birhanu, 2017). In addition, despite the importance of coffee production, there was an information gap on existing coffee production and marketing systems, market performance and producers’ benefit share in the study area. Despite the importance of the crop and its need to expand by the government, previously there is no study conducted to assess coffee production and marketing systems, identify and prioritize constraints and opportunities for wide research and development intervention in the zone. Hence, considering these gaps into consideration, this study was designed to conduct with the objectives to describe the status of coffee production and marketing systems, examining coffee market performance and identifying coffee production and marketing constraints in the study area.

Methodology

Description of the Study Area

The study was conducted in coffee production potential districts of East Hararghe zone. The Zone is located at the eastern part of Oromia regional state and at a distance of about 525 km from the capital city of the country and geographically situated between $7^0 32'$ to $9^0 44'$ North latitude and $41^0 10'$ to $43^0 16'$ East longitudes with the total area of about 26311 km^2. Its altitude ranges from 500 to 3405 m.a.s.l. Agro climatically; the zone is divided into three major agro-ecological zones. These are lowland, midland and highland which constitute 60.32, 32.24 and 7.44% of a total area of the zone respectively. The altitude ranges from 500 to 3,400 meters above sea level. The annual rainfall of the zone ranges from 400 to 1010 mm, and the temperature also ranges between 14 to 25°c (EHZ FEC, 2018).

Agriculture is the dominant economic activity and the base for livelihood of the majority of the residents of the zone. The agricultural activities in the Zone are characterized by a peasant farming system that involves mixed farming i.e. crop and animal production. Different types of crops from cereals such as sorghum, maize, wheat, barley, pulses, oil seed, vegetables, fruits and cash crops such as coffee and chat are produced in the zone. However, various impediments such as market problems, disease, drought and poor infrastructure development have hampered the development of the sector in the area.

Sampling Method and Sample Size

Three-stage sampling techniques were used to select districts, kebeles, coffee grower farmers and traders from the study area. In the first stage, three districts (Bedeno, MelkaBalo and Deder) were purposively selected based on coffee production potential. In the second stage, coffee-growing kebeles and coffee market centers in each district were listed and identified. Once coffee-growing kebeles were identified, six kebeles from MelkaBalo and Deder districts (three kebeles from each), and four kebeles from Bedeno district were selected using a simple random sampling technique. This resulted in a total of ten coffee-growing kebeles being selected from three districts for this study. Meanwhile, a total of six coffee market centers were purposively selected based on coffee supply and market. In the third stage, a total of 164 coffee producer farmers, and 32 coffee traders were randomly selected and interviewed. This also resulted in a total of 196 respondents being interviewed for this study. In addition, about 100 coffee producer farmers, experts, Development Agents and leaders of farmers' cooperatives were purposely selected also participated in this study through Key informant interviews (KII) and focus group discussions (FGDs) in the study area.

Sources of Data and Methods of Collection

The study used primary and secondary data sources to collect data. Primary data were collected through individual interviews using semi-structured questionnaires from selected coffee grower farmers and traders of the area. The primary data collected from farmers include demographic and socio-economic characteristics, coffee production; the quantity of coffee produced and sold sales price, varieties grown, and constraints and opportunities. Primary data from traders include

socio-demographic characteristics, type of trade, experience in the coffee trade, cost of transport used, selling and buying price of coffee, quantities purchased and sold, source and destinations of coffee and, constraints and opportunities of coffee. In addition, key informant interviews and focus group discussions were held with the farmers, development agents and experts by using checklists to support primary data collected through individual interviews. Secondary data required for the study were taken from Central Statistical Agency's website, and district agricultural and natural resource offices.

Method of Data Analysis

Descriptive statistics such as frequencies, percentages, means and standard deviations were used to examine the socioeconomic characteristics of sampled coffee producer farmers, and coffee production and marketing systems of the study area. In addition, trend analysis, ranking and preferences were used to analyze coffee production status, preference, and coffee production and marketing constraints in the study area. The collected data were analyzed by using SPSS statistical software package version 20.

Results and Discussion

Socioeconomics Characteristics of Households

The survey result shows that the family size of the respondents ranged from 2 to 13 with an average family size of 7.4 persons in the study area. Concerning the age of coffee grower farmers, the average age of the sample coffee grower farmers was 39.84 years with the minimum and maximum ages of 20 and 70 respectively in the study area (Table 1). The average coffee farming experience was 26 years with a minimum and maximum of 6 and 50 years respectively (Table 1). This shows that farmers have a good experience in coffee production, and the majority of coffee farmers during the focus groups discussion reported that coffee production practices were learned from their families and other farmers in time through experience. Landholding is one of the factors that affect farm productivity, and the farmers in the study area use their land for all farming activities which include the production of food crops and cash crops. The average land holding in the study area is 0.52 hectares with a minimum and maximum of 0.125 and 2 hectares of landholding respectively; which is small as compared to the holdings in other parts of the country.

Table 1. Socioeconomic characteristics of households (continuous variables)

Variables	Min	Max	Mean	SD
Family size (numbers)	2	13	7.4	2.46
Age of the farmers(years)	20	70	39.84	12.12
Farming experience in coffee(years)	6	50	26.02	9.59
Total land holding(hectare)	0.125	2	0.51	0.34

Source: Survey result, 2020

Regarding the educational level of sample coffee grower farmers, the survey result revealed that the majority of respondents have attended formal education (about 55.5%) of the sampled household heads were attended formal education. The result of the study indicates that about 96.3% of the responding coffee farmers were male and most of them (98.2%) were married

(Table 2). The intention here was to consider the relevance of gender in coffee production as women play a significant role in most agriculture in general and coffee farming in particular. The survey result also shows that about 55.5% of the coffee grower farmers were attended formal education in the study area. This indicated that the majority of coffee producers in the study area were educated which in turn could help to boost the production and productivity of coffee, and this might be the contribution of expansion of educational institutes in the study area.

Table 2. Summary of socioeconomic characteristics of sampled wheat grower farmers

Characteristics	Category	N=164		
		Frequency	%	X^2-test
Education level	Illiterate	73	44.5	5.18***
	Literate	91	55.5	
Sex of household head	Male	158	96.3	9.24***
	Female	6	3.7	

Source: Own survey result, 2020, **, and *** indicates significance at 5% and 1% respectively.

Institutional Services and Support Provision

Experts and development agents (DAs) from the Office of Agriculture and Natural Resources, cooperatives and Unions were the main sources for farmers to get extension services/ advisory services in the study area. The major extension services given to the smallholder farmers were technical support and training to the farmers on organic coffee production and management, compost application, coffee disease management, harvesting, sorting, drying, and marketing in the study area. The survey result indicates that about 53% of the coffee grower farmers were accessed extension services on coffee production and marketing activities, and about 47% of the farmers reported that they didn't access any type of extension and advice services on coffee production during 2019/20 production year in the study area. As to the frequency of extension contact, the survey result also indicates that on average; about 86% of the coffee farmers had rarely extension contact with service providers in the area (Table 3). It implied that the majority of farmers in the areas did not get the important extension services. The respondents reported that the extension service they received from the extension agents was not sufficient. The FGD farmers also reported as nobody is concerned and gives attention to coffee production in the study area and the major gap in access to extension services includes limited services and a lack of modern technologies and knowledge transfer demonstration. The result is allied with other findings which revealed that coffee productivity is low as a result of low extension services availability (Berhanu, 2017).

The result of the survey further indicated that out of total coffee grower farmers, 57% of sample coffee farmers participated in training on coffee production and management practices in the study areas (Table 3). As to access to information on improved coffee production practices, about 51% of the coffee farmers have acceded to information regarding improved coffee production practices from different sources in the study area (table 3). The survey result further indicated that on average, 95.7% of coffee grower farmers had no access to financial services and support in the study area. Concerning membership in a cooperative, about 68 % of the total

respondents were members of the farmers' cooperatives in the study area (table 3). The survey result shows that about 53% of the households were members of cooperatives.

Table 3. Proportion of households on access to institutional services and supports

Access to services	N=164	
	Frequency	%
Accessed to extension services on coffee production(yes)	87	53.29
Accessed to training on improved coffee production(yes)	96	57.07
Access to coffee market information(yes)	130	79.27
Membership to cooperative (yes)	121	74.36
Accessed to financial service (no)	157	95.7

Source: Survey result, 2020

Major Crops Grown

As shown in table 4 coffee, maize, sorghum, wheat, potato, onion Khat and banana are the major crops grown in the study area for cash and family consumption. The survey result indicates that on average, 100% and 68.29 of the farmers grew coffee and chat as a source of cash respectively, and most of the farmers produced maize (91.46%), sorghum (58.54%) and wheat (20%) for home consumption in the study area.

Table 4. Major crops produced in the study area during 2019/20 production season

Major crops grown	Proportion of farmers		
	Frequency	%	Rank
Coffee	164	100	1
Sorghum	96	58.54	4
Maize	150	91.46	2
Wheat	33	20.12	5
Onion	24	14.63	7
Potato	22	13.41	8
Khat	112	68.29	3
Banana and others crops	28	10.66	6

Sources: Survey result, 2019

Coffee Production and Productivity

The result of the survey indicates all of the sample coffee producer farmers practiced backyard or garden type coffee production systems with sole planting of coffee, and others are practiced intercropping coffee at an early stage with annual and perennial crops in the study area. The result of the survey indicates that on average, 0.26 hectares of land were allocated to coffee production by coffee grower farmers in the study area (Table 5). This implied that about 51% of the total area was allocated to coffee production by coffee farmers in the study area, and the result of the survey indicated that the area of land allocated for coffee production is small as compared to other parts of the country and this is due to small landholding characteristics of farm households in the study area. The result of the survey also indicated that the average productivity of coffee in the study area was 4.68 quintals per hectare with a minimum and maximum of 2.36 and 6.90 quintals per hectare respectively during the 2020 production season (Table 5). As a result, the average yield of coffee in the study area is lower than that of the average national coffee yield which is 5.78 quintals per hectare (CSA, 2020).

Table 5. Land allocated, production and productivity of coffee in 2019/20

Variables	Minimum	Maximum	Mean	Std.D
Average land holding(ha)	0.125	2	0.51	0.340
Average land allocated to coffee (ha)	0.063	0.75	0.26	0.146
Average productivity (qt/ha)	2.36	6.90	4.68	2.10

Source: own survey result, 2020

Low productivity of coffee in the study area could be attributed to various reasons, and the majority of coffee farmers during the focus groups discussion reported that coffee diseases occurrence, lack of growth of improved varieties and availability of limited support services are the main factors responsible for low coffee productivities in the study area. Figure 1 shows the trends of coffee production in the study area. The result shows that from 2010 to 2012 production years the trend of coffee production showed a decreasing trend. Figure 1 showed that coffee produced in 2010 was 41,989.71 quintals which are declined to 17,624.10 quintals in 2012 production year (Figure 1). Figure 1 further showed that from 2012 to 2014 years the trend of coffee production showed an increasing trend and starting from 2014 to 2015 years the production was declined and then the graph was upward from 2015 to 2016 years. As it can be seen from the graph below, the coffee production trend fluctuated over the year in the study area.

Figure2. Trends of production of coffee in the study area (2010 to 2016)
Source: Compiled from CSA data

As it can be seen from the graph below, the majority (85%) of the farmers perceived that coffee production in terms of area coverage and volume of production was decreased in the last five years, while only about 7% of the farmers perceived that coffee production in terms of area coverage and volume of production was increased in the last five years the study area.

Coffee Varieties Grown and Farmers' Preference

Coffee varieties grown by sampled farmers in the study area are local. The result of the survey indicated that about 97.52% of coffee producer farmers were growing local coffee varieties in the study area. The focus group discussion participant farmers reported that the farmers are growing low-yielding local coffee varieties in their coffee fields, and the products obtained from local varieties depend on climatic conditions and the severity of diseases in the study area. The farmers reported that low-yielding local cultivars and lack of improved varieties were the most important problems to coffee grower farmers in the study area. The most frequently grown coffee varieties were Fendisha, Shenkuye, Abadiro, Torbi and Cherchero in the study area (Table 6). The result of the survey indicated that about 19%, 17%, 15%, 14% and 13% of the farmers grow Muyira, Abadiro, Shenkuye, Cherchero, and Fendisha varieties, respectively (Table 6). The result of the survey also indicated that about 7.08%, 6.60% and 3.30% of the farmers were producing Torbi, Black coffee/Buna-Guracha and Shek-Hussien varieties, and about 5.19% of the farmers are growing coffee trees but they did not know the name of the coffee varieties producing on their farm fields in the area (Table 6).

Table 6. Major local coffee varieties grown by the farmers in study area

Coffee varieties	N=164	
	N	%
Fendisha	27	14
Muyira	40	19
Shenkuye	32	15.09
Abadiro	36	17
Torbi	15	7.08
Cherchero	30	14.15
Black coffee	14	6.60
Shek-Hussien	7	3.30
Unknown	11	5.19

Source: own survey result, 2020

Coffee Trees Owned, Age, and Yield of Coffee

The survey result indicates that the average number of trees of coffee varieties planted in the study area was 247 per household head with a minimum and maximum of 60 and 350, respectively (Table 7). As to the age of coffee trees, the average age of coffee trees was 38.52 years with a minimum and maximum of 12 and 70 years, respectively. The farmers reported that low-yielding of local cultivars, lack of improved cultivars, and diseases lead to low productivity of coffee which is less than 5 quintals per hectare in the study area (Table 7).

Table7.Number of coffee trees owned, age and productivity of coffee in the study area

Variables	N=164			
	Minimum	Maximum	Mean	SD
Number of coffee trees grown	60	350	247	230
Age of coffee trees (in years)	12	70	38.52	37.98

Source: own survey result, 2020

Local Coffee Varieties Characteristics and Farmers Preferences

The survey result indicates that there are farmers' preferences for specific local coffee varieties due to differences in attributes (Table 8). The major attributes used by the farmers for preferring local coffee varieties include disease resistance; high yielder, early maturity (fast growth and providing yield), drought tolerance, coffee bean size and quality/taste to attract a premium market price are important attributes for selecting best local coffee varieties in the study area. Based on these attributes, Muyira variety was ranked first whereas Fendisha, Shenkuye and Cherchero varieties ranked as second, third and fourth preferred coffee varieties in the study area. The farmers reported during the survey, that Hararghe coffee varieties are facing the danger of extinction due to severe diseases, climate change (drought and high temperature) and lack of attention for coffee from anybody, and nobody is concerned about coffee in the areas.

Table 8. Preferred characteristics and ranking of coffee varieties by sample farmers

Coffee varieties	Local coffee variety attributes	Rank
Fendisha	High yielder, drought tolerance, resistance to diseases, preferred bean for market, and high bean quality but it is late to provide production	2
Muyira	High yielding, early maturity, drought tolerance, diseases tolerance, preferred bean for market, high bean quality	1
Shenkuye	High yielding, early maturity, diseases tolerance, preferred bean for market, high bean quality	3
Abadiro	High yielder, early maturity, drought tolerance, preferred bean for market, high bean quality, but it is susceptible to CBD	6
Torbi	High yielding, early maturity, drought tolerance resistance to diseases, preferred bean for market, high bean quality/taste	5
Cherchero	High yielder, less susceptible to diseases and high quality, but it has small bean size	4
Black coffee	Less susceptible to diseases, but it has low yielder, small bean size, and low quality	7

Source: own survey result, 2020

Sources of Coffee Seedlings

As it can be seen from Table 9, the sample coffee grower farmers have been getting coffee seedlings from government organizations/government nurseries and fellow/other farmers and from their own sources. The survey result revealed that on average, about 41.46%, 24.39%, 21.95% and 12.20% of the sample farmers in the study area accessed coffee seedlings from government nursery/agriculture office, other farmers who raised seedlings, family/own seed and government nursery/agriculture office and other farmers, respectively (Table 9).

Table 9. Sources of coffee seed/seedling in the study area

Sources	Frequency	%
Family/own	40	24.39
Government nursery/Agriculture office	68	41.46
Agricultural Research Centre	16	9.76
Agricultural office and farmers	20	12.20
Farmers (in form of seed/seedlings)	36	21.95

Source: own survey result, 2020

Coffee Management Practices

Coffee planting method: the survey result showed that about 94% of farmers were found planting coffee seedlings by using row planting. However, coffee tree planting densities, distance tree to tree and distance row to row are varied in the areas that use wide inter-row spaces, and this allows them to intercrop their coffee with other crops such as maize, onion and fruit trees. **Use of organic fertilizer:** coffee farmers usually use farmyard manure to improve the productivity of coffee grown in the study areas. The survey result revealed that about 92.68% of the coffee grower farmers are used organic fertilizers in coffee fields in the study areas (Table 10). Organic fertilizers are usually prepared by mixing animal manure and leaves of grasses and crop leafs left after animal feeding and transporting them to coffee fields.

Use of inorganic fertilizers and pesticides (fungicide, insecticide): the result indicated that no one is using any inorganic fertilizers and pesticides in their coffee farms in the study areas. This makes coffee produced and delivered to the market as organic coffee. The FGD farmers noted that 30 years ago(during derge), the government was provided a chemical which was called Octave to control coffee diseases. Now, no one is accessing chemicals to coffee grower farmers to control coffee disease and insect pests in the study areas. However, the farmers noted that the productivity of coffee decreased from time to time, due to soil fertility problems, diseases occurrences, and a lack supply of input in the study area. Hence the farmers requested and need to apply appropriate balance and rates of inorganic fertilizers and chemicals that can boost coffee productivity by controlling diseases without losing their organic nature.

Mulching/soil mulching and conservation: the survey result showed that about 58.54% and 87.80% of the coffee grower farmers are practiced mulching/ soil mulching and Conservation/Earthling, respectively in the study area (Table 10). The farmers reported practicing soil mulching on the coffee farms and around individual coffee plants gave better yields. **Shading:** the survey result showed that about 73.17% of the farmers are used shade trees in the coffee fields in the study area(Table 10). Trees such as *Cordia africana*, *Acacia albida*, and *Croton mycrostachs* are commonly used for coffee shade by coffee farmers in the study areas. The farmers preferred these trees which are holding their leaves for a long time, cooling/regulating temperature and soil fertility.

Pruning: the results of the survey revealed that only 4.27% of the farmers were practiced coffee pruning, and farmers prune older coffee trees to rejuvenate (Table 10). The culture of old coffee stumping and pruning is not practiced by the coffee farmers in the study area. Instead, the farmers want to manage old-aged coffee trees in their farm fields, and this may also create

favorable conditions for the occurrence of coffee diseases and pests which is a severe problem in the study area. The farmers and DAs during the survey noted that the practice is introduced recently in the area and some farmers have already started to use the practice, but lack of awareness and shortage of materials are limiting factors to addressing more farmers in the area.

Table 10. Farmers coffee management practice in the study area

Practices	Frequency	%e
Row planting	155	95
Organic fertilizers use	152	92.68
Mulching/ soil mulching	96	58.54
Earthling/tie ridging	144	87.80
Shading	120	73.17
Pruning	7	4.27

Source: own survey result, 2020

Major Coffee Diseases and Insect Pests, and Farmers' Management Practices

The result of the survey revealed that Coffee berry disease, coffee wilt disease, bacterial blight of coffee, coffee leaf blight, Coffee leaf rust and coffee stem drying are was identified by the farmers as the major and most known coffee disease types which have been occurred in coffee farms in the study area. The farmers' focus group discussion and key informants also reported that the prevalence of coffee berry disease, a bacterial blight of coffee, coffee wilt disease, coffee leaf blight, coffee leaf rust, coffee leaf spot and coffee stem drying diseases are very significant and challenging coffee producer farmers in the study area. Other coffee diseases such as coffee stem die bag, coffee thread blight, coffee bark disease, coffee root rot and dieback are also coffee diseases that are damaging coffee trees for coffee production in the study area.

In addition to disease, the focus group discussion farmers reported that insects and pests such as bean borer, Anthestia, cutworm and termite are causing a decrease in coffee yield year to year in the study areas. Traditionally the farmers used different cultural practices to control coffee diseases such as spraying animal waste (urine) on infected coffee branches, burning crop residue and leaves in coffee fields, cutting and burning infected coffee trees parts, pruning infected branches, uprooting infected tree to control coffee diseases in the study area.

Actors involved in coffee production and marketing and their function

The summary of coffee actors involved in coffee is presented in Table 11. Different actors public and private are engaged in coffee production and marketing systems in the study area. The result of the survey showed that the coffee actors identified were smallholder farmers, collectors, cooperatives, cooperative unions, suppliers, processors and exporters mainly engaging in production, processing and marketing activities in the study area (Table 11). Table 11. Major actors and functions engaged in coffee production and marketing

Actors	Functions, services provided
Smallholder coffee producer farmers	Produce coffee, harvest, dry, hull, and sell coffee to cooperatives, collectors, suppliers, processors
Office of Agriculture and Natural Resource	Coffee nursery establishment, raising selected coffee varieties seedlings, distribution of coffee seedlings, extension and training services such as production and management, quality aspects and market information
Primary cooperatives and Unions	In the study area, cooperatives and unions play a crucial role in providing services and support to coffee farmers. They collect coffee from members, value addition practices such as hulling/processing, clearing, sorting and packaging, and supply to exports at ECX, provide training and technical support to members on organic coffee production, disease management, harvesting, drying, cleaning and storing
Agricultural Research Center	Conducting adaptation research, providing training for producers, DAs and experts, and coffee technologies promotion in the study area
Collectors	Those buy coffee from smallholder farmers, assembly and supply to suppliers/processors in the area
Processors/coffee milling owners	In the surveyed area, those who have their own coffee huller machine and involved in providing processing services for farmers, collectors and suppliers, and they also purchased coffee from individual farmers, and collectors and supplied coffee to exporters at Dire Dawa (ECX)
Suppliers	Those traders who bought coffee from individual farmers and collectors at the district market, packed and delivered coffee to ECX, and sold coffee to exporters
Ethiopian Commodity Exchange (ECX)	Marketplace facilitates both export and domestic coffeetrading by different actors, provide a centralized and standardizing service, grading, warehousing, and trading services
Commission agents	Those who physically handle coffee products at ECX and they work between suppliers and exporters.
Non-government organization (NGOs)	Capacity building on organic coffee production, irrigation development, providing training/facilitation, market linkages, and capacity building.

Coffee Marketing

The result of the survey showed that the coffee producer farmers sold their coffee produce mainly to primary cooperatives (46.34%) followed by assemblers/collectors (37.80%), suppliers (25.61%) and processors (15.24%) in the study area (Table 12).

Table 12. Proportion of coffee farmers sold their coffee to different traders

Market actors	n=164	
	Frequency	%
Assemblers (collectors)	62	37.80
Suppliers/wholesalers	42	25.61
Processors/suppliers	25	15.24
Primary cooperatives	76	46.34

Source: own survey result, 2020

Coffee Market Channels

In coffee, the government has been established a market system called the Ethiopian Commodity Exchange market through which only wholesalers are made to buy coffee from the producers and sell it to the exporters through the ECX market. This intervention was made for improving the coffee market and maintaining coffee quality by minimizing the handling by the different actors. As can be seen in Figure 4, there are assemblers, suppliers/wholesalers, cooperatives, unions and processors which perform a linking function between producers and exporters. The survey result indicated that five major marketing channels were identified for coffee in the study area, and the total volume of coffee which would follow to market by the sampled coffee producer farmers through all channels was estimated to be 1230 kg in the study area. The main receivers of coffee from producers are primary cooperatives and assemblers/collectors and they take 40.6% and 30.5% of the total coffee sales conducted by farmers, respectively (Figure 4). Following primary cooperatives and assemblers/collectors, suppliers and processors are the third and fourth actors that share 18.35% and 10.55 % of coffee sold by farmers in the study area.

Coffee Market Performance

The major coffee market participants and gross marketing margins are presented in table 13. The coffee suppliers and processors are taking the largest gross margin in all the cases followed by the assemblers/collectors in the study area. The suppliers and processors obtain relatively highest gross marketing margin (69.02%) and (69.68%) of exporter price in channels 4 fand 5 followed by assemblers/collectors which were 30.44% and 31.27% in channels 1 and 2 respectively among coffee traders in the study area (Table 13). The result of gross margin analysis also shows that coffee producers are not benefiting from the final price paid by the exporters as compared with the other actors in the study area. The result in table 18 shows that the producers obtain the lowest market margin (21.89% in channel 1) and relatively obtain a high market margin (31% in channel 3) in the study area. This indicates that there should be an improvement in the coffee market chain which makes the coffee producers benefit more from the coffee market in the study area.

Table 13. Coffee marketing margin for different channels in the study area

Actors of coffee market	Value of gross marketing margins (%) for each channel				
	Channel 1	Channel 2	Channel 3	Channel 4	Channel 5
Producers	21.89	20.16	31.0	30.32	30.98
Assemblers/Collectors	30.44	31.27	-	-	-
Cooperatives	-	-	33.0	-	-
Unions	-	-	36.0	-	-
Suppliers	48.56	-	-	-	69.02
Processors	-	48.57	-	69.68	-

Source: own survey result, 2020

Coffee Production Constraints

Coffee is produced predominantly by smallholder farmers in the study area. The survey result showed that the average yield of coffee was 4.8 quintal per hectare, which was lower than the national average yield. The most important constraints identified by coffee producer farmers in the study area include coffee diseases, lack of access to improved coffee varieties, climate change (rainfall, high temperature), limited extension services, inadequate services and support and irrigation water shortage in the study area (Table 14). Out of those coffee production constraints, about 96.34% of sampled coffee producer farmers reported that coffee diseases as the major constraint faced by farmers and it ranked first in the study area. The results of this findings is in lined with the findings of Kinati (2017), and Tesfaye *et al.* (2020) reported that high incidence of Coffee Berry Disease and shortage of improved cultivators as major constraints to coffee producers in southern Ethiopia. Despite the presence of a high incidence of disease and pests, no one uses pesticides on their coffee farms to control coffee disease and insect pests in the study area, and this is related to producing organic coffee to market. However, the farmers who participated in the focus group discussion noted and requested the need to research intervention on the use of appropriate balance and rates of inorganic fertilizers, and

chemicals that can boost coffee productivity without losing the organic nature of the coffee production in the study area.

The result of the survey also shows that the shortage of access to seeds of improved coffee varieties with (95.73%) was identified as the second most important constraint to coffee production followed by climate change (86.59%) and limited extension services (76.22%) in the study area (Table 14). The farmers participated in the focus group discussion and key informants reported that lack of access to high yield and disease-resistant coffee improved varieties are the main factors responsible for low coffee productivity in the study area, and they noted that availability of inadequate support and weak research extension linkage, and as a result, the farmers use local coffee varieties which are susceptible to diseases in the area. The farmers also noted that limited farmer access to extension services, inadequate services and supports related to the use of improved coffee production technologies and knowledge transfer, promotion of improved management practices and inadequate coffee research extension were perceived by coffee farmers as important constraints to coffee production and they ranked fourth and fifth level in the study area. The findings of this study is in lined with the findings of Kinati (2017) revealed that weak linkage between research, extension services and producers are a major problem to coffee farmers in Ethiopia. Furthermore, the results of the survey revealed that irrigation water shortage was reported as a constraint to coffee production and they ranked at the sixth level in the study area (Table 14).

Table 14. Major constraints of coffee production in study area

Constraints	N=164		
	Frequency	%	Rank
Lack of improved coffee varieties	157	95.73	2
Diseases	158	96.34	1
Climate change (rainfall, high temperature)	142	86.59	3
Inadequate services and supports	92	56.10	5
Limited extension services	125	76.22	4
Low soil fertility	55	33.54	8
Land shortage	86	52.44	7
Irrigation water shortage	104	63.41	6

Source: own survey result, 2020

Other coffee production constraints such as traditional cultural practices of coffee production, shifting to other crops, low capacity of government organizations/institutions in providing quality services and support for coffee actors, promotion of improved coffee management practices, farmers growing coffee intercropped with other food crops (coffee quality problem), harvest and post-harvest handling problem, mixing high-quality coffee with low quality and weak regulatory and controlling system on coffee harvesting, storing, transporting and processing activities reported by the farmers as major problems to the coffee sector in the area.

Producers' Coffee Market Constraints

The major marketing constraints raised by farmers and traders of the study area were low price of the coffee, lack of transparency in coffee market, problems in market information flow (lack

of timely market information flow), absence of price premium for quality, transportation problem, coffee price fluctuation and illegal traders hinder fair price were the main market constraints to producers the in the study area (Table 15). The survey result indicated that the low price of coffee (96.95%), lack of transparency in the coffee market (85.98%) and coffee price fluctuation (84.32%) were major market constraints encountered by coffee producers in the study area and they ranked first, second and third level respectively in the study area (Table 15).

The result also indicated that illegal traders hinder producers fair price (82.93%), transportation problems (64.63%) and absence of price premium for a quality product (51.83%) was reported by the majority of producers and ranked fourth, fifth and sixth as the most important constraint in coffee marketing (Table 15). The survey result indicated that majority of the farmers pointed out transportation as a key factor that is adversely influencing the marketing of coffee due to the absence of roads and lack of access for vehicles to producers in the study area. The results of this study was in line with prior study by FAO (2014) that market inefficiencies, excessive margins from traders over producers, high transport and marketing costs are the main constraints to coffee markets in Ethiopia.

Table 15. Major coffee market constraints to producers in study area

	N=164		
Coffee marketing constraints	Frequency	%	Rank
Low price of coffee	159	96.95	1
Lack of transparency in coffee market	141	85.98	2
Problem in market information flow	75	45.73	7
Absence of price premium for quality	85	51.83	6
Transportation problem	106	64.63	5
Coffee price fluctuation	138	84.32	3
Lack of storage facilities	62	37.80	8
Illegal traders hinders fair price	136	82.93	4

Source: own survey result, 2020

Traders' Coffee Market Constraints

The survey result revealed that major coffee market constraints such as the decline of coffee products supplied by producers, low quality of coffee products due to diseases, drought and insufficient product handling, involvement of unlicensed and illegal coffee traders in the coffee market, lack of transparency on coffee price setting at ECX market, rejection of coffee product by ECX without unknown reason, absence of primary coffee transaction center at the near town, the problem of packing materials (high cost), lack of proper information flow and high transport cost due to road and transport problems were reported by traders and processors as major coffee market constraints in the study area.

Coffee Production and Market Opportunities

Farmers indigenous knowledge in coffee production, coffee serves as shade and prevents erosion, availability of both domestic and export market, increasing demand of organic coffee, government policy emphasis on coffee crop, the existence of coffee genetic diversities, availability processing plants, availability of universities and research centres are some of the major opportunities available for the improvement and expansion of coffee production in the study area.

Conclusions and Recommendations

The study was conducted in coffee production potential districts of East Hararghe Zone of Oromia Region, with objectives to assess and describe coffee production and marketing systems, coffee market performance and identify coffee production and marketing constraints and opportunities in the study area, and three-stage sampling procedures were used to select a total of 164 sample coffee producers and 32 coffee traders. Primary data were collected from sampled producers and traders through a household survey using questioners, focused group discussions and key informant interviews, and analyzed using descriptive statistics.

The result indicates that on average, 0.26 hectares of land were allocated to coffee production by coffee grower farmers in the study area. The result of the survey also indicated that the average productivity of coffee in the study area was 4.68 quintals per hectare with a minimum and maximum of 2.36 and 6.90 quintals per hectare respectively. Coffee varieties grown by sampled farmers in the study area are local varieties, and the result of the survey indicated that about 97.52% of coffee producer farmers were growing local coffee varieties in the study area. The survey result further indicates that the average number of trees of coffee varieties planted was 247 per household head and as to ages of coffee trees, the average age of coffee trees was 38.52 years. Coffee berry disease, coffee wilt disease, bacterial blight of coffee, coffee leaf blight, coffee leaf rust and coffee stem drying being identified by the farmers as the major coffee disease types in the study area.

The survey result indicated that five major marketing channels were identified for coffee which coffee follows to market by the sampled producers in the study area. The main receivers of coffee from producers are primary cooperatives and assemblers/collectors and they take 40.6% and 30.5% of the total coffee sales conducted by farmers, respectively. The gross marketing analysis shows that the producers obtain the lowest market margin whereas the suppliers and processors obtain the relatively highest gross marketing margin of exporter price in the area.

The most important constraints identified by coffee producer farmers in the study area are coffee diseases, lack of access to improved coffee varieties, climate change (rainfall, high temperature), limited extension services, inadequate services and support and irrigation water shortage. Low price of coffee, lack of transparency in the coffee market, problem in market information flow (lack of timely market information flow), absence of price premium for quality, transportation problem, coffee price fluctuation and illegal traders hinders fair price were the main market

constraints to producers the in the study area. The survey result also revealed that major coffee market constraints such as the decline of coffee supplied by producers, low quality of coffee products, involvement of illegal traders, lack of transparency on coffee price setting, lack of proper information flow and transport problems were reported by traders as major coffee market constraints in the area. Based on the findings of this study, the following recommendations are given: the majority of the sample producers indicated that low productivity of coffee is the main constraint in coffee production, introducing productive and disease resistant improved coffee varieties, research centres and Universities should be coffee production improvement intervention, and multiplication and distribution system designed for sustainable multiplication and distribution of coffee planting materials, need research intervention on applying appropriate balance and rates of inorganic fertilizers and chemicals to coffee production, and coffee disease protection and management and introduction and promotion of improved coffee agronomic practices.

Strengthening extension service provisions and coffee research extension linkage to increase coffee productivity, improve access to inputs, and strengthen farmers' cooperatives. Therefore, strong efforts should be needed to aware and intensively train coffee farmers and extension agents about coffee diseases management through practical training, enhance extension services to improve farmers' skills and knowledge of coffee production and marketing systems, and establishment of coffee markets places in the near producers and traders. Strengthening coffee seed-producing institutions is vital to motivating coffee producers in the study area and area. Strengthening coffee extension services should be considered an important input for improving coffee productivity in quantity and quality, facilitating and improving the quality and types of market information delivery used by coffee producer farmers and traders shall take policy attention, improving ownership of transportation facilities and road infrastructures can increase the accessibility of producer, traders and processors market coffee outlet in the area.

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