COLLEGE OF DEVELOPMENT STUDIES

CENTER FOR RURAL DEVELOPMENT

THE IMPACT OF CLUSTER FARMING ON CROP PRODUCTIVITY IN AMHARA REGIONAL STATE, ETHIOPIA: EVIDENCE FROM DEJEN *WOREDA*

WONDIMU DIRAR TESFAYE

A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS IN RURAL LIVELIHOOD & DEVELOPMENT

JUNE 16, 2022

ADDIS ABABA, ETHIOPIA

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DECLARATION

I, Wondimu Dirar, declare that this thesis is my original work and has not been presented at any other University. All sources of materials used for this thesis have been duly acknowledged and credits are given.

This thesis is submitted in partial fulfillment of the requirements for a Master of Arts in Development Studies (Rural Livelihood and Development).

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This is to certify that this thesis is prepared by Wondimu Dirar Tesfaye, entitled: **The Impact of Cluster Farming on Crop Productivity in Amhara Regional State, Ethiopia: Evidence from Dejen Woreda**, submitted to the Center for Rural Development in partial fulfillment of the requirements for a Masters of Arts in Development Studies (Rural Livelihood and Development) complies with the regulations of the university and meets the accepted Standards concerning originality and quality.

APPROVED BY THE EXAMINATION BOARD

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Advisor	Signature	Date

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LISTS OF ACRONYM AND ABBREVIATIONS

ACC	Agricultural Commercialization Clusters
ADLI	Agricultural Development Led Industrialization
AGP	Agricultural Growth Program
ATA	Agricultural Transformation Agency
ATT	Average Treatment Effect on Treated
BCR	Benefit-Cost Ratio
CF	Cluster Farming
CFNP	Cluster Farming Non-Participant
CFP	Cluster Farming Participant
CSA	Central Statistics Agency
DA	Development Agent
DWOA	Dejen Woreda Office of the Agriculture
ESS	Ethiopian Statistics Service
Eth cal.	Ethiopian Calendar
FGD	Focused Group Discussion
FPC	Farmer Production Clusters
FSSIM-Dev	Farming System Simulator Model for Developing Countries
IRR	Internal Rate of Return
KII	Key Informant Interview
Msal	Meters above sea level
MoA	Ministry of Agriculture
NGO	Non-Governmental Organization
NN	Nearest Neighbor
NPV	Net Present Value
PSM	Propensity Score Matching
SNNPR	Southern Nations Nationalities and People's Region
TLU	Tropical Livestock Unit
VIF	Variance Inflation Factor

ABSTRACT

Cluster farming is one of the approaches formulated in the Ethiopian agricultural sector to uphold location-based initiatives with an aim to modernize the smallholder farming subsector and leap forward from the traditional, less productive, and subsistence farming to a new and systematic way of production. In the case of Ethiopia, cluster farming is not a thing any farmer could adopt unless whose land falls into selected suitable sites. This study was initiated to understand the impact of cluster farming on teff crop productivity by drawing evidence form Dejen Woreda. And at the same time to understand how clusters are formed and how farmers are perceived the approach. Both quantitative and qualitative types of cross-sectional data were collected from randomly selected 384 participant and non-participant households and both descriptive and econometrics (Propensity Score Matching) data analysis tools were used by taking the approach (CF) itself as a determinant of productivity. Accordingly, the results show that the formation process was top-down and not in complement with ATA's framework when it comes to consulting famers, providing explanations, providing training. In relation to farmers perception, results show that farmers have positively accepted and perceived the approach even if most of them believed that participation hasn't brought change except input usage, getting more extension service and lowering of pest infestation. In terms of teff productivity, the average treatment effect on the treated (ATT) estimation also show that participant farmers had advantage of teff productivity by 208 kg/ha or 2 quintals compared to non-participants. The study asserted that the approach indeed has a positive impact on teff productivity and it is positively accepted. Thus, finding of the study suggest that the approach has encouraging roles to capitalize on and some loopholes that needs attention of the Agricultural Transformation Agency (ATA), the Ministry of Agriculture (MoA), Dejen woreda agricultural office, woreda official, experts' development agents and farmers themselves regarding sensitization and awareness creation, provision of training, facilitating credit services and other essentials including the quality of extension services, input, technology and market as per the approaches recommendations and packages.

***Key words**: Cluster, Cluster farming, Propensity score matching, Crop productivity, Ethiopia, Teff.*

UNIT ONE: INTRODUCTION

1.1.Background Of the Study

Ethiopia is the second-most populous county in Africa with an estimated 119 million population size (WB, 2021). Agriculture constitutes and remains the backbone of the economy of the country in terms of GDP contribution, the share of export, and employment. According to Diriba (2020) and USAID (2021), the sector contributed nearly 27.5 billion dollars or nearly 34.1% of the GDP, nearly 80 % of the exports, employed nearly 75 % of the working force and serves as a major source for raw material and capital for market and investment. Nevertheless, as noted in Gebeyanesh et al. (2021), it is dominated by smallholder farming systems and characterized by small and fragmented land holding, subsistence production, low yield and always struggling with climate variability, a decline of natural resources and increasing degradation. The smallholder farming subsector generates close to 94% of the Ethiopian agricultural GDP (Louhichi et al., 2019).

In countries like Ethiopia, the potential to sustainably grow hinges on the development of the agricultural sector. Cognizant of this, many development efforts, policies, strategies, and interventions by Ethiopian governments to accelerate growth, reduce poverty, and achieve sustainability is highly dependent and buildup on the agricultural sector (Louhichi et al., 2019). Some of the examples include, the Agricultural Development Led Industrialization (ADLI), the two Growth and Transformation Plans (GTP I & GTP II), and the Agricultural Commercialization Clusters (ACC) initiative mainly in the post-1990.

The ACC was initially introduced in the first growth and transformation plan - GTP I (2010-2015), and its anchor the Agricultural Transformation Agency (ATA) was established in 2010 (ATA, n.d.; Diriba, 2020; Mamo, 2019). Concerning location-based development, the approach makes up the main policy intervention devised for the agricultural sector to uphold geographically-targeted interventions (ATA, n.d.), and at the same time stimulate commercialization within the smallholder farming and create opportunities to connect the subsector with agro-industries and global agri-food value chains (Poli, 2018). The smallholder farming subsector holds a major role in the approach while working on market and value chains, integrating the subsectors and widening cooperation among different agents and actors remain central.

Experiences in other countries show that there are two types of clustering farming approaches, area-based, and commodity-based for the purpose of production and as a marketing mechanism. In the first case, neighboring farmers produce the same type of commodity by consolidating their plots and by farming together. In the second case, farmers produce the same type of commodity without consolidating their plots without the need to be neighbors (Montiflor et al., 2009). The second approach is mainly designed as a marketing strategy to deliver in volume. In the case of Ethiopia, as noted in Mamo (2019), neighboring farmers consolidate their plots for selected crop types and produce together.

In Ethiopia, three-step processes to identify and prioritize commodity types, and select geographical areas were done before starting cluster production. The processes include a selection of commodity types with the highest comparative advantage, the selection of suitable *Woreda*s based on the selected commodities and other additional market factors, and at the end, individual farmers numbered between 30 to 200 are grouped into clusters. Groups are expected to adopt and implement ATA's recommendations including the use of improved seeds, modern technologies, fertilizer, and other farming best practices, and to become commercial companies over time. Following the kick-off of the approach in 2010, 29 clusters in four regional states namely Amhara, Oromia, SNNPR, and Tigray formed and nine priority commodities including sesame, malt barley, wheat, maize, tomato, onion, avocado, banana, and mango were selected. Later, *teff*, haricot bean, and apiculture value chains were included (ATA, n.d.)

According to Getahun Milkias (2021), in 2020, only 5.19 percent of farmers participated in cluster farming at the national level and the cultivated area used for cluster farming were not exceeding 7.21 percent. An annual report by ATA (2021) also indicated that between 2020 and 2021, nearly 2.8 million hectares of land were cultivated with maize, *teff*, malt barley, and sesame commodities by about 3.7 million smallholder participant farmers. Currently, the approach is practiced in most parts of Ethiopia with its all prospects and challenges with or without support, and with or without consistency of ATA's framework (Poli, 2018).

In the Amhara region, Dejen is one of the *Woreda*s implementing cluster farming. According to Dejen *Woreda* Office of Agriculture (2022), the practice was officially started in 2018 with two crops *teff* and sorghum. In terms of area coverage and priority, *teff* is the main crop but sorghum is included later with a focus on low lands in the Abay (Nile) river gorge. The *Woreda* practices

cluster farming with and without the support of ATA. Albeit, the changes in terms of productivity, the benefits it brings, and constraints of the approach are not well studied in the country let alone the *Woreda*

1.2.Statement Of the Problem

The agriculture sector in Ethiopia is at its heart and forms the biggest part of most of its social and economic development efforts. Nearly, 80% of its population dwells in rural areas and the livelihood of most is dependent on and earned from the sector. However, the sector is largely dominated by smallholder farmers and branded with its rain-fed, low productive labor-intensive subsistence farming (Getahun & Milkias, 2021), low adoption and less access to credit services and improved inputs including knowledge (Diriba, 2020). And at the same time, it is characterized by a fragmented and customary land tenure system, low intake of modern technologies (Poli, 2018; Louhichi et al., 2019). Understanding these, different governments of Ethiopia introduced different interventions, approaches, policies, and programs. Cluster farming is one of them. The approch was introduced in 2010 to uphold geographically-targeted interventions (ATA, n.d.; Poli, 2018).

Cluster-based agricultural was commenced to achieve inclusive, rapid, and sustainable development with targeted agricultural commodity value chains by intensifying the use of improved and modern inputs, technologies and extension service. The approach is modeled on the success and experiences of predecessor countries by mixing indigenous lessons and past experiences (ATA, n.d.). Empirical reviews and evidence drawn from experiences of countries show that the practice has been fruitfully exercised in southeast Asia, Europe, some parts of Africa, the Latin America, and the United States of America (Clark et al., 2015; Gálvez-Nogales, 2010; Karki et al., 2021; Montiflor M. , 2008).

Among others, studies asserted that cluster farming plays a vital role in improving product and productivity, provides market and related benefits (Rola-Rubzen et al., 2013; Washim et al., 2015), enhances income (Montiflor et al., 2009), it helps to foster adoption of technology (Gálvez-Nogales, 2010). On the contrary, there are some concerns related to the tendency of monocropping (Poli, 2018), susceptibility to environmental-related risks, market failure, and product quality issues (Mamo, 2019)

Despite its benefits, findings of Hailu & Temesgen (2021) and Poli (2018) indicated that the approach in Ethiopia suffers from low availability and less access to inputs, modern technologies

and issues linked to cluster formation and purpose. For example, cluster formation and purpose according to Poli (2018) are in contradiction with ATA's framework and strategy. On top of these, very little was done in realizing the marketing benefits i.e., to advance value addition, upgrade rural markets, and integrate with agro-industries and other markets.

Beyond some success stories told on TV and in newspapers, only limited research was done to understand the Ethiopian way of cluster farming. Some efforts however were done with a focus on agricultural extension systems by Getahun &Milkias (2021), to understand factors affecting smallholder farmers' participation in cluster crop production by Hailu & Temesgen (2021), examination of productivity performance and upscaling of the ACC by Louhichi et al (2019), and an attempt to understand the Ethiopian way of agrarian transformation with a focus on cluster farming by Poli (2018). And yet, none was done to understand the comparative advantages of cluster farming participation and its real impact on crop productivity. Moreover, compared to wheat cluster farming, *teff* commodity, a steeple crop in Ethiopia, is yet an untouched part of the studies of cluster farming.

This study was, therefore, initiated to assess the comparative advantage of cluster farming and its impact on *teff* crop productivity. In doing so, the study specifically examines the formation and organization processes of cluster farming, assesses farmers' perception of the approach, and measures the impact of the approach on *teff* productivity.

1.3.Objective Of the Study

1.3.1. General Objective

The main objective of this study is to assess the comparative advantage of cluster farming and its impact on *teff* productivity in Dejen *Woreda*.

1.3.2. Specific Objective

Specifically, this study strives to address the following specific objectives:

- To examine how cluster farms were established and organized in Dejen *Woreda*.
- To assess the perception of farmers towards cluster farming.
- To measure the impact of cluster farming on *teff* productivity.

1.4.Research Questions

- What were the steps, processes, realities, and facts of cluster formation in the study *Woreda*?
- Do participant farmers have differential access to inputs compared to non-participants?
- What advantages do farmers receive from cluster farming?
- What was the perception of participant and nonparticipant farmers on the approach?
- What changes occurred in the level of crop productivity?

1.5.Significant Of the Study

Generally, only finger count research has been done concerning cluster farming in the case of Ethiopia. Even if done, their focuses are limited and narrow. This study therefore would be significant to fill research gaps related to understanding the advantages of cluster farming and its impact on teff crop productivity by exploring experiences through comparatively studying participants and non-participants. Additionally, this study would provide benefit to policymakers, planners, and practitioners by recommending better ways to fully harness the benefits of the approach.

1.6.Scope and Limitation of the Study

The scope of the study was limited to understanding the impact of cluster farming participation on *teff* crop productivity in the Dejen *Woreda*/district. Thus, this study was limited due to its spatial and temporal coverage; geographically, the study was conducted only in Dejen *Woreda*, temporally the study was limited due to its usage of cross-sectional data of the 2021 cropping season, and conceptually the study focused on organizational, farmers perception and productivity nature of cluster farming.

1.7.Organization of the Thesis

This thesis is organized into five chapters. The first chapter deals with the introductory parts constituting background of the study, problem statement, objectives, research questions, and the significance of the study. The second chapter presents a review of the conceptual, theoretical, and empirical literature. Following, description of the study area, the research design, and methods are presented in the third chapter. Then, results are presented and discussed in detail in the fourth chapter. At last, based on the main findings, summarized results, conclusion, and appropriate recommendations are presented in the fifth chapter.

UNIT TWO: REVIEW OF RELATED LITERATURES

2.1.Conceptual Literature: Definition and Description of Key Terms

The concept of clustering according to Karki, et al. (2021) becomes evident in economic development research and policy practices following the popularity of "Competitive Advantage of Nations" a review article by Michel E. Porter, (1990). Sölvell et al (2003) specified that when understanding and popularity of the concept widened, the idea become prevalent in regional and international economic development agendas and discourses. Many countries use the approach to harness economies of scale resulting from access to finance, access to concentrated knowledge, information, group marketing, and fostering innovation (Lewis, 2016). The concept of clustering represents new ways of thinking about the national, state, and local economies; and dispenses roles for institutions, companies, and governments to upscale competitiveness (Porter, 2000). Compared to the agricultural sector the concept of clustering has been practiced for long period of times in the industrial sector. Definition and concepts are therefore largely shaped by the economic development modeling borrowed from the industry.

2.1.1. What is Clustering?

In simplest terms, clustering is geographic concentrations of interrelated companies, specialized suppliers, service providers, firms in related industries, and other supplementary institutions with a particular field based on commonality and complementarity, to cooperate and compete (Porter, 2000). Clusters comprise a collection of horizontally and vertically connected companies, institutions, and other related stakeholders. Vertically, clusters economically connect and concentrated on a single type of product or processing. Horizontally, clusters connect based on the closeness of the types of products or processing (FAO, 2017). Clusters also include governmental and non-governmental institutions like universities, standards agencies, trade associations, think tanks, vocational training providers, education centers, information centers, researchers, and other technical support providers in line with suppliers and manufacturers of complementary products (Porter, 1998)

2.1.2. Clustering in the Agricultural Sector

Clustering in the agriculture sector is all about location and concentration-based practices applied to producing at farms, agro-processing, agribusinesses, agro-clusters, and the like. Most commonly, it involves a vertical linkage between different actors i.e., raw material producers,

suppliers, processors, exporters, and retailers; a horizontal linkage among producers; relations among supporting service providers i.e., public and private sectors, NGOs, research institutes, and universities and agglomeration in mass to harness economy of scale and other benefits (Clark et al., 2015).

Historically agro-based clusters were believed to emerge around the 1960s and 1970s without much attention to production clusters for the smallholder farming subsector. Nevertheless, a marked expansion of agro-based clusters in developing countries was noted onwards the 1990s and the following decades with a focus on export commodities (Poli, 2018). Until some time, the involvement of smallholder farmers was hardly noticed in agribusiness value chains (Clark et al., 2015)

Later on, the approach starts involving smallholder farmers to reduce amassed poverty in the subsector by enabling the farmers to produce high-value commodities either as suppliers to agro-processers and/or as surplus producer for themselves (Cluster Farming, n.d.). Karki et al. (2021) claim cluster farming is a tool to assist farmers to reduce risks related to production and agribusiness development by enabling relevant initiatives to focus resources and practices on specified endpoints for the smallholder farming subsector. Or, as stated in Richards (2018), it is a tool to equip individual farmers at the micro-level to leverage their collective influence for betterment and development of infrastructure, to share available information on input selection, production, and how to more efficiently use resources and adapt to local contexts.

In this context, cluster farming can be explained as an agricultural mode of production by bringing together geographically interconnected plots to work together on selected crops for efficient use of resource and to harness associated benefits related to economy of scale and marketing. In some cases, the approach is operationalized with the involvement of commercialization. The main objectives are to produce together, deliver in bulk and increase income (Mamo, 2019; Montiflor M. , 2008).

Kumse et al. (2021) stated cluster farming is intended to empower small and medium holding farmers and agro-processers to have “collective actions” and “knowledge and information spillovers” emanated from and due to easy access to information, access to public goods, combined effect, specialized inputs, and innovation. Besides, the approach has expected to have positive spill-over effects on local and rural development efforts (Sharma & Anupam, 2014).

2.1.3. Clustering in the Ethiopian Agricultural Sector

Clustering in the Ethiopian agricultural sector was first introduced comprehensively within the framework of ACC to modernize and leap forward from the traditional, less productive, and subsistence farming to a new and systematic way of production (Hailu & Temesgen, 2021). The main objective of ACC according to ATA (n.d.) is to increase the income of smallholder farmers; substitute imports and increase export through developing domestic markets; industrialize the agriculture sector, and enhance off-farm employment. In other words, the ACC initiative was commenced to stimulate commercialization within the smallholder farming subsector and to create opportunities side by side to connect it with agro-industries and global agri-food value chains (Poli, 2018). In its current status quo, the ACC emphasizes interventions that could advance crop productivity by reducing degradation, improving access to markets, increasing agro-processing and value-additions, creating employment opportunities, and by enhancing coordination of implementation.

Key enablers of ACC include increased productivity through timely and easy access to quality inputs, reduction of post-harvest loss, assuring scale of economy for input dissemination and output accumulation; upgraded production quality and competitiveness through improving quality of output and minimizing the cost of production, market-driven output production; and improved linkages among value chain actors with greater role of the private sector, through direct market linkages, creating favorable environment for private sectors, distribution investments, expanding employment, capacity-building and training opportunities (ATA, 2015).

Among the four objectives of ACC, the first two are anticipated to be achieved at the field level through promoting farmer production clusters (FPC). FPCs are a subset of ACC to realize key strategies of ACC. FPCs are supposed to bring farmers/plots together to stimulate faster diffusion of research recommendations, improve farming practices, simplify access to input finances, and to increases marketable surplus through nurturing an economy of scale. FPCs are also believed to ease and promote the use of modern technologies including machinery, enhance bargaining power, enable stronger market linkages, and improve profitability through encouraging commercialization (ATA, 2021). On top of these, FPCs are hoped to be learning centers where good practices are being scaled up and spread to maximize production and productivity through integrating commercialization in every process (ATA, n.d.)

2.1.4 Process of Cluster Establishment in the Ethiopian Agriculture

According to ATA (2019), cluster groups formation process has 7 general steps starting from establishment to registration. They include: selecting suitable *Kebele*s and farms, organizing sensitization and awareness meetings, enlisting and registering willing farmers, giving training, forming groups and electing leaders/committees, recording farmers' profiles, and getting identification numbers and registering the group. The same document pointed out that farmers who could join cluster farming groups should at least have 0.25 hectares of land and must be willing to join and must trained. In a least case scenario farmers should be given an onboard training. The document also indicated following the selection of suitable *Kebele*s and participant farms, farmers will take part in orientation and discussion programs and it is after that those who are willing to join get registered.

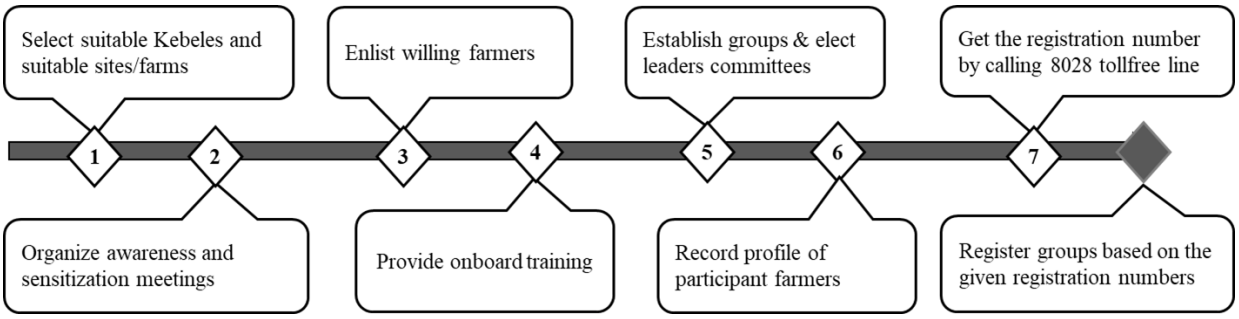

Figure 1:Clustr group establishment processes and steps
source (ATA, 2019)

2.2.Theoretical Literature

Location and concentration are basic elements in the modeling and theorization of geography-based economic development. Whilst location remains central, it must be accompanied by concentration to call it and take advantage of clusters. Modeling of location-based planning and economic development modeling according to FAO (2017) dated back to the era of Adam Smith and the publication of his acclaimed work - The Wealth of Nations and later shaped by von Thünen, Alfred Marshall, and most prominently by the Harvard University professor Michael Eugene Porter.

Talking of location, as quoted in Kellerman (1989) von Thünen mentioned for his primordial scrutinization of location through his model on agricultural location in "The Isolated State (1826)." His theory of Agricultural location has played role in modeling agricultural land use and spatial

arrangement of agricultural land location and allocation. According to von Thünen, farm location or distance of farm from market places aligned with costs of production, costs of transportation and earned yield would have a determinant effect on surplus or rent. His theory contains different agricultural land use rings. The ring nearest to the market must be most perishable agricultural product and it is with the highest returns. The profitability of subsequent rings decreases but believed to be simplified by transportation. Given the increment in market interdependence and simplification of agricultural product transportation, the relevancy of his model is diminished through time but still influencing economic decisions and land use (FAO, 2017).

Talking of concentration, Marshall as quoted in FAO (2017) is mentioned for his remarkable contribution for practices of clustering industries. He claimed, that bringing supporting industries in the same area eases interflow and passing of knowledge, and skills and gives the advantage to have concentrated specialized skills and trained labor. His modeling and theory are developed based on von Thünen's work.

Furthermore, Weber 1909, as quoted in FAO (2017) has expanded the theory of location of industries with a focus on transportation cost, labor distribution, and real estate. He has also examined driving factors of industrial accumulation additionally.

Deferent from others, Michael Porter's theory of clustering and his related works are praised for putting a clear foundation and shaping the practice of clustering. Porter clarified and explained the benefits of co-locating interrelated industries and other complementaries like suppliers, universities, research units, etc. in very specific geographic locations based on commonalities. According to him, the benefits will derive from and through vertical and horizontal linkages, arrangements, synergies, and involvements of value chains among others. He argued, that geographic agglomeration will provide better advantages like robust information, closer relationships, powerful incentives, access to specialized supplies, etc., and brings competition through (1) improving the productivity of companies; (2) steering direction and pace of innovation; and (3) facilitating commercialization and formation of new businesses within if innovation is availed (Porter, 1990; 1998). His theory has built upon and spun around the "competitiveness diamond model" and other driving forces of competitiveness.

Aside from Porter, Krugman (1990), Nadvi (1999) and Mytelka (2004) had played a huge role in explaining and expanding the theory of cluster-based economic development, modeling, and other advantages (Clark et al., 2015).

While understanding of the model expanded, the approach adopted to the agricultural sector to take advantage of proximity/location related and other accompanying benefits including access to and use of information, knowledge, spillover effect, access to specialized supplies, etc. (Brasier et al., 2007).

In many of its forms, the agriculture sector is dominated by smallholder farmers. Individually, the smallholder farmers lack the necessary knowledge, information, and collective power to improve their mode of production and harness different gains from their practice, and contribute to economies. As stated in Porter (1998; 2000) and Gálvez-Nogales (2010), collectively and when brought together, smallholder farmers are believed to have advantages related to accessing basic information, capital, knowledge, technical support, etc. and can easily establish horizontal and vertical linkage between themselves and other supplementals based on proximity, commonality, and complementarity. To this end, a location and concentration-based farming practice, an economic development model relatively long practiced in the industrial sector has been adopted in the agricultural sector by modeling and builds upon the works of Michael Porter.

2.3.Empirical Literature

In 2021, Chala Hailu and Fikiru Temesgen conducted a study to examine factors affecting smallholder farmers' participation decisions in cluster crop production in the Ejersa-Lafo, and Bako-Tibe districts of the Western Shewa zone. Their study revealed that being male or a household led by a male, having a lower economic dependency ratio, experience, awareness level, and frequency of contact with extension workers, having at least some level of education, and producing marketable surplus supply positively affected probability and decision of participation in cluster farming. Whereas, owning a large number of livestock negatively affected participation decisions. Furthermore, they learned marketing and related issues were at a minimal stage and yet needed strong effort (Hailu & Temesgen, 2021).

In the same year, 2021, a study was carried out in the southeastern region of the United States to assess the impact of the cluster farming initiative by Karki et al. (2021) following a project intervention the by United States Development Agency (USDA). Their study revealed that

clustering was found vital in enhanced operations of small and limited resource farmers and/or socially and historically disadvantaged farmers. After the formation of clusters, training, workshops, meetings, field days, farm loans, and materials/equipment i.e., mobile and stationary cold storage facilities were provided/conducted by the program. In shortest range, changes were recorded on conservation stewardship, post-harvest practices (i.e., 100% of participants have changed their harvesting and packaging containers), use of cold storage technology (i.e., 42% of participants started using some form of cold storage), and information access to the program. In the midterm, the capacity of producers was strengthened and production costs got lowered due to the adoption of improved technologies and cultivation/production practices.

Income-wise, evidence from Indonesia by Wardhana et al. (2020) on farmers' cooperation in agro-clusters showed that the initiative led to an improvement in farmers' income. They also understood being located in an agro-cluster increased farmers' likelihood to cooperate. Besides, they found being male, being economically better, and owning and operating large plots positively influenced the attitude of farmers to cooperate in cluster farming. On the contrary, food insecure households have a negative effect on cooperation.

Similiarly, Louhichi et al. (2019) conducted a study to analyze the impacts of the ACC initiative on the performance and livelihood of smallholder farmers in Ethiopia using the FSSIM-Dev (Farming System Simulator for Developing Countries) model. FSSIM-Dev is a "micro-simulation tool to evaluate policy impacts on food security and rural poverty alleviation in the specific context of low-income developing economies" (p. 21). Cognizant of the limitation in the model, (i.e., the model considered all farms in the four studied regions adopted ACC packages, output market prices were assumed exogenously given, etc.), their study revealed that policy-wise the initiative has helped to:

- Increase in production in main commodities, i.e., wheat, *teff*, maize, and barley were increased by 29.6%, 21.1%, 12.8%, and 12.6% respectively.
- Improve both gross and net farm incomes at different levels (around 14% on average)
- Increase in both food and non-food consumption due to the increase in production and income
- Positive impact on market participation decisions
- Reduction in extreme poverty i.e., 2.1% at the country level

All along with the above observations, Poli (2018) in his study of the Ethiopian way to agrarian transformation with a focus on agricultural clusters in South Wollo, learned that cluster formation (Ethiopian way) and its execution have some flaws. He for instance identified, cluster formation, purpose, and commodity selection processes conflicted with the national ATA/ACC strategy and frameworks i.e., farmers joined clusters through compelling or convincing, and in some cases with "threats and violence", the purpose of clustering and selection focused on "solving food poverty" and commodity selection carried out through "top-down", rarely called participation farmers (pp. 207-208). He also noted there was overdependence on one product in the name of "pursuing specialization" (instead of diversification) and "generating surplus", which according to him was in contradiction with science and farmers' cropping and coping strategy (pp. 212 - 213).

A study conducted in Bangladesh by Washim et al. (2015) to investigate stakeholders' involvement in marketing to determine the efficacy of cluster farming on good prices and better raw materials quality. They investigated a complicated marketing channel that involved up to eight parties starting from producers to processors or exporters. Their study revealed the approach simplified marketing channels, farmers started receiving better prices and the approach helped farmers to directly contact their buyers without the involvement of middlemen and to provide high quality with better prices. Formerly, farmers used to have less control over market prices and auction markets. This exposed farmers to pass through the prolonged market processes and quality decline. Yet, cluster farming simplified the lengthy market process, contributed to the reduction of post-harvest losses, and noticeably let the farmers trade more than 75% of their products directly from local depots.

An impact evaluation was also done by Rola-Rubzen et al. (2013) to identify the effects of clustering on vegetable farmers in the southern Philippines, a program by Catholic Relief Services (CRS), highlighted for the most part clustering was empowered beneficiaries to increase their products, helped individual farmers and households to receive a better price, to increase their net and overall income. The program used an iterative eight-step intervention model that starts with and passed through site selection to product supply, market chain study to scale up, and cluster strengthening. They did a comparative study between clustered and non-clustered and compared the before-after scenarios. Thus, they found clustered farmers received higher incomes on average than non-clustered i.e., their income increased by about 47% after clustering. Besides, they learned

spillover effects were considered at a 5% adoption rate, the net present value (NPV), internal rate of return (IRR), and benefit-cost ratio (BCR) increased to 106.9 million pesos, 81.5%, and 3.8, respectively.

In the same region, but earlier than Rola-Rubzen et al.(2013), Montiflor et al. (2009) assessed the socio-economic impact of cluster farming on smallholder farmers in Mindanao. In an interview done for 84 smallholder cluster participants farmers, they learned that the average income of participants had improved or in the least case scenario most of the respondents believed they were financially better off than before. Montiflor and his friend learned too, that farmers had also received other non-financial benefits like improved access to wet and institutional markets, market information, market and production linkages, technical and financial support, and production inputs. Since farmers were exposed to other areas, other markets, and key people (such as experts, institutional buyers, and government personnel), their understanding of market dynamics was improved as well.

2.4.Conceptual Framework of the Study

The formation of cluster farming groups in Ethiopia is done by consolidating neighboring plots. Farmers that share boundaries will form farming/production clusters if the area that their plot belongs to is selected as a suitable site by officials, experts or development agents. As noted in Poli (2018) the formation process is “top-down” in which it never determined or chosen by the farmers themselves.

Formation of cluster farming groups has seven general steps. Selection of suitable sites by *Woreda* officials, experts or development agents is the first task. Accordingly, experts or officials locate suitable areas based on the *Woreda’s* plan or intention without consultation or getting consent from the farmers. It is after that the owners of the land get informed that their area is selected for the cluster farming practice. That means, the owners of the land won’t have any saying in the process and the choices will not give to them to determine their participation. They have only two options, either to participate or give it to share cropping. In this case, different socioeconomic and demographic variables will not determine participation and thus will not be seen as a factor that affects crop productivity or determinant of adoption or participation in cluster farming. The assumption therefore is to see the role that selected demographic, socioeconomic, institutional

factors/variables could play in increasing crop productivity within the framework and participation of cluster farming.

Instead of increasing the area for production, the approach focuses on increasing land productivity through availing necessary inputs, services, and technologies. Hypothetically, clusters are formed to harmonize access to improved inputs, encourage usage of modern technology and inputs, avail financial resources, and provide necessary technical support through training, field-level follow-ups, and assistance. Taking into account these assumptions, the immediate result of participating in cluster farming is an increase in productivity

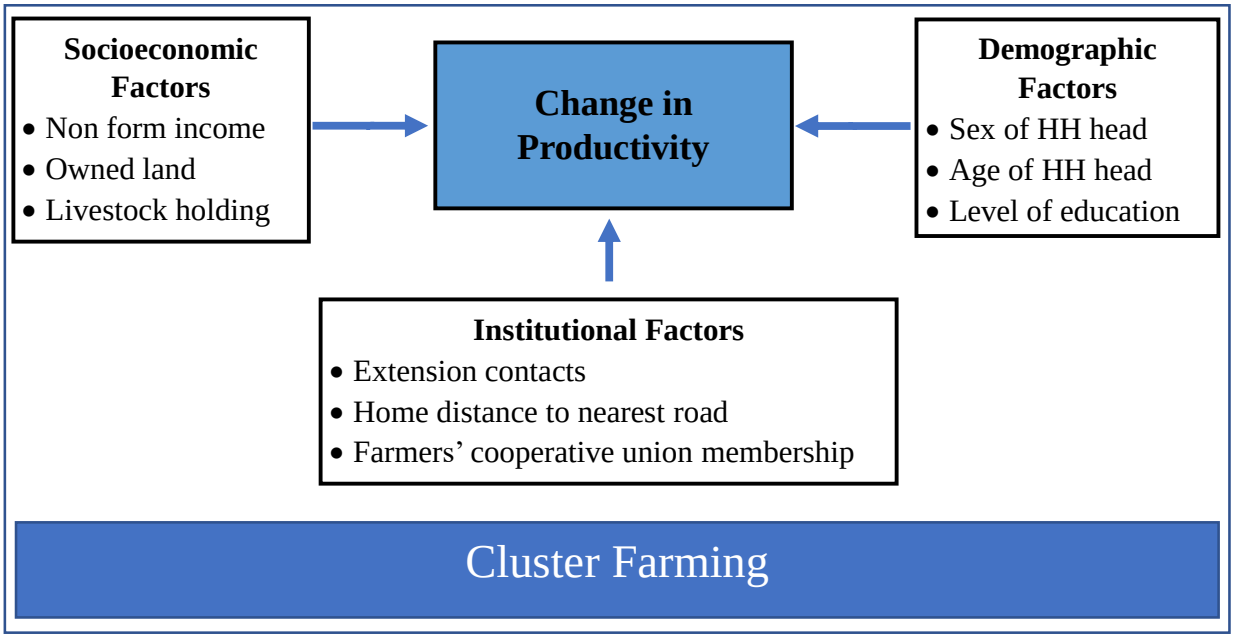

Figure 2:Conceptual framework of the study
(Own construction based on the literature review)

UNIT THREE: RESEARCH METHODOLOGY AND MATERIALS

3.1.Description Of the Study Area

3.1.1. The Study *Woreda*

Dejen *Woreda*/district is located in the East Gojjam Administrative Zone of Amhara National Regional State on the main road from Addis Ababa to Bahirdar. It is bordered to the west by Awabel *Woreda*, to the east by Shebelberenta, to the north by Enemay, to the northwest by Debaytilatgen *Woreda*, and to the south by Wore Jarso *Woreda* of the Oromia Regional state. Dejen town is the capital of the *Woreda* which is located about 234 km from Addis Ababa, 335 km from Bahirdar, the regional capital, and 70 km from Debre Markos, the zonal capital. Currently, the *Woreda* has 18 rural and 2 semi-municipal urban *Kebele*s. *Kebele* is the smallest administrative unit in Ethiopia.

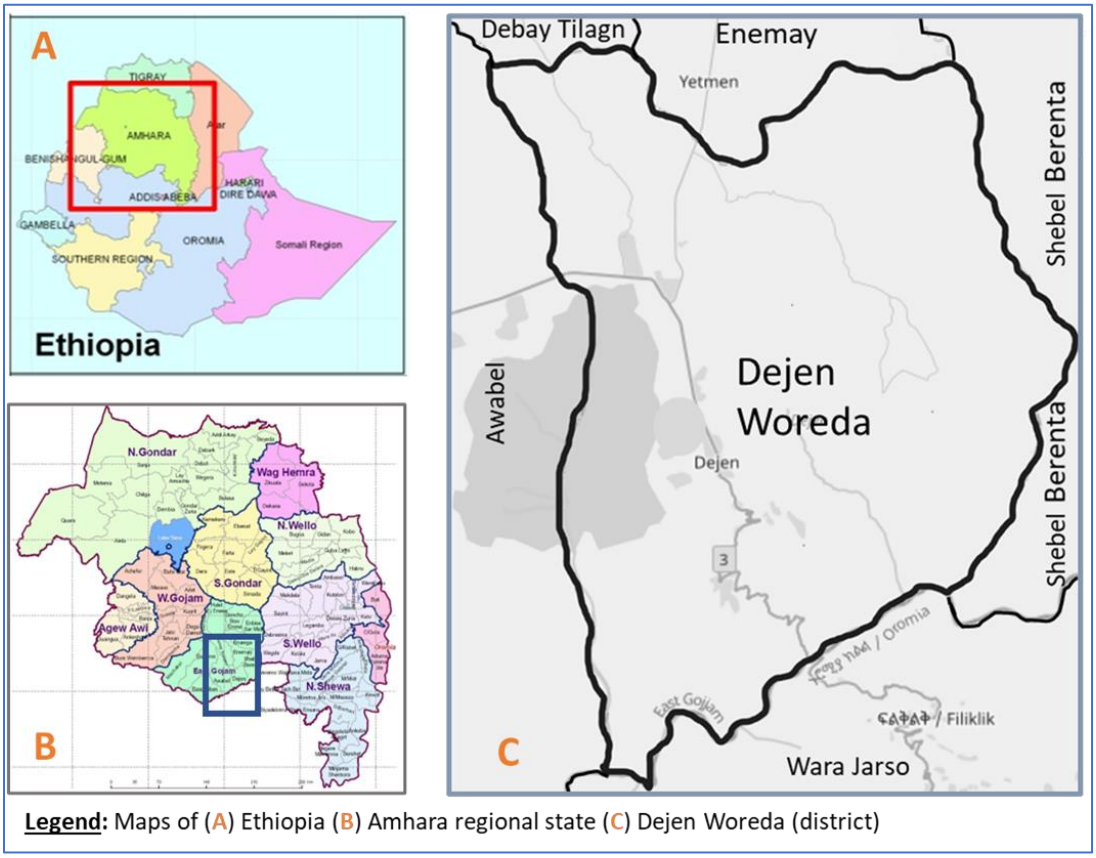

Figure 3:Map of the study area
Source A-Wikipedia (2021), B-EthioDemographyAndHealth.org (2021), and C-mindat.org (2022)

The *Woreda* has a latitude and longitude of 10°10′N and 38°8′E, covers a total land area of 63,398 hectare and is situated at an elevation ranging between 1000 and 3000 meters above sea level

(masl). The climate condition of the *Woreda* is divided into *Dega* (2%), *Weynadega* (75%), and *Kola* (23%). Out of the total 22 *Kebele*s, the 15 are located in *Weyina Dega*, with little *Dega* characteristics in one *Kebele*, and the rest 7 are found in *kola* areas in the Abay gorge (DWOA, 2022). The average annual rainfall and temperature were estimated at 900 mm and 16.6^{o}c respectively in 2017. The area has mainly one rain season stretching from June to September (Haregitu, 2019).

Most of the *Woreda*'s land area (more than half) is used for cultivation and the rest is used for settlement, forest, and the like. The coverages for each category are: cultivation (58.4%), settlement (19%), forest (7.76%), bush and shrubs (3.82%), and grazing (3.12%) (DWOA, 2022).

3.1.2. Population

According to the 2007 Ethiopian population census report by the Central Statistics Agency (CSA) (2007), the total population of the *Woreda* was 123, 373 (59,514 male and 63,859 female) with an estimated population density of 198.68. Out of which, urban inhabitants were estimated at 15,158. Similarly, the number of households was counted as 25,511 and the average family size was 4.01.

In 2021, according to pupation projection by ESS (2021), the *Woreda* population was projected to be about 130,301 by 2021, with 67,390 females and 62,911 males. According to the estimate by the *Woreda* 112,183 were residents of rural areas (DWOA, 2022). Using the family size of the 2007's census (4.01) the number of households at present is estimated to be nearly 32,494.

3.1.3. Agricultural Practice

According to Haregitu (2019), mixed farming agriculture is the main source of living in the *Woreda*. Cattle, sheep, goats, and poultry are kept by most farmers in line with growing crops. Major crops grown in the *Woreda* includes *teff*, sorghum, wheat, barley, maize, chickpea, and vetch (DWOA, 2022).

Cluster farming (farmers production cluster) is practiced in *Teff* and Sorghum commodity types. Out of the 22 *Kebele*s (smallest administrative unit in Ethiopia) the 18-practice cluster farming on the two mentioned commodities with and without supports from and based on ATA packages and recommendations. The rest 4 *Kebele*s are not practicing cluster farming due to their agroecology i.e., they are found in kola areas their topography is not suitable for the practice. According to the

recording of the *Woreda* total of 228 *teff* and 16 sorghum cluster groups are practicing the approach (DWOA, 2022).

3.2.Research Design and Methods

3.2.1. Research Design

This study was carried out on selected cluster farming participants (CFP) and non-participant (CFNP) farmers. The study utilized a cross-sectional study design through a concurrent mixed methods approach. Compared to qualitative, the study largely utilized quantitative data.

3.2.2. Sampling Procedures

A multi-stage sampling technique was employed. In the first place, Dejen *Woreda* was purposively selected for its potential of growing *teff* and its involvement in *teff* cluster farming.

Following, four *Kebele*s were selected randomly using a lottery method out of the eighteen-cluster farming practicing *Kebele*s. Then, the sample households were proportionally distributed to selected *Kebele*s per the number of households in the *Kebele*s and selected using a systematic sampling method by selecting every k^{th} from the *Kebele*s logbook (a record) of the participant and non-participant farmers. The sample size was determined using Cochran's (1977) formula given as follows:

$$n_o = \frac{z^2\, pq}{e^2}$$

Where: n_o = the desired sample size**,** Z = 95% confidence limit i.e., 1.96**,** P = 0.5 (proportion of the population to be included in the sample i.e., 50%) q = 1-p i.e. (0.5) and e = margin of error or desired degree of accuracy (0.05). Using the formula, $n_o = \frac{(1.96)^2\,(0.5)(0.5)}{(0.05)^2}$ the samples size at 95 % confidence level and ± 5% precision the sample size of this study equals 384.16 ≈ 384

Table 1:Categories of respondents, sample size and sampling technique

No	Types of Population	Size	Techniques
1.	Households	*384*	*Systematic*
2.	Developmental agents	*4*	*Purposive*
3.	*Woreda* agriculture office (leader, team leader & expert)	*3*	*Purposive*
4.	Community representatives (elder, women, religious)	*3*	*Purposive*
5.	Cluster group leaders/committee members & members	*15*	*Purposive*

Table 2:Distribution of sampled respondents by Kebeles

No.	Name of sampled *Kebele*s	Number of households	Number of sampled households
1	Enajima	*705*	*63*
2	Hagereselam	*1362*	*122*
3	Yetnora	*1073*	*96*
4	Workamba	*1152*	*103*
	Total	***4292***	***384***

3.2.3. Data Collection Tools and Procedures

The study used both primary and secondary data sources. For the first case, qualitative and quantitative data were collected from sampled participant and non-participant farmers, community representatives, development agents, *Woreda* agricultural office head, team leader, and experts through and using key informant interview (KII), focused group discussion (FGD) and questionnaire. In the second case, secondary data including most produced crops in the *Woreda*, number of farming cluster groups, types of priority commodities for clustering, agroecology data of the *Woreda*, and other sociodemographic and socioeconomic data were collected

3.2.4. Method of Data Analysis

The study employed both qualitative and quantitative analysis methods. Qualitatively, data generated from FGD, KII, and observation were described and summarized per each theme after transcribed, coded and categorized.

Quantitatively, both descriptive statistics and econometric method – (propensity scoring matching (PSM)) were used to analyze the data. Descriptive statistics like ratio, mean, range, standard deviations, and variance were used to describe the characteristics of the respondents. Besides, descriptive statistical tests like t-test and/or chi-square were used to weigh the relationship between the dependent variable and independent variables.

3.2.4.1. Propensity Scoring Matching (PSM)

Measuring the impact of cluster farming on *teff* productivity by making comparison between participants (CFP) and non-participants (CFNP) of the approach was one of the objectives of this study. In its nature, PSM is a suitable econometrics technique to concoct an artificial control group by matching each treated unit (CFP) with the non-treated unit (CFNP) in the absence of randomization. The probability of a given farm household falling into a treatment or control

category depends, among other factors, on the participation of the initiative and score of other explanatory variables. Hence, PSM was found to be ideal for its suitability in simulating randomization, building artificial control group and for avoiding omission/selection bias.

3.2.4.2.Specification Of the Model

The main purpose of PSM, according to Li (2013), is to substitute many confounding covariates in an observational study with one function of these covariates or with a single propensity score/index. Bearing in mind the objective of the study, the establishment of the counterfactual non-treated group (cluster farming non-participants) based on observed characteristics similar to the treated group (cluster farming participants) is needed. Each participant (treated group) would be matched based on observed similar characteristics of the non-participant (control group) and the average difference in the outcome of interest (crop productivity) between the two groups could be compared to get the effect of cluster farming using the following equation.

$$E [Y_1 - Y_0|C = 1] = E [Y_1|C = 1] – E [Y_0|C = 1] \quad \ldots\ldots (1)$$

The equation assumes the value 1 for participants, or the treatment group, and 0 for non-participants, or the control group, and an outcome variable indicated by Y. Thus, the outcome of interest is the average difference in Y_1 and Y_0.

For the case of this study, groups were matched based on observational data. Thus, as noted in Arpino & Mealli (2011), the causal effect would be defined using the Average Treatment Effect on the Treated (ATT) i.e.,

$$E [Y_1 - Y_0|Z, C = 1] = E [Y_1|Z, C = 1] – E [Y_0|Z, C = 1] \quad \ldots\ldots (2)$$

Z is a set of covariates that is influencing cluster farming participation. If the probability of participating is determined by Z, then it is possible to form a control group, or non-participant in the same way as participants to estimate the Average Treatment on the Treated (ATT)

$$ATT= E [Y_1 - Y_0|P(Z), C = 1] = E [Y_1| P(Z), C = 1] – E [Y_0| P(Z), C = 0] \quad \ldots\ldots (3)$$

P(Z) is the probability of being cluster farming participant conditional on the observable characteristics of Z or it is the propensity score (Pscore) given the observable characteristics.

Which is: $P(Z) = P (C_i = 1|Z)$

3.2.4.3.Hypothesis and Variables Definition

Dependent and outcome Variable

Crop productivity was an outcome of interest for this study. It must be preceded by participation to bring the intended impact, and thus participation is a dichotomous dependent variable recorded in 1 and 0; where '1' stands for cluster farming participant households (CFPs), while '0' stands for cluster farming non-participant households (CFNP). Crop (*teff*) productivity was an outcome variable. It is a continuous and measured in terms of total yield in kilogram per hectare (kg/ha) and calculated as $Teff\ productivity = \frac{Teff\ output(\boldsymbol{kg})}{Area\ planted\ (\boldsymbol{ha})}$

Explanatory Variables

The study hypothesized participation in cluster farming and other determinants of farmers' participation that can be explained by socio-economic factors, availability, access to modern and improved inputs, etc.

- **Sex of the household head**: It is a dummy variable taking 1 for males and 0 for females. As indicated in most studies, male-headed households are more productive the counterpart. Compared to female-headed households, male-headed households are better advantages that could contribute to crop productivity. The advantages are sometimes emanated from and due to cultural (norm and tradition), social and economic factors (Asres Elias et al., 2013).
- **Age of the household head**: Age is a continuous variable. When it comes to crop productivity and actively participating and applying the package and recommendation of CF, as noted in Asres et al. (2013), has two faces. In the first instance farmers of younger ages may be recipients of such recommendations (change) and people in old age may resist such recommendations (change) and applying the recommendations. In the second instance, through age, the farming experience tends to be refined and on the contrary, those younger may lack such experience.
- **Level of education:** It is a categorical variable taking 1 for illiterate, 2 for nonformal education and 3 for enrolling into formal education. The education level of literacy of the head of the household is believed to have a positive relationship with the uptake of cluster farming packages. According to Asres et al. (2013), the level of education influences

productivity which it enhances the absorption of information and the adoption of technologies.

- **Owned land size:** It is a continuous variable expressed in hectarage. Land size owned by the family increases the assets endowment and has an influential role in crop productivity (Krupnik et al., 2021). Asset endowment or wealth including land helps farmers to supplement credit-related gaps and provide finance for investment in inputs (Zerfu & Larson, 2010). Besides, it may play role to dedicate more plot to *teff* and their chance of participating in different CF groups
- **Home to the nearest road distance:** it is a continuous variable measured in minutes. Generally speaking, the availability of rural roads is believed to simplify access to modern inputs and technologies (Gebresilasse, 2018). According to Krupnik et al. (2021), home-to-road distance summed up with other factors has a role in crop productivity
- **Extension contacts**: It is a categorical variable taking 1 for yes, which means all the time, 2 for sometimes and 3 for never. It is expected that extension service widens households' chance to enhance their knowledge and practice regarding the use of improved and modern inputs and through increasing on-field and off-field technical support (Kamara, 2004).
- **Membership in farmers' cooperative unions:** It is a dummy variable taking 1 for yes and 0 for no. Membership in farmers' organizations like cooperative unions has a positive effect on enhancing the well-being of participant smallholder farmers. Well-being in this case means they are relatively better off in different conditions so that they may not face financial constraints (Ahmed & Mesfin, 2017).
- **Non-farm income:** It is a dummy variable taking 1 for having a non-farm income and 0 for not having a non-farm income. Studies revealed that having non-farm income has a significant positive role in enhancing agricultural productivity by providing additional financial resources to invest in inputs (Rashidin et al., 2020).
- **Owned livestock:** It is a continuous variable measured in the number using the tropical livestock unit (TLU) conversion factor. TLU serves as a unit of measurement of livestock holdings by converting them into common units using the conversion factor (Storck et al., 1991). Thus, the TLU equivalent conversion factors are 0.20 for Calf, 0.75 for Heifer and Bull, 1 for Cows & Oxen, 1.10 for Horse/Mule, 0.70 for Donkey, 0.13 for Sheep & Goat, and 0.013 for Chicken/poultry. According to Asres et al. (2013), the highest TLU means

better wealth and it helps by solving credit-related issues. Thus, TLU can play role in productivity by providing financial resources.

Table 3:Summary of variables

Variables	Notation	Category	Measurement	Sign
Outcome and Dependent				
Crop (*teff*) *productivity*	*Teff*_Productivity	Continuous	Kg per hectare (ha)	
CF participation	CF_Participation	Dummy	1=Participant 0=Non participant	
Crop (*teff*) *productivity*	*Teff*_Productivity	Continuous	Kg per hectare (ha)	
Explanatory/ Independent/				
Sex of the HH head	HH_Sex	Dummy	1=Male 0=Female	+
Age of the HH head	Age	Continuous	Years	±
Farming year of experience	FarmingExp_yrs	Continuous	Years	±
Family size	Fam_Size	Continuous	Number	±
Educational status of the HH head	EDUC_status	Categorical	1=Illiterate 2=Nonformal 3= Formal	+
Owned land size	Land_Size	Continuous	Hectares	+
Home to nearest road distance	HtoR_Dist	Continuous	Minutes	-
Extension contacts	Ext_cont	Dummy	1=Yes 0=No	±
Membership in farmers' cooperative union	FCU_mship	Dummy	1=Yes 0=No	+
Nonfarm income	NonF_Inc	Dummy	1=Yes 0=No	+
Livestock holding	TLU	Continuous	TLU	+

3.3.Ethical Consideration

A support letter was written by the Center for Rural Development, College of Development Studies before deploying fieldwork. At the field, permission and consent were granted by the *Woreda* Office of Agriculture and by each respondent. Orientations and explanations were provided for respondents and the office of the agriculture on the purpose of the study and that their responses would be kept confidential.

CHAPTER FOUR: RESULTS AND DISCUSSION

This chapter presents major findings of the research based on descriptive and inferential analysis of primary data which was collected using a cross-sectional design from sampled cluster farming participants and nonparticipant households. Descriptive statistics were employed to analyze and describe the general demographic, socioeconomic and institutional factors that affect cluster farming's impact on crop productivity. The econometrics method was concurrently utilized to understand the impact of the cluster farming approach and other determining factors on *teff* productivity.

Results presentation and analysis were done based on 369 observations out of the total sampled 384 respondents. Data were collected from all sampled households at field. However, 15 questionnaires were dropped in the stage of data cleaning due to errors related to filling the questionnaire and unfilled questions.

4.1. Characteristics Of the Respondents

4.1.1. Sociodemographic Characteristics

Among the contacted 369 households, the majority as depicted in Table 4 were headed by males, 324 (88%), and the rest 41 (11.2%) were headed by females. In a same manner, the 93.3% and the 6.7% among the CFPs, and the 84.1% and the 15.7% among the CFNP were headed by males and females in respectively. The Pearson chi^2 test show that there was a significant difference between CFPs and CFNPS in terms of sex of the household head at ($p=0.005$, $x^2=7.843$). The marital status of respondents similarly corroborated among the whole 369 households the 300 (81.3%) of them were married, the 34 (9.2%) were single, the (22) 6.0 % were divorced, and the 13 (3.5%) were widowed. The x^2 value 7.807, at $p=0.05$ show that there was significant difference between the two groups in the case of marital status

The Educational status of respondents also revealed that, out of the total interviewed 113 (30.6%) were illiterate, the 128 (34.7%) were with some sort of literacy obtained from nonformal education and the 128 (34,7%) of them were with some forms of formal education in which among them the 87% with were primary, the 12% were with secondary and the other 2% were the tertiary level of educations. Similarly, the chi^2 result ($p=0.45$, $x^2 = 1.566$) shows that there was no significant difference between CFP and CFNP in relation to educational status.

Table 4:Sex, marital status and educational status of respondents per cluster farming participation

Characteristics of respondents	All sample (N=369)		CFP (N=193)		CFNP (N=176)			
	N	*%*	*N*	*%*	*N*	*%*	*P-value*	x^2- value
Sex								
Male	*328*	*88.9*	*180*	*93.3*	*148*	*84.1*	*0.005*	*7.843***
Female	*41*	*11.1*	*13*	*6.7*	*28*	*15.9*		
Marital status								
Single	*34*	*9.2*	*24*	*12.4*	*10*	*5.7*		
Married	*300*	*81.3*	*156*	*80.8*	*144*	*81.8*	*0.05*	*7.807***
Divorced	*22*	*6*	*8*	*4.1*	*14*	*8*		
Widowed	*13*	*3.5*	*5*	*2.6*	*8*	*4.5*		
Educational status								
Illiterate	*113*	*30.6*	*59*	*30.6*	*54*	*30.7*		
Nonformal	*128*	*34.7*	*62*	*32.1*	*66*	*37.5*	*0.45*	*1.566*
Formal	*128*	*34.7*	*72*	*37.3*	*56*	*31.8*		

**represents p< 0.05 (Source: Owen survey result, 2022)

The family size of respondents as presented in Table 5, was 4.95 on average with a standard deviation of 1.81. The CFPs were having a mean family size of 5.02 compared to CNFPs which was 4.86. All samples were having an average of 4.95 with a 1.81 stand deviation. When it comes to age, all samples were having an average age of 50.7 with a standard deviation of 11.6. Per level of participation, CFPs were having an average age of 49.7 and the CFNPs were having 51.8. The independent t-test result of age (1.697) and family size (0.832) per CF participation level show that there was no significant different between the two groups.

Table 5:Age and family size of respondents per cluster farming participation

Item	All sample (N=369)		CFP (N=193)		CFNP (N=176)		
	Mean	*Std. Dev.*	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*	*t* – value
Age	*50.7*	*11.6*	*49.72*	*11.51*	*51.79*	*11.63*	*1.697*
Family size	*4.95*	*1.81*	*5.02*	*1.788*	*4.86*	*1.837*	*0.832*

(Source: Owen survey result, 2022)

4.1.2. Socioeconomic Characteristics

The socioeconomic characteristics of respondents outlined that the average farming experience in years for all samples was 28.68 years with a standard deviation of 12.094 and a range between 2 and 63 years of experience. The independent t-test between CFP and CFNP show the two groups were not significantly different (i.e., t=1.523). Regarding to land holding, the average size in hectares (ha) was 1.39. On average 1.146 ha of land was allocated for the production of *teff*, which is the most produced and main staple crop in the study area (DWOA, 2022). The independent sample t-test of both land holding and land allocated for *teff* shows that there has not been a significant difference between the two groups (CFP and CNFP) regarding the two variables at significant level (α) 0.004 for land holding and 0.047 for land allocated for *teff*. Having such land size and *teff* plot, all samples were producing an average of 1543.94 kilograms (kg) while the participant (CFP) farmers produced an average of 1628.75 kg and the nonparticipants (CFNP) were 1450.93 kilograms (kg/ha) of *teff*, and the standard deviation for both were 543.5. In terms of *teff* production the two samples independent test result show that the CFP and CFNP were significantly different from each other at t=3.177.

Table 6:Socioecomic characteristics of respondents

Item	All sample (N=369)		CFP (N=193)		CFNP (N=176)		
	Mean	*Std. Dev.*	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*	*t – value*
Year of experience	*28.68*	*12.094*	*27.763*	*12.036*	*29.697*	*12.112*	*1.523*
Land size (ha)	*1.39*	*0.744*	*1.440*	*0.813*	*1.343*	*0.658*	*1.271*
Land allocated for *teff* (ha)	*1.146*	*0.523*	*1.180*	*0.558*	*1.108*	*0.481*	*1.324*
Teff Production per hectare in kg	*1543.94*	*543.53*	*1628.75*	*542.31*	*1450.93*	*530.97*	*3.177***

**represents p< 0.05 (Source: Owen survey result, 2022)

Income-wise, most of the earnings of the respondents came from farm-related activities which were on average 38,191.83 Birr per year for all samples. However, some respondents were having nonfarm income with an average of 4011.491 Birr a year in the Ethiopian calendar (Eth cal.) 2013. The independent sample two test shows the two groups were not statically different at t=1.523.

Regarding livestock holdings (TLU), using the conversion factors for Tropical livestock unit (TLU) by Storck et al. (1991), a total of an average of 4.41 TLU was measured for all respondents

while 4.58 units for participants and 4.23 units for non-participants respectively. The t-value of TLU for CFP and CFNP show that the two groups were not statically different amongst themselves.

Table 7:Farm and nonfarm incomes, No. of oxen and TLU

Item	All sample (N=369)		CFP (N=193)		CFNP (N=176)		
	Mean	*Std. Dev.*	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*	*t – value*
Farm income (Birr)	*38,191.8*	*33,719.2*	*39,770.2*	*34,857.1*	*36,461.0*	*32,436.2*	*0.941*
Non-farm income (Birr)	*4,011.5*	*11,430.2*	*3,740.7*	*10,561.5*	*4,308.4*	*12,336.4*	*-0.476*
Livestock (TLU)	*4.414*	*2.104*	*4.573*	*2.157*	*4.240*	*2.037*	*1.520*

(Source: Owen survey result, 2022)

4.1.3. Institutional Factors

To understand the institutional factors that could affect crop productivity, respondents were asked if they had access to credit services, weather information, market information, extension service and if they were members of farmers' cooperative unions. As presented in Table 8, out of all samples, 211 (57.2%) responded yes to access to credit and the other 158 (42.8%) replied otherwise. Similarly, most of the respondents (52.8%) replied they never had access to weather information while the 42.2% and the 5.3 % said sometimes, and yes in a respective order. Related to getting market information, 18.13% of respondents said yes, we get it all the time, 35.9% said sometimes, and 45.88% respond never. Similarly, respondents who replied to a question regarding getting advisory services and other support from extension workers answered that most of them, 160 (43.3%) confirmed yes, the 47 (39.8%) respondents confirmed sometimes, and the rest 62 (16.8%) answered no. The number of average contacts with extension workers was 3.36 times per month. Related to being membership in farmers' cooperative unions most respondents (94.48%) said they were and 5.52% replied no.

The chi^2 results in the same table show 8.162 for getting market information, 12.164 for access to weather information, 9.367 for access to extension services, and 3.976 membership in farmers' cooperative. The results show that getting market information, access to weather information and access to extension services were significantly associated to CF participation at p-values 0.013, 0.002, 0.009 and 0.046 respectively. When it comes to access to credit services the chi^2 result 0.955 at p=0.328 show that access to credit was not significantly associated with CF participation.

Table 8:Access to credit, market information, weather information, extension service and membership to farmers' coopertive union

Variables	All sample (N=369)		CFP (N=193)		CFNP (N=176)			
	N	*%*	*N*	*%*	*N*	*%*	*p-value*	*x^2- value*
Getting market Information								
Yes	*66*	*18.1*	*44*	*23.2*	*22*	*126*	*0.013*	*8.612***
Sometimes	*131*	*36*	*70*	*36.8*	*61*	*35.1*		
No	*167*	*45.9*	*76*	*40*	*91*	*52.3*		
Access to weather Information								
Yes	*19*	*5.3*	*13*	*7*	*6*	*3.5*	*0.002*	*12.164***
Sometimes	*151*	*42.2*	*92*	*49.2*	*59*	*34.5*		
No	*188*	*52.5*	*82*	*43.9*	*59*	*34.5*		
Getting extension Services								
Yes	*160*	*43.4*	*98*	*50.8*	*62*	*35.2*	*0.009*	*9.367****
Sometimes	*147*	*39.8*	*65*	*33.7*	*82*	*46.6*		
No	*62*	*16.8*	*30*	*15.5*	*32*	*18.2*		
Membership in farmers' cooperative union								
Yes	*342*	*94.5*	*181*	*96.8*	*161*	*92*	*0.046*	*3.976***
No	*20*	*5.5*	*6*	*3.2*	*14*	*8*		
Access to credit								
Yes	*211*	*57.2*	*115*	*59.6*	*96*	*54.5*	*0.328*	*0.955*
No	*158*	*42.8*	*78*	*40.4*	*80*	*45.5*		

***, ** represent p<0.01 and 0.05, respectively (Source: Owen survey result, 2022)

As presented in Table 9, respondents confirmed that they have access to the input market with an average 24-minute walk on foot or 6.155 minutes by car with a statistically non-significant difference between the two groups at t -value accounts 0.293 and 0.592, and also to output markets with an average 35.5-minute walk on foot or 14.26 minute by car with the same non-significant difference between the CFP and CFNP at t-test results of 0.493 and 0.1081 respectively. On top of

these, the figures related to the distance of the home to the nearest road show that participants could get a road with an average 14.12-minute walk from home. In this regard, the independent statistics t-test (1.313) shows that the two groups were significantly not different from each other.

Table 9:Distance to nearest road, input and output markets

Variables	All sample N=369		CFP (N=193)		CFNP (N=176)		
	Mean	*Std. Dev*	*Mean*	*Std. Dev*	*Mean*	*Std. Dev*	*t – value*
Input market-home distance in minutes on foot	*24.00*	*15.810*	*23.65*	*15.894*	*24.38*	*15.84*	*0.293*
Input market-home distance in minutes by car	*6.155*	*6.2911*	*6.426*	*5.0914*	*5.842*	*7.4674*	*0.592*
Output market-home distance in minutes on foot	*35.50*	*24.94*	*36.11*	*25.89*	*34.83*	*23.90*	*0.493*
Output market-home distance in minutes by car	14.26	9.18	*14.33*	*8.93*	*14.18*	*8.53*	*0.108*
Home distance from the nearest road	*14.12*	*14.418*	*13.18*	*13.5*	*15.15*	*15.32*	*1.314*
No. of average extension contacts per month	*3.36*	*3.343*	*3.44*	*3.516*	*3.06*	*3.138*	*0.979*

(Source: Owen survey result, 2022)

4.2. Cluster Establishment, Purpose and Organization in the Study Area

Out of the total sampled 369 households, the 193 (180 males and 13 females) of them were a participant in cluster farming and the rest 176 were non-participants. Among all sampled households, the 193 cluster farming participants were asked about how cluster farming groups were formed and how they were joined, whether they have been consulted or requested for their consent to join, whether they received training if explanations were given, etc. Besides, information on the purpose and formation/organization processes and purpose were collected from focus group discussions and key informant interviews.

4.2.1. Formation Process

According to a project implementation guideline prepared by ATA (2019), the formation process has 7 general steps. They include: selecting suitable *Kebele*s and farms, organizing sensitization

and awareness meetings, enlisting and registering willing farmers, giving training, forming groups and electing leaders/committees, recording farmers' profiles, and getting identification numbers and registering the group. The same document pointed out that farmers who could join cluster farming groups should at least have 0.25 hectares of land and must be willing to join and must trained. In a least case scenario farmers should be given an onboard training. The document also indicated following the selection of suitable *Kebele*s and participant farms, farmers will take part in orientation and discussion programs and it is after that those who are willing to join get registered.

ATA portrayed farmers should be selected based on their willingness and must be ready to work with neighboring farmers, to implement the full package of the program (seed, fertilizer, technology, and other inputs recommendations), to share their experience, knowledge, and story for others, and should be willing to allow their plot selected for farmers field days and demonstrations (ibid).

According to the KII held with the head of the *Woreda* agricultural office and team leader, the first thing in cluster formation is site selection. Suitable sites are first selected by *Woreda* and *Kebele* officials, experts, and development agents (DAs). Following, the owners of the land informed that their land has selected. Since, cluster farming or "y*kuta getem erisha*" as its Amharic name implies needs adjacency or sharing borders between plots, hence, any farmer whose land falls into the selected area has no right to reject or oppose participation, otherwise should gave it out for sharecropping. In consistency with the findings of Poli (2018), farmers who own land in the selected area would participate in cluster groups with or without their willingness and the decisions are only come from the top. For example, the team leader in the KII said *"we only inform them that they have been selected for this project, and explain to them this would bring this and that benefits, we rather never requested for their consent."* Following, farmers form groups by consolidating their plots and the registration continued, given explanation about CF (not in all cases), and select their leadership committees. The other indicator of manifestation of top-down in the approaches was how decision were done. The FGD participants indicated that most decisions, even if they have selected leaders were done by the DAs. This revealed that the group leaders either have not empowered as envisioned in ATA (2019) guideline or deliberately trespassed by

the DAs. According to the document, group leaders are supreme decision makers when it comes to harvest time, input usage, facilitating credit service, facilitating mechanization

To this end, CFP respondents were first asked “Have you joined CF groups based on your willingness?” Out of the total 193 CFPs, 158 or 81.8 % asserted they have joined groups based on their willingness and the rest 35 or 18.1% confirmed they joined CF groups against their will.

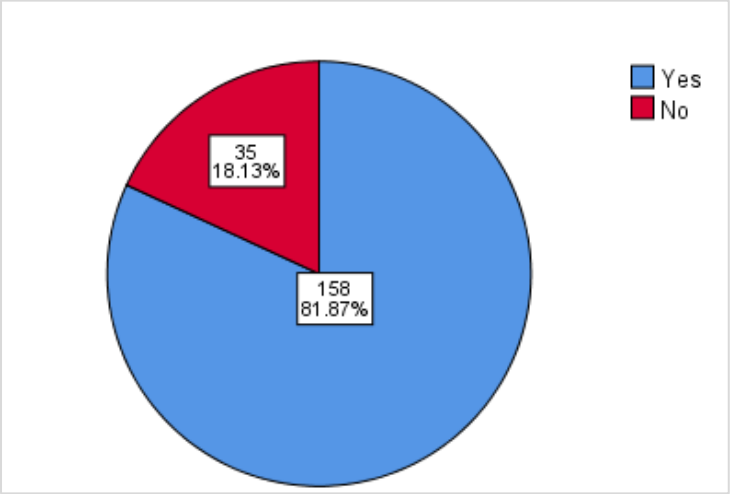

Figure 4:Willingness of joining CF

To further substantiate, the same group of respondents were also asked if they were getting any explanation about the benefit, relevance, importance, etc. of CF. Most of the respondents or 90 (48.7%) replied yes, we were given an explanation and the rest 70 (36.3%) and 29 (15%) said they have given an explanation to some extent and had not given explanation respectively. Even though the answer of most respondents gone to yes, nearly half or more still had doubts about the case. Referring to the focus group discussions and KIIs results, it is reasonable to say that the explanations were neither adequately given nor appropriately addressed key questions Why they should join? What is its purpose? What are the pros and cons and What are the prospects? To this effect, it was observed in KII and FGD discussion when participant farmers mixed the approach with other packages, referred to it as an improved seed multiplication program, and or mixed its purpose with improved seed multiplication programs.

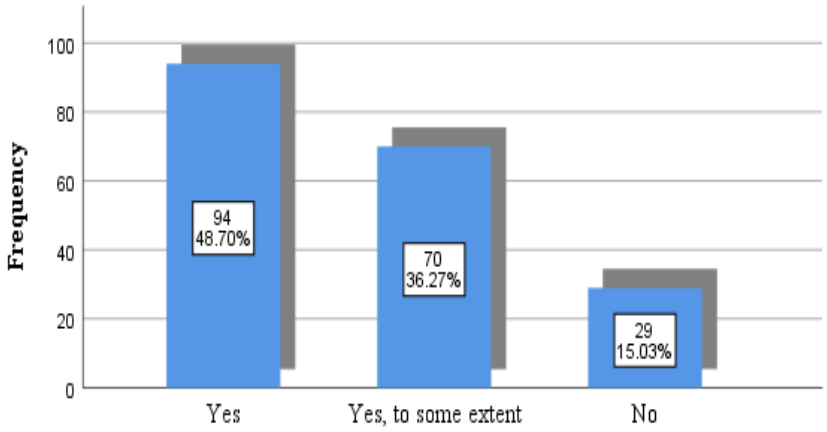

Figure 5:Getting explanation

Similarly, CFPs were asked whether they have been in training before in connection with cluster farming and its practice. As shown in the below figure, 50.5% answered they were not trained and the rest 49.5% said they were provided with the training.

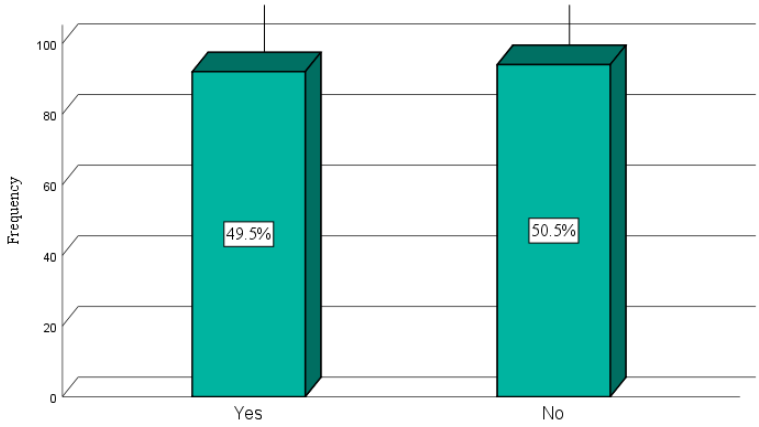

Figure 6:CF training participation

The above statements specified that the practice in its most aspects were in contradiction with ATA's frameworks when it comes to providing enough awareness, providing training, how decisions made and empowering the group leaders.

4.2.2. Understanding the Purpose

The purpose of forming clusters according to ATA (2019) is to make smallholder farmers surplus producers by grouping them into clusters and by changing the old and less productive system with technical and technological follow-up and support. Understanding the purpose of practicing cluster farming is in one or another way related to getting enough awareness. About understanding the

purpose, it was noted that there was a clear trade-off between cluster farming and seed multiplication referring to the approach. For instance, some respondents when asked about how they understood CF and what it is meant for them replied that "*it is all about seed multiplication*," while others also replied, "*it means sowing improved seed together; it means seed multiplication*." It is true cluster farming is suitable for seed multiplication but that was not the core reason of the approach. According to ATA (n.d.), the initiative was designed to modernize the smallholder farming subsector and leap forward from the traditional, less productive, and subsistence farming to a new and systematic way of production through stimulating commercialization and connecting the sub sector with agro-industries and global agri-food value chains.

The other indicator of this might arise due to the little or no explanations were a misconception of its nature and purpose. Some FGD and KII respondents for instance replied they have mixed fears that "if they could be forced to farm collectively or if this may be a restoration of collectivization" like in the pre-1991. During the pre-1991, farmers specifically in *Yetnora* area were used to farming collectively in a communal manner, in which they used to farm together, collect together and divide the yield equally despite the size of their plot and level of their involvements.

4.2.3. Organization of Clusters

According to ATA (2019), a cluster farm is organized in a manner with at least a minimum of 15 and up to 30 ha of land and with a member of farmers between 30 to 60 or more in some cases and would have 4 group leaders or committees selected by the members. The committees would have the role of chairperson, vice-chairperson, secretary, and control. The overall responsibility of the leader's committee includes coordinating activities related to farm preparation, seed selection and sowing time, pre-and post-harvest management, arranging mechanization, organizing meetings, and facilitating input and output market linkage. That means most of the decisions are taken by the committee. However as indicated in section 4.2.1 of this document most of the decisions were passed by the development agents. With this thinking and other assumptions, the CFPs were asked to rate the leadership capacity with a five-point Likert scale ranging from very low to very higher. Accordingly, 94 (48.96%) replied moderate, 63 (32.81) replied low, 26 (13.54%) replied high and the other 2 participants (1.04%) said very high. The mean score of the respondents was 3.244 which tells us the leadership capacity of the committees was moderate in reference with Sözen & Guven's (2019) note. The second response "low" has also implication on gaps and not deniable.

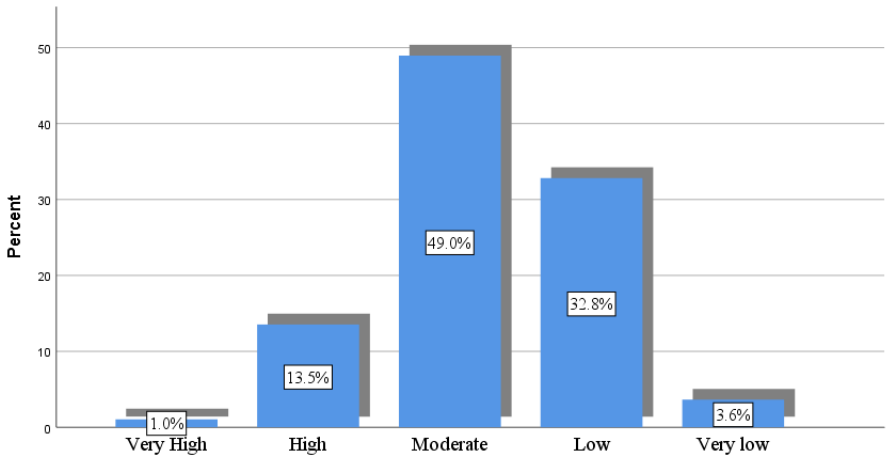

Figure 7:Leadership capacity of CF leaders committee

4.3.Perception Of Farmers on Cluster Farming

To understand their perception, all samples were asked about their views on working in CF or alone like the conventional. In addition, the CFPs were asked about their level of satisfaction and to compare the approach with the conventional farming system.

4.3.1. Willingness to Continue Working in CF, to Quit or Joining CF

To this effect, out of the 193 CFPs, 160 (82.9%) replied "yes" we want to continue and the rest 33 (17.1%) said they don't. Similarly, out of the 176 NCFPs, 122 (72.2%) "yes" we had a wish to work in CF and the rest 47 (27.8%) said no. The results show the approach has been accepted positively

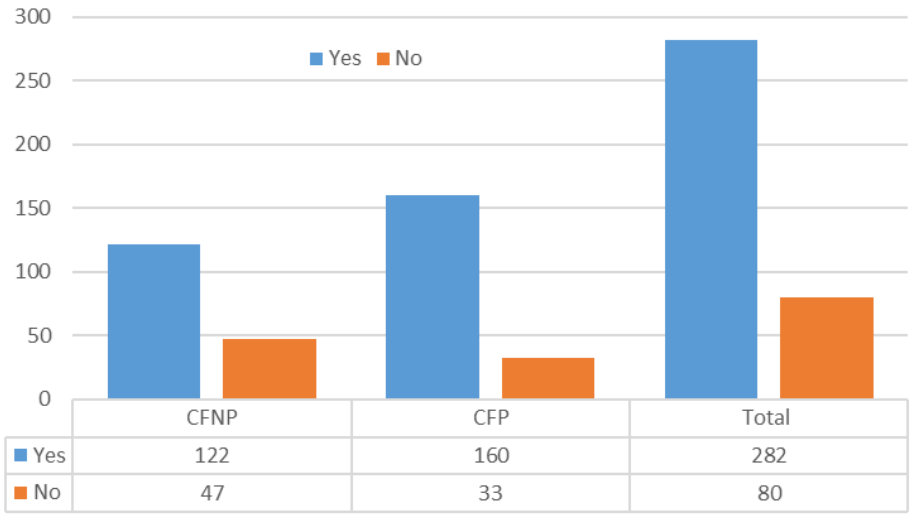

Figure 8:Willingness to continue in CF or join CF based on their participation

4.3.2. Cluster Farming or Conventional Farming

In a similar manner all samples were asked to compare and choose between the two approaches. Accordingly, among the CFPs, the 157 (82.2%) said working in cluster was better and the rest 17.8% said working alone would be better. Highest of the CNFP group, or 99 (77.3%), similarly choose the cluster farming approach and the rest 22.6 % choose the conventional farming. Similar to the survey participants, the FGD participants were asked which approach was best? CF or conventional farming and what are the pros and cons, most of them assured the CF was good in many ways and said it could be better if expanded despite some doubts about the success of the approach due to fragmented nature of their land, lack of resources and related to maintaining group cohesion.

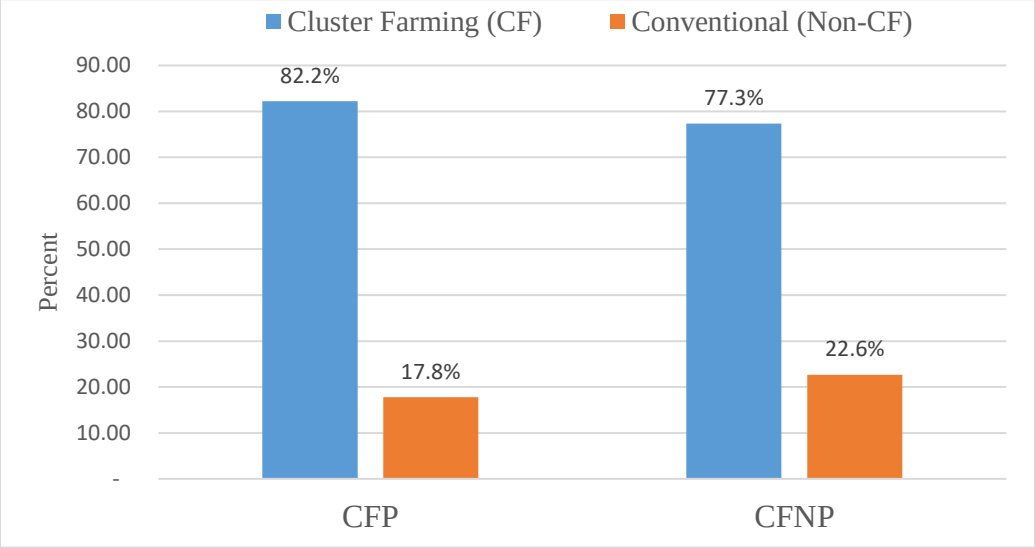

Table 10:Working in cluster or alone like previously

4.3.3. Comparison Between Cluster and Conventional Farming by the CFPs

For the sake of comparing the change CF brought and to understand their perception of it, the CFPs were asked to express their perception with five-point Likert scale questions. The scales include Much Lower (1), Lower (2), No Change (3), Higher (4), and Much Higher (5).

Cronbach's alpha reliability test was done to measure the internal consistency and to analyze a set of Likert scales in a group. Accordingly, a reliability test score of 0.73 was achieved as presented in table 10, which is beyond Cronbach's alpha reliability threshold (0.7). Accordingly, analysis was done for 10 Likert items by dropping “Getting market linkage while working in CF”. The item

was dropped based on the recommendation of the test, and to keep internal consistency and reliability at 0.73 and because there was another overlapping item.

Table 11:Cronbach's Alpha test and descriptive statistics

N. of Items	Reliability Statistics	Descriptive Statistics					
	Cronbach's Alpha	*N*	*Min.*	*Max.*	*Sum*	*Mean*	*Std. Dev*
10	*0.73*	*192*	*2.10*	*4.50*	*647.89*	*3.374*	*0.390*

(Source: Owen survey result, 2022)

Based on the test, the mean for the 10 Likert items was 3.374, which was found in the range between 2.61 and 3.40. Referring to the weighted mean range calculation taken from Sözen & Guven (2019) i.e., the calculation for 5-point Likert is done by subtracting the highest number by the lowest ($5 - 1 = 4$) and by dividing the result (4) by the scales (5) which is ($4 \div 5 = 0.80$). then, the weighted range will be established by adding the result (0.8) on each scale. With this, the mean value (3.374) belongs to the "No Change" average scale (2.6 – 3.9). The result, therefore, suggested that there was no significant change between cluster farming and conventional farming systems.

Table 12:Calculated weighted mean

Scales	Opinions	Weighted Mean
1	*Much Lower*	*1.00 – 1.79*
2	*Lower*	*1.80 – 2.59*
3	*No change*	*2.60 – 3.39*
4	*Higher*	*3.40 – 4.19*
5	*Much Higher*	*4.20 – 5.00*

Source (Sözen & Guven, 2019)

Individually, as shown in Table 13, most respondents replied that changes were higher when in it comes to access to extension service (57%), input usage (56.5%), and productivity (46.1%). But, in terms of mean score, referring to the above mean scoring (i.e., the score is higher when *M* 3.4 – 4.19), most respondents felt the input usage was higher *(M=3.65),* followed by extension service *(M=3.55),* and disease infestation was lowered *(M=3.5).* Additionally, most respondents answered that there was no change when it comes to access to credit (63.7%), getting market (55.4%), getting

a good price for their products (44.2%), access to inputs (48.7%), and product quality (47.7%). In contrast with higher ranks, the percentage and the mean scores were in agreement with each other.

Table 13:Comparison of Cluster Farming with conventional farming per each Scale and Likert items

Items (Being member of CF)	Percentage of the Respondents					
	M. Lower	*Lower*	*No Change*	*Higher*	*M. Higher*	*Mean value of the Scales*
Getting a good price for produce	*2.6*	*8.3*	*44.0*	*42.5*	*1.6*	*3.32*
Getting market	*1.6*	*8.8*	*55.4*	*32.1*	*1.0*	*3.2*
Access to input	-	*7.3*	*48.7*	*38.9*	*2.1*	*3.36*
Access to ext. services	-	*5.2*	*35.6*	*57.6*	*1.6*	*3.55*
Access to credit	*4.7*	*7.3*	*63.7*	*21.2*	*1.0*	*3.06*
Weed infestation	*8.5*	*30.7*	*42.9*	*16.9*	*1.0*	*3.28*
Disease infestation	*9.6*	*42*	*37.8*	*10.1*	*0.5*	*3.5*
Productivity	*0.5*	*11.4*	*38.3*	*46.1*	*1.6*	*3.37*
Product quality	*0.5*	*6.2*	*47.7*	*42.0*	*2.1*	*3.39*
Input usage	*0.5*	*4.1*	*31.7*	*56.7*	*6.7*	*3.65*

(Source: Owen survey result, 2022)

In comparison with the above survey results, the FGD and KII results showed that there were noteworthy differences between the two systems when it comes to input usage in general for CF and specifically for seed multiplication activities i.e., in terms of input usage and supply, and market linkage. That means, in contrast with the majority of CFPs, those who had a chance to participate in seed multiplication packages were having a market linkage with cooperative unions or other contract buyers. Respondents of both methods, for instance, mentioned that "*cooperative unions buy multiplied seeds by topping-up a 20% price from the normal product*."

On top of these, some respondents indicated that the approach brought many benefits including farm management, harvesting time (sowing and reaping), enhancing social networks and ties, etc. Some respondents for instance mentioned it helped them to rather strengthen their social interactions and became friendly and closer.

4.4.Impact Of Cluster Farming on Crop Productivity

Understanding the role of cluster farming on crop productivity with a focus on *teff* crops was an outcome of interest in this study. According to DWOA (2022), *teff* is the most produced crop in the study *Woreda*. Annual *teff* yield of sampled households during the farming season 2013/14 Eth cal. (2021) was collected in kilograms per hectare (kg/ha) from both cluster and non-cluster farms/plots. Based on that, propensity score matching (PSM) estimation was done with selected explanatory variables to grasp and predict the treatment effect and understand the role of cluster farming participation (treatment) on *teff* productivity.

4.4.1. Test for Multicollinearity

Before embarking to estimation, a multicollinearity test on independent variables were done to check if they were correlated. Based on that, the amounts were also measured using the variance inflation factor (VIF). The results of the tests show that there was no multicollinearity amongst variables as seen in the following table, i.e., VIF results below 5 or in rare cases below 10 are acceptable (O'brien, 2007).

Table 14:Variance inflation factor (VIF) test results

Variable	VIF	1/VIF	Variable	VIF	1/VIF
CF participation	*1.05*	*0.95*	Home to Road Distance	*1.05*	*0.95*
Sex of HH head	*1.20*	*0.83*	Extension contacts	*1.11*	*0.90*
Age of HH head	*1.28*	*0.78*	Membership in farmers' Coop.	*1.08*	*0.92*
EDUC status of HH head	*1.23*	*0.81*	Nonfarm income	*1.08*	*0.93*
Owned Land	*1.38*	*0.72*	Tropical livestock unit (TLU)	*1.25*	*0.80*
Mean VIF 1.17					

(Source: Owen survey result, 2022)

4.4.2. Estimation of Propensity Score and Distribution Samples

Generally, four steps namely, estimation of the propensity score (pscore), matching treated and control groups using matching algorithms, evaluating the quality of matching, and at the end, evaluating the outcomes or conducting sensitivity tests are expected to be done in PSM (Pan & Bai, 2015).

As noted in Caliendo & Scheel-Kopeinig (2008), choice of model and choice of variables are needs to be done before embarking on to estimation of the propensity score. In this case, a logit model

and independent variables including sex of the household head, age, educational status, land size owned by the households, the distance between home and road in minutes, membership in farmers' cooperative unions, availability of nonfarm income, and tropical livestock unit that could explain *teff* productivity (independent variable) were selected.

The variables were mainly selected to estimate the propensity score to build a counterfactual control group and to show how these variables could explain the impact of cluster farming participation on *teff* productivity within the cluster farming framework. According to ATA (2019) and in reference to KII and FGD results in section 4.1.4 of this study, cluster farming was not a thing that a given farmer can adopt. Rather, it was a thing that has decided by others including the *Woreda* officials, experts and DAs. Whatever experience and socioeconomic background farmers have they cannot decide on their participation. What matters most in this regard was, whether their land falls in selected sites or not. If the land of a given farmer falls into selected sites, participation was no choice despite the ascribed socioeconomic and/or demographic backgrounds. As presented in the below table, the Pseudo R2 (4.52%) was very small and only one variable (age) is found to be significant and reflected the negligible effect of other socioeconomic and demographic variables on farmers' participation on cluster farming. As stated above, farmers were selected mainly based on having adjacent land with other farmers in the area selected for cluster farming by agricultural experts and development agents. Thus, the main influential factor that affects being included in cluster farming is thus the opportunity to have land in the area of cluster faming which is adjacent to other farmers who are selected to form a cluster farm. Thus, it has to be understood that the variables used in the logit regression are mainly used to select the variables that help to build a counterfactual control group with respect to the variables.

Table 15:Logit model results: Likelihood of joining cluster farming

Dependent variable: *CF participation (0 and 1),* Outcome variable: *Teff Productivity*

Variables		Coef.	Std. Err.	Z	P>|z|
Sex of HH head	Male	*.426293*	*.2431217*	*1.75*	*0.080*
Age of HH head		*-.0158084***	*.0064475*	*-2.45*	*0.014*
EDUC of HH head	Non-formal	*-.1776114*	*.1713892*	*-1.04*	*0.300*
	Formal	*-.1551345*	*.1824061*	*-0.85*	*0.395*

Owned Land		*.1475868*	*.1062651*	*1.39*	*0.165*
Home to Road Distance		*-.0033763*	*.0049242*	*-0.69*	*0.493*
Extension contacts	Some times	*-.3688539*	*.1513011*	*-2.44*	*0.015*
	Never	*-.1731408*	*.2078281*	*-0.83*	*0.405*
Membership in Coop. unions	Yes	*.4283429*	*.3207134*	*1.34*	*0.182*
Nonfarm income	Having	*.0544152*	*.1475012*	*0.37*	*0.712*
Tropical livestock unit (TLU)		*.0182289*	*.0362793*	*0.50*	*0.615*
Constant		*.1033835***	*.4986837*	*0.21*	*0.836*
Pseudo R^2		0.0452			

** represents p<0.05 (Source: Owen survey result, 2022)

Following, a matching of treated and control households was carried out to know the common support region. The region of common support was selected between [0.1557601 to 0.81670083]. This means that households within this boundary were matched and distributed to either control or treatment groups based on their score. On top of this, households with propensity score value less than 0.1557601 and greater than 0.81670083 were discarded from consideration in the process.

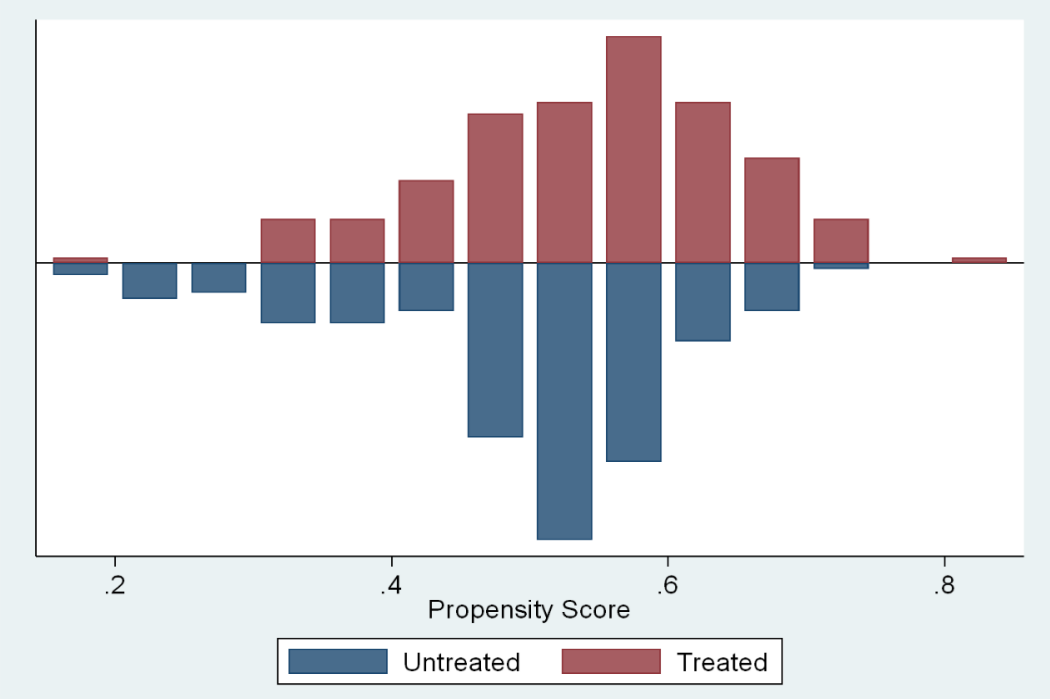

Figure 9:Psgraph
(Source: Owen survey result, 2022)

Based on the delimited boundary of common support, a total of 357 sample households were selected and the rest 19 were discarded. As depicted below, out of 193 CFP samples 186, and out of the 176 CNFP sampled 171 were selected based on the common support scores.

Table 16:Blocks of propensity score and common support

Blocks of p-score	Participation status		
	CFNP	*CFP*	*Total*
0.1557601	*2*	*1*	*3*
0.2	*31*	*16*	*47*
0.4	*116*	*112*	*228*
0.6	*22*	*56*	*78*
0.8	*0*	*1*	*1*
Total	*171*	*186*	*357*

- The common support option has been selected.
- The balancing property is satisfied

(Source: Owen survey result, 2022)

4.4.3. Choice of Estimator (Matching Algorithms)

Four alternative algorithms were employed to ensure the robustness of the estimating process of the impact of cluster farming on crop productivity and to correctly match treatment and non-treatment (control) groups. The estimation was done in Nearest Neighbor matching (one to one), Kernel matching, Radius and caliper matching (0.01), and Stratification matching methods.

Table 17:Performance of matching estimators for sample households

Matching Estimators	Matched Samples					
	Treated	*Control*	*Total*	*ATT (Yield kg/ha)*	*Bootstrapped Std. err*	*t-stat*
Nearest Neighbor (one neighbor)	*186*	*97*	*283*	*208.031*	*76.888*	*2.706*
Radius (caliper=0.01)	*181*	*159*	*348*	*126.515*	*67.946*	*1.862*
Kernel	*186*	*171*	*357*	*131.791*	*65.021*	*2.027*
Stratification	*185*	*172*	*357*	*101.552*	*71.253*	*1.425*

(Source: Owen survey result, 2022)

4.4.4. Balancing Test of the Matches

Quality check of balance between observed covariates is one of the processes in score matching endeavor. Satisfaction of balancing quality indicates that the ATT result is reliable and should considered. To this effect, balancing tests were done using *pstest* Stata syntax and are considered before and after matching tasks. Recommendable good balancing result rests mean bias score of below 5% for the matched. Thus, after repeated tests and trials, quality and balancing test of matching was found acceptable and reliable at mean bias 4.4%, which was |<5%|. In line with this, the Ps R2 for the matched (0.006), as presented in the table below¸ is satisfactory and fulfilled the recommendation of - best to be nearer to zero.

Table 18:Matching pstest output

Sample	Ps R2	LR chi2	p>chi2	Mean Bias	Med Bias	B	R	%Var
Unmatched	*0.036*	*18.00*	*0.035*	*15.0*	*14.0*	*45.1**	*0.82*	*29*
Matched	*0.006*	*3.04*	*0.963*	*4.4*	*3.5*	*18.0*	*1.29*	*14*

* If B>25%, R outside [0.5; 2]

(Source: Owen survey result, 2022)

4.4.5. Impact of Cluster Farming on Crop Productivity

After passing through a rigorous process of pscore estimation, determining common support region, matching between treated and non-treated (control), and establishing the average treatment effect on treated (ATT), the result obtained show that *teff* yield (productivity) for treated was 1622.61kg and that of the control was 1414.58 kg. Which means, the treatment group was produced comparatively 208 kg or nearly two quintals above compared to what was produced by the control group. Based on this, it could be reasonable to say that participating in the cluster farming approach, mainly in Dejen *Woreda* was having a significant role in *teff* productivity by 208 kilograms or 2 quintals. The changes among others might be attributed by high input usage, high frequency of extension contact and other benefits related to farm management. As discussed above, one of the good things about participating in cluster farming was, high input usage including seed, fertilizer and other agrochemicals, i.e., 56.5 (*M=3.65*) of the CFPs were responded that their input usage was improved compared to conventional farming. To add other example, utilization of chemical fertilizer according to DWOA (2022) and the findings of this study was found to be higher than the *Woreda's* recommendation 2.6 quintal per hectare (q/ha), i.e., by singling out the

teff farms, all samples were used on average 3.07 quintals while the CFP used 3.17 quintals and the CFNP used 2.96 quintals per hectare during 2013/14 Eth cal. (2021) farming season. The other thing was the benefits it brought related to farm and harvest management citing FGD and KII results.

The average treatment effect on the treated (ATT) of cluster farming participants and the estimated impact of CF participation on teff productivity as presented in the Table below was done using nearest neighbor (NN)-one neighbor methods among the four algorithms.

Table 19:Average Treatment Effect on Treated (ATT) result of Teff productivity (kg/ha)

Variable	Sample	Treated	Controls	Difference	S.E.	t-stat
Teff Productivity	*Unmatched*	*1622.611*	*1457.103*	*165.508*	*57.093*	*2.90*
	ATT	*1622.611*	*1414.580*	*208.031*	*76.887*	*2.71*
Matched samples: *Treated 186, Untreated 171, total 357*						

(Source: Owen survey result, 2022)

4.4.6. Sensitivity Analysis

In some instances, matching estimators including PSM are faced with inconsistency when and if the outcomes were altered by unobservable selection bias (hidden bias) that at the same time affects an assignment to treatment and the outcomes and thus leads us to biased inferences about the output of estimations. As noted in Caliendo & Scheel-Kopeinig (2008), since the possibility of evaluating the issue of selection bias in a non-randomized assignment is difficult, the issue must be addressed through making sensitivity analysis and by measuring how strongly the variable unforeseeably influenced the selection and the matching process. To this end, a Rosenbaum bounds [rbounds] sensitivity analysis was done as presented in the table 20 below.

As noted in Baiocchi et al. (2020, p. 751), “unlike for P values where there is agreement on cutoff points … there is not currently a consensus about what constitutes a cutoff point for a gamma.” Accordingly, this study took into account significant levels for the test of sensitivity instead of using gamma. Based on the test, the upper significant at the upper gamma level 1.5 became 0.06 and the lower was 1.1e-. In this case, a given sample was assigned to either the treatment or control groups without influences of hidden biases.

Thus, it is fair to say, the finding of this study was insensitive to bias arising from unobserved variables up to a gamma. Or, the ATT matching estimation result and conclusion won't be affected by the biases since done with observed characteristics and with the assumption of conditional independence.

Table 20: Sensitivity analysis result

Gamma	Upper significant (sig+)	Lower Significant (sig-)
1	*.000069*	*.000069*
1.05	*.000211*	*.00002*
1.1	*.000569*	*5.9e-06*
1.15	*.001368*	*1.7e-06*
1.2	*.002977*	*4.6e-07*
1.25	*.005939*	*1.2e-07*
1.3	*.01097*	*3.3e-08*
1.35	*.01893*	*8.7e-09*
1.4	*.030753*	*2.2e-09*
1.45	*.047347*	*5.7e-10*
1.5	*.06948*	*1.5e-10*

* *gamma* - log odds of differential assignment due to unobserved factors

sig+- upper bound significance level

sig- - lower bound significance level

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1. Summary

Teff is the most principal grain in Ethiopia. Its benefits vary from nourishment to economic and social benefits. The crop found itself among the most produced cash crops and cereals in line with wheat, maize, coffee, and sorghum. Dejen *Woreda*, the district where the study was done is among the potential *teff* producers in Ethiopian and Amhara regional states. The livelihood of the people of the *Woreda* is highly dependent on this crop commercially and for sustenance. With a growing population and dwindling productivity of the soil, the value of the crop and its yielding capacity found itself in an ambivalent quandary. Overall and with other crops, different mechanisms including devising extension packages and other initiatives, introducing an agricultural growth program (AGP), and expanding the cluster farming approach have been done so far. As it is well cognized, the introduced packages have brought many benefits with all their odds. Cluster farming, the subject matter of this study, was introduced in Ethiopia following an understanding of its role played in other countries and other sectors (i.e., industry). *Teff* crop is one of the commodities the approach has focused on, and being implemented in different parts of the country including Dejen *Woreda*.

It is reasonable to say cluster farming approach was introduced with stretched ambition by mostly targeting the smallholder farming system and without systematically targeting its attached socioeconomic complications discussed in the background and literature review parts of this study. Unless the attached problems are approached systematically, the fate of cluster farming would not be different from the long-established farming system. Despite its ambition, the people are us and the natural resources are the same, otherwise depleted.

This study was done to understand the impact of cluster farming on crop productivity through learning how cluster farms were established and organized; how farmers perceived the approach and through measuring its impact on *teff* productivity by drawing evidence form Dejen *Woreda.* In the process both quantitative and qualitative types of cross-sectional data were collected from randomly selected 384 participant and non-participant households, and both descriptive and econometrics (Propensity Score Matching) tools were used to make analysis.

On main sociodemographic characteristics of the respondents' results revealed that among the sampled households, the majority were headed by males with an average age of 50.7, most respondents were married (81.3%), the average family size of all samples was 4.9, and education-wise, most respondents were with some forms of formal and nonformal education.

On main socioeconomic and institutional features results exhibited that all respondents were having an average of 28.7 years of experience in farming, CFPs were having more land holding than CNFPs and all were having an average of 1.39 hectares, CFPs were also having more livestock holding (TLU) than the counterpart and all were having an average 4.4 TLU. When it comes to institutional factors most respondents assured they could reach input markets with an average 24-minute walk on foot or 6.155 minutes by car, they also asserted they could reach to nearest road with a 14.1 average minute walk, they could access credit services (57.2%) and the rest (42,8 %) couldn't, the majority of the respondents couldn't get weather information but the rest 5.3% and 42.2% could get always and sometimes respectively, and at the same time, 43.36% replied yes to having access to extension service, and the remainder 39.84% and the other 16.8 % said they sometimes and never respectively.

To understand the cluster farming group formation process and understanding its relevancy to them, participant respondents were asked if they joined on their willingness, have trained, and whether they have been given an explanation. In line with these, to understand their perception and to measure their level of satisfaction all samples and only participants were asked different critical questions. To these ends, most respondents, 81.8 % of CFPs assured that they have joined on their willingness. Regarding getting explanation, 48.7 %, and the rest 36.27% and 15.03%, replies they have explained, to some extent and no they did not respectively. The provision of training was half to half, while 49.5 % said they have trained, the rest 50.5% affirmed no to getting training. Related to the establishment, FGD and KII findings confirmed that groups were established by the *Woreda*, not by the farmers themselves. Thus, formation process was found to be against ATA's project implementation guidelines, especially when it comes to training and provision of explanation.

Besides, Measurement of perception were done by asking their willingness to continue in CF practice or not, or if they were willing to practice CF if they were non participant, and by giving alternatives for all CFPs or CFNPs to choose between CF and conventional farming approaches.

In addition, the level of changes that might cause by the CF approach was measured using 11 items 5 level Likert scales by asking participant farmers to rate the changes in comparison with the before states. The findings of all tell us, out of all CFPs 82.9% were ok to continue and the rest 17.1% needn't. Out of all CFNP, 72.2% expressed they were good to join and the rest 27.8% affirmed they were not. Related to the choices, out of the CFPs 82.2%, out of the CNFPs 77.3 % choose CF and the other 17.8% and 22.6% respectively from both groups said they choose conventional or working alone. The measurement of the changes in Likert scales also show (i.e., M =3.325), that there had not been a significant change compared to the before scenarios except improvement in input usage and getting extension contact, and decrease in weed infestation. The measurement was done following Cronbach's alpha consistency and reliability test assurance at 73%. Opposite to the preceding findings, responses of the FGD and KII substantiated that the approach has brought different advantages and many benefits including farm management, harvesting time (sowing and reaping), enhancing social network and ties, etc.

In the end, with the use of PSM method, the study assessed the impact of participating in the cluster farming approach on *teff* crop productivity. This was done first by drawing an artificial control group to identify sampled treatment and control groups based on common support and observable characteristics. An estimation of the ATT was done for matched 357 (186 treatment and 171 control) samples from both the CFP and CFNP groups. According to the analysis, the treated sample households was found to be advantageous and enjoying an average of 208.03 kg/ha or 2 quintals more product than non-participant samples. The overall production of the two groups were on average 1622.61 kg/ha and 1414.58 kg/ha yield for treated and control groups in a corresponding manner.

5.2. Conclusion

Given the results observed in the study, CF farming was found beneficial for *teff-growing* farmers in Dejen area. Accordingly, it could be fair to make inference that cluster farming can be taken as a solution to enhance crop productivity and must be scaling up. In addition to crop productivity, the participation had advantages like enhancing social ties, improving farm and harvest management.

The observations related to the establishment of clusters and formation processes portrayed that some courses of actions were against ATA's framework. Or, the practice starting from planning

to implementation were having some flaws with regards to the level of awareness given to the farmers aligned with other add-ons including the quality of extension services, linkage to and provision of inputs and output ends, in terms of on-field and off-field supports as per the ATA's recommendation and package of the approach.

Due to little or no explanation and lower or no awareness creation activities, participant farmers have failed to clearly grasp the purpose/objective of cluster farming, and in some cases, farmers mix the objective/purpose with other packages like seed multiplication. The perception of farmers (participants, or non-participants) towards cluster farming was positive, even if most participants said there was no change related to getting good price for CF products, getting market, access to input, getting credit services, and product quality. This implies that, the approach has perceived positively with all its odds and can be more beneficial if the provisions and recommendations were being kept and implemented as per the project document.

5.3. Recommendations

Building upon the results of descriptive and econometrics analysis, the practice of cluster farming was found to be a good mechanism to improve crop productivity and to enjoy other noneconomic benefits despite the undeniable predicaments manifested in its practice starting from formation to its ends. Accordingly, the following recommendations are suggested for future research, practitioners, policy frameworks, and intervention.

Formation and Organization: regarding the establishment process there was a trade-off between who should initiate the approach, the farmers themselves, or the experts. The approach by itself would be very commendable in terms of the project packages and envision it carried. Programs and interventions like this most of the time fail either due to planning or practice. Living aside these issues, participatory, informed and consent-based establishment/ formation summing up with creating awareness, providing an explanation, and providing pragmatic on-field or on-board training as stated in the project document (guide) could be better done proactively. Thus, since the mandate of establishing and organizing groups belongs to the *Woreda*, the agriculture offices should take precautionary note of the above facts and should capacitate its experts, development agents, and other involved professionals. Besides, ATA and the Ministry of Agriculture (MoA) in collaboration with regional governments should establish a concrete follow-up and review mechanism and take timely adjustments.

Practice and Perceptions: related to the practices, findings on the perception indicated that the approach has embraced positively. Despite that, the practice mainly in the supply side show there has no or little difference equated with the conventional farming. As a show case and how things could work well when all recommendations being fulfilled were at least seen in seed multiplication participant clusters. Beyond making it a plan vs achievement political issue that focuses on increasing numbers (quantity) for reporting purpose, it would be beneficial to work on quality issues by intensifying unhindered provision related to expanding access to input, facilitating input credit, creating pre and postharvest market linkages, enhancing quality of extension services and packages including other supports as per the ATA's recommendation and packages of the approach. On this side, most of the tasks fall in to the *Woreda* and are followed by ATA and MoA. Since some of them have a policy and budget implications, the government should dedicate a fair budget and revise policies related to credit facilitation, i.e., collateral and interest rate issues (since they are well known) to make input credit more accessible.

The above notes could be means to the end, at least for the intermediate outcomes of the approach - increasing crop productivity. All in all, the findings of this study recommend that expanding cluster farming with a higher emphasis on quality than quantity could play an irrefutable role to increase crop productivity and for the betterment of the country through achieving economic and non-economic benefits. Thus, the government, the Ministry of Agriculture (MoA), and the ATA, should devise exhaustive mechanisms to tackle the bottlenecks in the practice, and pre-to post-harvest two ends.

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APPENDIX

I. Questionnaire for the Households and Guiding Questions for KII and FGD

1. Questionnaire for the Households

Dear respondents:

I am a graduate student of Addis Ababa University, College of Development Studies, center for rural Development. Currently, I am conducting a study on "*The Impact of Cluster Farming on Crop Productivity in Amhara Regional State, Ethiopia: Evidence from Dejen Woreda*." The purpose of the study is to assess the comparative advantage of cluster farming and its impact on teff productivity in Dejen Woreda. Specifically, the purpose of the study is to examine how cluster farms are established and organized in Dejen Woreda, to assess the perception of farmers towards cluster farming, and to measure the impact of cluster farming on teff productivity in the Woreda/

Thus, you are humbly required to provide your sincere and genuine cooperation in answering each question is highly important for the success of the study. The information you provide will be treated confidentially and will only be used for academic purposes. Please give the right answers to the following questions to the best of your knowledge

General information on the interview

a. The kebele where the interview takes place:_____
b. Date, month, and year of interview _____
c. Full Name of the interviewer/data collector _____

Demographic characteristics of the Household

1. Gender: 1. Male 2. Female
2. Age: _____
3. Marital status: 1. Unmarried 2. Married 3. Separated 4. Widow
4. Religion: 1. Orthodox Tewahedo 2. Islam 3. Protestant 4. Catholic 5. Other Specify____
5. Educational status: 1. Unable to read and write 2. Nonformal education 3. Formal education
6. If answered formal education please specify the grade/level _____
7. Family size

Age	Male	Female	Total
<= 14			
15-64			
> 64			

8. Farming working experience in years _____

Socioeconomic characteristics

9. Total land size owned by household in hectares _____
10. Livestock holding and size in number :1 Oxen_____ 2. Cow _____ 3. Heifer _____
    4. Young bull_____ 5. Calf_____ 6. Horse_____ 7. Mul_____ 8. Donkey___
    9. Sheep_____ 10. Goat_____ 11. Chicken _____ 12. Beehive_____
11. Where is there a market in your area to buy agricultural inputs? 1. Yes, 2. No
12. What minute it will take to reach (**per minute)**? 12.1. On foot _____12.2. By car _____
13. Was there a market in your area to sell agricultural inputs? 1. Yes, 2. No
14. What minute it will take to reach (**per minute)**? 14.1. On foot _____14.2. By car _____
15. Do you ever get market information? 1. Yes, all the time 2. Sometimes 3. Never
16. If your answer is yes for Q15 what is the source 1. Mass media (TV, Radio …) 2. Extension workers 3. From the two 4. Other source_____
17. Is there a nearby road in your area? 1. Yes, 2. No
18. How long take you to reach the nearby road (**in minutes**)? _____
19. Do you ever get agriculture extension services from extension workers (Development Agents)?
    1. Yes, all the time 2. Occasionally 3. Never
20. If you can get the service, how often on average you get the service per month?_____
21. Have you ever participated in farmers' field day, extension demonstration, etc.?
    1. Yes, all the time 2. Occasionally 3. Never participated
22. Are you a member of informal social arrangements? (i.e., Edir, Ekub)? 1. Yes, I am 2. I am not
23. Are you a member of farmers' cooperative unions? 1. Yes, I am 2. I am not

Cluster farming (CF) related information

24. Were you a member of cluster farming groups in the past 2013/2014 (Eth cal.) farming season?
    1. Yes, I was 2. I was not
25. **[only for CF members]** When did you join (become a member) cluster group_____

26. **[only for CF members]** What was the variety you produced in your cluster farm

No.	What you produced	Name of the variety
26.1	Teff	
26.2	Other, please specify_____	

27. **[only for CF members]** Did you join cluster farming groups on your willingness?
    1. Yes 2. No
28. **[only for CF members]** Did you get any explanation regarding the benefits, advantages, and disadvantages, of being a member, or did you practice in any sensitization or awareness creation events about CF before joining CF 1. Yes, adequately 2. Moderately 3. Never
29. **[only for CF members]** What is your role in the CF group? 1. Member 2. Chairperson 3. Secretary 4. Control 5. Other please specify _____
30. **[only for CF members]** How do you rate your level of satisfaction in CF participation
    1. Very low 2. Low 3. Moderate 4. High 5. Very high
31. **[only for CF members]** Do you recommend other farmers to become a member of CF groups?
    1. Yes, I do 2. No, I do not
32. **[only for CF members]** If your answer for Q 31 is "No, I do not," please specify your reasons

    _____

    _____

33. Have you ever participated in training related to CF? 1. Yes 2. No
34. If you are a member of CF, do you wish to continue participating in CF? Or, if you are not a member of CF, do you wish to participate in CF? 1. Yes, I am interested 2. No, I am not interested
35. What do you choose between farming in a cluster, in groups, and working by yourself like the conventional farming approach? 1. Farm in the cluster 2. Work by myself like the previous times
36. How do you rate the capacity of members of the leader's committee of the cluster group you are participating in?
    1. Much higher 2. Higher 3. Medium 4. Lower 5. Much lower
37. How do your measure the changes of cluster farming participation in comparison with the before statuesque based on the following criterion?

No.	Criteria	Much Lower	Lower	No Change	Higher	Much Higher
1	Getting good price for produced	1	2	3	4	5
2	Getting market	1	2	3	4	5
3	Getting market linkage	1	2	3	4	5
4	Access to input	1	2	3	4	5
5	Access to extension services	1	2	3	4	5
6	Access to credit	1	2	3	4	5
7	Weed infestation	1	2	3	4	5
8	Disease infestation	1	2	3	4	5
9	Productivity	1	2	3	4	5
10	Product quality	1	2	3	4	5
11	Input usage	1	2	3	4	5

Access to Credit

38. Questions related to accessing credit

		1. Yes	2. None
1	Is there and credit and saving institution in your area		
2	Can you access credit services in cash or in-kind?		
3	If you can't access or don't want to access credit services, please specify the reasons 1. There is no supply 2. High-interest rate 3. Not finalized repaying of the last loan I took 4. I have no interest in taking loan 5. Other reason? Please specify_____		

Crop Product General Information

39. Amount of Teff produced by the family in the cluster and non-cluster farms during farming 2013/14 (2021) season

No.	Farm Type	Variety	Farm size in ha.	Produced in kg	Fertilizer used in kg	Improved seed used in kg	Local variety used	Pesticide/ herbicide used in liters	Post-harvest wastage in kg	Sold in kg
1	Cluster									
2	Non-Cluster									
3	All									

Annual Income Information

40. Average annual income of the family during 2013 (2021/2022)

No	Source of income	Annual income in Birr
1.	Sale of crops	
2.	Sale of by-products	
3.	Livestock sale	
4.	Sales of animal products (milk, butter, eggs, etc.,)	
5.	From employment or salaried work	
6.	From rent (house, land, cattle, etc.)	
7.	Sale of wood and charcoal	
8.	Handcraft sale	
9.	From relatives	
10.	Other, specify	

2. KII Guiding Questions (Key Informant Interview)

Dear participants

1. How do farmers are recruited for cluster farming?
2. How do CFs organize? What the organization looks like?
3. Do CF groups farm the same type of crop every time?
4. What do you think are the benefits the CF approach brought compared to conventional farming? Agriculture Your work With Compared (how do you describe it in terms of the following benchmarks, either positively or negatively)
    - 4.1. In terms of getting agricultural inputs?
    - 4.2. In terms of market
    - 4.3. In terms of market linkage
    - 4.4. In terms of information exchange
    - 4.5. In terms of farm productivity
5. Does all member of a single CF farm the same type of crop?
6. Does all member of a single CF farm the same type of crop?
7. Does the source of agricultural inputs the same for participant and non-participant farmers?
8. Are there any opportunity CF has brought?
9. What do you think are the reasons that farmers may hesitate to join CF?
10. What do you think is the negative sides of working in CF?
11. Are there any success story, best practice or case scenarios that should share?

3. FGD guiding questions

A. The kebele where the discussion conducted _____

B. Date, month, year_____

C. Facilitated by _____

Guiding Questions

1. How do you understand cluster farming in your area? How do you describe it?
2. When did the approach started in your area? (Can we say the approach is new incident in the area and the whole Ethiopia)?
3. How do you describe the advantages cluster farming has brought to the community in your area compared to the conventional farming? What about the disadvantages?

4. How do the community perceive CF in terms of societal culture, values and norms?
    a. If there is any new thinking, practice, or perception it has brought about social interactions
    b. Are there any examples that the approach might discouraged?
5. Do you think the approach will bring economic change if scaled up? How?
6. Are there any challenge encountered when practicing the approach?
7. What do you think is better done to fully implement the approach? What are the expectations from the government, the community, religion institutions, scholars, community elders etc.?
8. Is there any worry by the farmers that their plot's boundaries might lost while join clusters?
9. How do critical and main decisions are taken and executed (by the leadership committee or by the general assemble

No.	Main Tasks	Leaders committee	General Assemble	DA	Experts of the woredas
1	Of agriculture time (Season)				
2	Crop type				
3	Crop variety				
4	Amount of fertilizer				
5	Pesticide				
6	Harvesting time				
7	Weeding time				
8	Trashing time				

10. Any idea that should mentioned or you want to add?

II. Tropical livestock unit conversion factors

No	Animals	Tropical Livestock Unit (TLU) (TLU equivalent)
1	Calf	*0.20*
2	Heifer and Bull	*0.75*
3	Cows and Oxen	*1*
4	Camel	*1.25*
5	Horse	*1.10*
6	Donkey	*0.70*
7	Sheep and goat	*0.13*
8	Chicken/ Poultry	*0.013*

Source: (Storck et al., 1991)

III. Multicollinearity test results

```
. pwcorr HH_sex Age EDUC_status Land_Size HtoR_Dist Ext_cont FCU_mship NonF_Inc TLU
```

	HH_sex	Age	EDUC_s~s	Land_S~e	HtoR_D~t	Ext_cont	FCU_ms~p
HH_sex	1.0000						
Age	0.0824	1.0000					
EDUC_status	0.1567	-0.2952	1.0000				
Land_Size	0.1211	0.3830	-0.1288	1.0000			
HtoR_Dist	-0.0190	-0.0123	-0.0538	-0.0422	1.0000		
Ext_cont	-0.2117	0.0608	-0.2304	-0.0293	0.0983	1.0000	
FCU_mship	0.1847	0.0118	0.1022	0.1596	-0.0079	-0.0738	1.0000
NonF_Inc	-0.0887	0.0265	0.0837	0.0788	-0.1688	-0.0647	-0.0264
TLU	0.3011	0.1225	0.0957	0.3456	0.0261	-0.1161	0.1103

	NonF_Inc	TLU
NonF_Inc	1.0000	
TLU	-0.0240	1.0000

IV. Estimation of the propensity score using the probit model

```
Iteration 0:   log likelihood = -247.13832
Iteration 1:   log likelihood = -238.20351
Iteration 2:   log likelihood = -238.16847
Iteration 3:   log likelihood = -238.16846

Logistic regression                               Number of obs   =        357
                                                  LR chi2(9)      =      17.94
                                                  Prob > chi2     =     0.0359
Log likelihood = -238.16846                       Pseudo R2       =     0.0363
```

CF_Partici~n	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
HH_sex	.6932261	.3948353	1.76	0.079	-.080637	1.467089
Age	-.0255721	.010889	-2.35	0.019	-.0469143	-.00423
EDUC_status	-.1090915	.1499675	-0.73	0.467	-.4030223	.1848394
Land_Size	.2092502	.1724789	1.21	0.225	-.1288022	.5473025
HtoR_Dist	-.0066305	.0077123	-0.86	0.390	-.0217464	.0084854
Ext_cont	-.2434111	.158125	-1.54	0.124	-.5533304	.0665082
FCU_mship	.661603	.5341234	1.24	0.215	-.3852596	1.708466
NonF_Inc	.0792766	.2376482	0.33	0.739	-.3865053	.5450585
TLU	.020999	.0585751	0.36	0.720	-.0938061	.1358042
_cons	.4576989	.924333	0.50	0.620	-1.35396	2.269358

V. Description of the estimated propensity score in region of common support

Estimated propensity score

Percentiles		Smallest		
1%	.2132071	.1557601		
5%	.3108349	.1589942		
10%	.3632131	.1647634	Obs	357
25%	.4696892	.2132071	Sum of Wgt.	357
50%	.5345804		Mean	.5210084
		Largest	Std. Dev.	.1105578
75%	.5943306	.7298359		
90%	.6516319	.7301393	Variance	.012223
95%	.6787334	.7361266	Skewness	-.6996504
99%	.7298359	.8167008	Kurtosis	3.65972

VI. Bootstrapped ATT estimation using four matching algorithms

```
ATT estimation with Nearest Neighbor Matching method
(random draw version)
Bootstrapped standard errors
```

n. treat.	n. contr.	ATT	Std. Err.	t
319	31	256.425	128.820	1.991

```
Note: the numbers of treated and controls refer to actual
nearest neighbour matches
```

ATT estimation with the Radius Matching method
Bootstrapped standard errors

n. treat.	n. contr.	ATT	Std. Err.	t
181	159	126.515	64.209	1.970

Note: the numbers of treated and controls refer to actual matches within radius

ATT estimation with the Kernel Matching method
Bootstrapped standard errors

n. treat.	n. contr.	ATT	Std. Err.	t
186	171	131.791	55.784	2.363

ATT estimation with the Stratification method
Bootstrapped standard errors

n. treat.	n. contr.	ATT	Std. Err.	t
185	172	101.552	56.961	1.783

VII. PSM estimation result on the impact of CF participation on *teff* productivity

```
.
. psmatch2 CF_Participation, outcome (Teff_Productivity) pscore(mypscore)
```

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
Teff_Productiv~y	Unmatched	1622.61188	1457.10351	165.508373	57.0938839	2.90
	ATT	1622.61188	1414.58065	208.031237	76.887544	2.71

Note: S.E. does not take into account that the propensity score is estimated.

VIII. Result of balancing test for matching quality

```
. pstest HH_sex Age EDUC_status Land_Size HtoR_Dist Ext_cont FCU_mship NonF_Inc TLU, both
>  graph
```

Variable	Unmatched / Matched	Mean Treated	Mean Control	%bias	%reduct |bias|	t-test t	t-test p>|t|	V(T)/ V(C)
HH_sex	U	.93011	.8538	24.7		2.35	0.019	.
	M	.93011	.91935	3.5	85.9	0.39	0.695	.
Age	U	49.704	51.848	-18.6		-1.76	0.080	0.96
	M	49.704	49.758	-0.5	97.5	-0.04	0.965	0.84
EDUC_status	U	2.0753	2.0117	7.9		0.74	0.459	1.06
	M	2.0753	2.0538	2.7	66.2	0.26	0.798	1.06
Land_Size	U	1.4386	1.3445	12.7		1.19	0.234	1.50*
	M	1.4386	1.4059	4.4	65.3	0.40	0.689	1.14
HtoR_Dist	U	13.274	14.895	-11.2		-1.06	0.291	0.78
	M	13.274	12.806	3.2	71.1	0.32	0.746	0.91
Ext_cont	U	1.6452	1.8129	-23.4		-2.21	0.028	1.08
	M	1.6452	1.6398	0.8	96.8	0.07	0.943	1.06
FCU_mship	U	.96774	.92398	19.4		1.84	0.066	.
	M	.96774	.98387	-7.1	63.1	-1.01	0.313	.
NonF_Inc	U	.35484	.33918	3.3		0.31	0.757	.
	M	.35484	.30645	10.1	-209.0	0.99	0.323	.
TLU	U	4.5772	4.2842	14.0		1.32	0.186	1.12
	M	4.5772	4.4302	7.0	49.8	0.68	0.500	1.09

* if variance ratio outside [0.75; 1.34] for U and [0.75; 1.34] for M

Sample	Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
Unmatched	0.036	18.00	0.035	15.0	14.0	45.1*	0.82	17
Matched	0.006	3.04	0.963	4.4	3.5	18.0	1.29	0

* if B>25%, R outside [0.5; 2]

IX. Result of Sensitivity analysis

```
. rbounds delta, gamma(1 (0.05) 1.5)

Rosenbaum bounds for delta (N = 186 matched pairs)

Gamma           sig+      sig-    t-hat+    t-hat-       CI+       CI-
-------------------------------------------------------------------------
    1         .000069   .000069    196.65    196.65     96.65       300
 1.05         .000211    .00002       182       211     82.45       316
  1.1         .000569   5.9e-06    168.35       224     69.35       330
 1.15         .001368   1.7e-06       155       240     56.65    344.35
  1.2         .002977   4.6e-07       142    252.74     43.33    358.35
 1.25         .005939   1.2e-07       130    266.65        30       370
  1.3          .01097   3.3e-08    116.68       280      17.8    381.65
 1.35          .01893   8.7e-09    106.65    291.65      6.65       395
  1.4         .030753   2.2e-09        96       300  -6.10001    406.65
 1.45         .047347   5.7e-10        85       310    -17.35    416.65
  1.5          .06948   1.5e-10     77.35       321    -29.25     427.8

* gamma  - log odds of differential assignment due to unobserved factors
  sig+   - upper bound significance level
  sig-   - lower bound significance level
  t-hat+ - upper bound Hodges-Lehmann point estimate
  t-hat- - lower bound Hodges-Lehmann point estimate
  CI+    - upper bound confidence interval (a=  .95)
  CI-    - lower bound confidence interval (a=  .95)
```

X. Plagiarism Assessment Report

Curiginal

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Template for Reporting Plagiarism Assessment

Name of the Center Rural Development Program of study Continuing Program level (Masters/PhD):_____Masters_____ please, check one: Regular/Continuing.

Name of the Adviser/s: Advisor: Abate Mekuriaw (PhD)

Topic of the thesis: The Impact of Cluster Farming on Crop Productivity in Amhara Regional State, Ethiopia: Evidence from Dejen Woreda.

S/N	Name and ID.NO. of the student/candidate	Percentage of plagiarism confirmed	Comments given and improvements made by the student/candidate
1	Wondimu Dirar ID No. GSE/3597/09	2%	The student was advised on usage of scholarly work and plagiarism from the beginning of his work. Based on the URKUND report, he was advised to paraphrase those which seem serious and the report is attached below.

Remark by advisor

The student has corrected as shown in the table attached.

Name of the center head/coordinator Esubalew Abate (PhD); Signature_____Date: 16/06/2022

1. Name of the adviser Abate Mekuriaw (PhD) Signature  Date 16/06/2022

Center for Rural Development
College of Development Studies
Addis Ababa University

MA thesis report by Wondimu Dirar

Improvements was made on the following similarity text

	Similarity text	Changes made	page
	economies of scale for input distribution and output aggregation; enhanced production competitiveness	assuring scale of economy for input dissemination and output accumulation; upgraded production quality and competitiveness	9