Journal of Business and Economic Options

Irrigation Interventions and Food Security in The Case of Ethiopia's East Hararghe Lowlands

Manie Fetene[a]
Ahmed Kedir[b]

Abstract
This study addresses the pressing issue of food insecurity in Ethiopia by examining the impact of irrigation interventions on income generation and food security among smallholder farm households in the East Hararghe lowland areas. Given the critical importance of irrigation technology in enhancing agricultural productivity and sustainability, particularly in water-scarce regions, this research aims to provide empirical evidence to inform policy decisions and interventions. The study utilizes cross-sectional data collected from 400 randomly selected sample households during the 2022/23 production season. Through the application of Propensity Score Matching and logistic regression analysis, the research assesses the factors influencing household participation in irrigation technology and examines the outcomes in terms of income generation and food security status. The findings reveal that various socio-economic factors, including the educational level of the household head, cultivated area, social status, livestock holding, oxen ownership, and irrigation distance, significantly influence the decision of households to participate in irrigation practices. This highlights the importance of considering these factors in the design and implementation of irrigation interventions. Moreover, the results demonstrate that households participating in irrigation practices experience improvements in both calorie intake and farm income compared to those not involved in irrigation. This suggests that irrigation interventions have a significant, positive, and robust impact on key outcome variables related to food security and economic well-being. Overall, the study underscores the importance of promoting and supporting irrigation technology adoption among smallholder farm households in Ethiopia's lowland areas to enhance agricultural productivity, income generation, and food security. By addressing the identified socio-economic factors and ensuring targeted interventions, policymakers and stakeholders can effectively harness the potential of irrigation to alleviate food insecurity and promote sustainable agricultural development in the region.
Keywords: Food Insecurity, Irrigation Interventions, Smallholder Farmers, Socio-Economic Factors
JEL Codes: 13, Q12, Q16

1. INTRODUCTION

Ethiopia's population of nearly 123 million is predominantly rural, with around 80 percent of its people living in rural areas and relying on agriculture for their livelihoods. This demographic composition underscores the critical importance of agriculture to the country's economy and food security (Kassegn & Endris, 2021). Despite facing challenges such as uneven distribution of resources and varying ecological conditions, Ethiopia possesses significant agricultural potential and ecological diversity. The country's diverse climate zones, ranging from highlands to lowlands, provide favorable conditions for the cultivation of a wide range of crops and the rearing of various livestock species (Wassie, 2020; Qasim & Tariq, 2019; Tesfay, 2021). One of the key factors contributing to improved livelihoods in rural Ethiopia is access to water resources. Improved access to water for both domestic and productive uses has been associated with positive outcomes in terms of income generation and food security for rural communities. Kibatu et al., (2008) have highlighted the importance of water access in enhancing livelihoods and reducing vulnerability to food insecurity. Efforts to improve water access in Ethiopia include initiatives aimed at water resource management, irrigation development, and watershed rehabilitation. These efforts not only support agricultural production but also contribute to the overall well-being of rural communities by providing water for drinking, sanitation, and hygiene. Ethiopia's agricultural sector plays a central role in the country's economy and the livelihoods of its people, particularly those in rural areas. Access to water resources is crucial for sustaining agricultural productivity, improving food security, and lifting rural communities out of poverty. Continued investment in water infrastructure and management will be essential for ensuring the long-term sustainability and resilience of Ethiopia's agricultural sector.

Ethiopia's development challenges, including chronic poverty, vulnerability, and food insecurity, underscore the importance of addressing water-related issues as a key priority. The country's national policy priorities reflect a recognition of the

[a] Department of Agricultural Economics, Haramaya University, Dire Dawa, Ethiopia
[b] Department of Agricultural Economics, Haramaya University, Dire Dawa, Ethiopia

Received: 20-12-2023 **Revised: 01-02-2024** **Online Published: 01-03-2024**

central role of water in tackling these challenges. Ethiopia's growth strategy places significant emphasis on the agricultural sector, recognizing its potential to drive economic development and poverty reduction. However, the realization of this potential is hindered by various factors, including high levels of risk and vulnerability, as well as inadequate access to critical assets such as land and water. Slaymaker et al. (2021) highlight the constraints faced by Ethiopia's agricultural sector, particularly in terms of water access and management. Addressing these constraints requires comprehensive policies and investments aimed at improving water resource management, enhancing irrigation infrastructure, and promoting sustainable agricultural practices. Efforts to boost agricultural productivity and resilience must also consider the need to reduce vulnerability to climate variability and change. Climate-smart agricultural practices, such as water harvesting, soil conservation, and drought-resistant crop varieties, can help mitigate the impacts of climate-related risks on farming communities. In addition to agricultural water management, investments in water infrastructure for domestic use, sanitation, and hygiene are essential for improving health outcomes and overall well-being, particularly in rural areas where access to clean water remains limited. Ethiopia's focus on water-related interventions as part of its development agenda reflects a recognition of the critical role that water plays in addressing poverty, vulnerability, and food insecurity. By prioritizing investments in water infrastructure and management, Ethiopia aims to unlock the full potential of its agricultural sector and improve the livelihoods of its people.

Ethiopia's agricultural sector, despite its central role in the economy, faces significant challenges that hinder its ability to ensure food security for the population. One of the major issues is the discrepancy between food production and population growth. The agricultural output has not kept pace with the increasing demands of a growing population. This has led to persistent food insecurity and malnutrition in many parts of the country. Moreover, the natural resources vital for agriculture, such as land and water, have been subject to degradation and depletion. Soil erosion, deforestation, and water scarcity have all contributed to a decline in agricultural productivity (Yigezu Wendimu, 2021; Ahmad & Khan, 2021; Naeem & Hameed, 2017). These environmental challenges further exacerbate the difficulties in increasing food production to meet the needs of the population. The rapid population growth in Ethiopia adds another layer of complexity to the issue. With a growing population, the demand for food continues to rise, placing additional pressure on the already strained agricultural sector. It is estimated that Ethiopia will need to significantly increase its cereal production by 2025 to keep pace with the population growth and ensure food security for its people. Addressing these challenges requires concerted efforts from the government, international organizations, and local communities. Investments in sustainable agricultural practices, soil and water conservation efforts, improved access to modern farming techniques, and infrastructure development are crucial to enhancing agricultural productivity and ensuring food security in Ethiopia. Additionally, policies aimed at population management and promoting family planning could help alleviate some of the pressure on the agricultural sector by reducing the rate of population growth.

Irrigation plays a crucial role in contributing to the national economy of Ethiopia by providing numerous benefits, particularly for rural communities. One of the significant impacts of irrigation is its potential to alleviate poverty and improve the livelihoods of the rural poor. At a micro level, irrigation systems lead to increased agricultural productivity, resulting in higher yields per hectare. This increase in productivity translates into higher incomes for farmers, improved consumption patterns, and enhanced food security for households.

Specifically, irrigation offers several benefits to smallholder farmers, who make up a significant portion of Ethiopia's agricultural sector. Irrigation allows farmers to cultivate their land more efficiently, leading to higher production levels compared to rain-fed agriculture. This increase in agricultural output can contribute to overall economic growth and development. By providing a consistent water supply, irrigation helps ensure optimal growing conditions for crops, leading to higher yields per unit of land. This not only boosts farmers' incomes but also enhances food security by increasing the availability of food crops. Irrigation reduces the risk of crop failure associated with dependence on unpredictable rainfall patterns. With a reliable water supply, farmers can better manage the risks associated with droughts or erratic weather conditions, thereby safeguarding their livelihoods. Irrigated agriculture supports year-round farming activities, creating opportunities for both farm and non-farm employment. This can help reduce seasonal unemployment and provide a more stable source of income for rural communities. Irrigation enables farmers to diversify their cropping patterns and cultivate a wider range of crops throughout the year. This flexibility allows them to respond to market demands and capitalize on high-value cash crops, thereby improving their economic prospects. The investments in irrigation infrastructure and technology have the potential to transform Ethiopia's agricultural sector, lifting rural communities out of poverty and contributing to sustainable economic development. However, it is essential to ensure that irrigation schemes are implemented in a manner that is environmentally sustainable and socially inclusive, taking into account the needs and priorities of local communities.

Since 2005, the Government of Ethiopia, in partnership with numerous development organizations, has shown a strong commitment to prioritizing food security as a fundamental public concern. Recognizing the severity of both chronic and temporary food insecurity issues in the country, the government and its collaborators have dedicated significant resources to implement a wide range of programs aimed at addressing these challenges. Various initiatives related to food security have been rolled out across Ethiopia, reflecting a concerted effort to alleviate the widespread suffering caused by food insecurity. These programs encompass diverse strategies designed to improve agricultural productivity, enhance access to food, and build resilience among vulnerable populations (Ahmad & Ali, 2016). The government has implemented initiatives to boost agricultural productivity and promote sustainable farming practices. These programs often involve the distribution of

improved seeds, training in modern agricultural techniques, and support for smallholder farmers to adopt climate-smart agricultural practices. Ethiopia has established safety net programs to provide vulnerable households with access to food during times of crisis. These programs may include cash transfers, food distribution schemes, and public works programs aimed at improving community infrastructure while providing employment opportunities. Addressing malnutrition is a critical aspect of food security efforts. The government and its partners have implemented nutrition programs focused on improving access to nutritious foods, promoting breastfeeding and maternal health, and addressing micronutrient deficiencies. Given Ethiopia's susceptibility to natural disasters such as droughts and floods, disaster risk management measures are essential for safeguarding food security. The government has invested in early warning systems, emergency response mechanisms, and resilience-building initiatives to mitigate the impact of disasters on vulnerable communities. Efforts to address food security have also involved policy and institutional reforms aimed at enhancing the enabling environment for agricultural development, improving market access for smallholder farmers, and strengthening governance in the food sector. The commitment of the Government of Ethiopia and its development partners to tackling food insecurity has been evident through the mobilization of resources and the implementation of a comprehensive range of programs. While significant progress has been made, ongoing efforts are needed to sustainably improve food security and resilience across the country, particularly in the face of ongoing challenges such as climate change and economic volatility.

Climate change indeed poses a significant threat to food security worldwide, impacting all dimensions of food availability, accessibility, utilization, and the stability of food systems. Its effects are felt across agricultural food systems, affecting both exporting and importing countries, as well as those relying on subsistence farming for their livelihoods. Climate change can disrupt agricultural production by altering temperature and precipitation patterns, leading to changes in crop yields and livestock productivity. Extreme weather events such as droughts, floods, and heatwaves can damage crops, reduce yields, and destroy agricultural infrastructure, reducing the availability of food. Changes in climate can affect access to food by influencing transportation networks, market prices, and income levels. For example, disruptions to transportation routes due to extreme weather events can impede the distribution of food from surplus to deficit areas, leading to food shortages and price spikes. Reduced incomes resulting from crop failures can also limit households' ability to purchase food, exacerbating food insecurity. Climate change can impact food utilization by affecting dietary diversity and nutritional quality. Changes in temperature and precipitation patterns can alter the availability of certain food crops and lead to shifts in dietary habits, potentially affecting nutrient intake and overall health. Additionally, extreme weather events can contaminate water sources and compromise food safety, increasing the risk of foodborne illnesses. Climate change can disrupt the stability of food systems by increasing the frequency and severity of shocks and stresses. This includes not only direct impacts on agriculture but also secondary effects on food processing, distribution, and storage infrastructure. Instability in food systems can lead to market volatility, trade disruptions, and social unrest, further exacerbating food insecurity. Addressing the impacts of climate change on food security requires coordinated action at global, national, and local levels. Strategies may include investments in climate-resilient agriculture, improved water management practices, enhanced social safety nets, and policies to promote sustainable food systems. Additionally, efforts to mitigate greenhouse gas emissions and adapt to climate change are essential for building resilience and ensuring food security in the face of a changing climate.

Poverty in Ethiopia is a multifaceted issue deeply rooted in the country's agricultural landscape. With a significant portion of the population relying on subsistence farming for their livelihoods, vulnerabilities stemming from factors like unpredictable weather patterns and limited off-farm employment opportunities are magnified. Erratic rainfall, a common occurrence in Ethiopia, poses a considerable threat to agricultural productivity, leading to crop failures and food shortages. The cyclical nature of drought exacerbates these challenges, perpetuating a cycle of poverty and food insecurity. In response to these challenges, the Ethiopian government, in collaboration with various development partners, has recognized the critical importance of investing in irrigation infrastructure. By expanding access to water for agricultural purposes, irrigation can mitigate the risks associated with rain-fed farming and provide a more reliable means of sustaining livelihoods. Moreover, irrigation allows farmers to diversify their crops and engage in higher-value, market-oriented production, thereby increasing their income and food security. The significance of irrigation extends beyond agriculture alone. It has the potential to catalyze broader economic development by stimulating growth in rural areas, creating employment opportunities, and improving access to nutritious food for vulnerable populations. Additionally, investment in irrigation aligns with Ethiopia's long-term development goals, including poverty reduction and sustainable economic growth. However, the successful implementation of irrigation projects requires not only financial resources but also careful planning, sustainable water management practices, and community involvement. Ensuring equitable access to irrigation technologies and infrastructure, particularly among marginalized communities, is essential for maximizing the benefits of these initiatives and addressing underlying inequalities.

2. METHODOLOGY

The study was conducted in the lowland areas of East Hararghe Zone, located in the Oromia region of Ethiopia. According to the 2010 projected Census conducted by the Central Statistical Agency of Ethiopia (CSA), the Zone has a total population of 2,999,513, showing a significant increase of 48.79% over the 1994 census. This population comprises 1,523,103 males and 1,476,410 females. Notably, a substantial proportion of farmers in the area have small landholdings, with about 44% of landholdings not exceeding 0.5 hectares, and 82% of farmers possessing less than 1 hectare of land. This

trend highlights the critical issue of land fragmentation, as farmers' main capital, aside from labor, is becoming increasingly fragmented. The prevalence of extreme land pressure in the region has led to significant environmental degradation, particularly in the form of vast deforestation and the cultivation of unsuitable slopes in the highlands and mid-highlands. These practices have resulted in severe environmental damage, threatening the sustainability of agricultural livelihoods and exacerbating issues of food security and land degradation. As such, addressing the challenges of land fragmentation and unsustainable land use practices is crucial for the long-term environmental and socio-economic stability of the East Hararghe Zone and its inhabitants.

The livelihoods in the East Hararghe Zone predominantly rely on mixed farming, which encompasses both crop production and livestock rearing. The primary source of income for many households in the area is derived from crop cultivation, particularly the production of crops like sorghum, maize, common beans, highland pulses (such as beans and peas), and various vegetables including potatoes, onions, garlic, and leafy greens. Additionally, fruits like bananas and mangoes are also grown in the district, contributing to the agricultural diversity of the region. To gather information for the study, both primary and secondary data sources were utilized. Primary data were collected through the use of semi-structured questionnaires administered by trained enumerators. These questionnaires allowed for the collection of specific information directly from individuals within the community. Secondary data, on the other hand, were obtained from various sources such as published and unpublished documents from agricultural and rural development offices, water resource development offices, and other relevant institutions. These secondary data sources provided additional context and information to supplement the primary data collected during the study.

To ensure the reliability of the information and to understand the importance of irrigation technology, a two-stage random sampling technique was employed to select sample households for this study. In the first stage, four kebeles were purposively selected as representative areas for the study. Within each selected kebele, the total households were stratified into two groups: irrigation users and non-users. In the second stage, sample farmers were selected from each stratum using a simple random sampling technique, with the selection being proportional to the size of each group. This method ensured that both irrigation users and non-users were adequately represented in the sample. Ultimately, a total of 400 sample respondents were interviewed, providing a diverse range of perspectives and insights into the utilization and impact of irrigation technology in the study area. In this study, Propensity Score Matching (PSM) was utilized to assess the impact of irrigation practice on farm income and food security status. Food security at the household level was evaluated through direct surveys of income, expenditure, and consumption, which were then compared with the minimum subsistence requirement as outlined by Von Braun et al. (1992). PSM allowed for a rigorous statistical analysis by matching households with similar propensity scores but differing in irrigation practice, thus enabling the estimation of the causal effect of irrigation on farm income and food security outcomes.

3. RESULTS AND DISCUSSION

Table provides the outcomes of logistic regression, the logistic regression model demonstrates overall statistical significance, a satisfactory level of explanatory power, and a high degree of confidence in its results, as indicated by the significant LR chi2, Pseudo R2, and Prob > chi2 values. These findings suggest that the specified independent variables are meaningful predictors of participation in the analyzed context. The intercept or constant term, which is calculated as -1.4852, serves as the baseline log odds of participation when all independent variables are set to zero. The associated odds ratio of 1.5177 suggests that the odds of participation increase by approximately 51.77% when all other independent variables are held constant at zero. This provides a baseline understanding of the likelihood of participation in the absence of any other influencing factors.

Based on results sex plays a significant role in participation, with a coefficient of 0.6551 and an odds ratio of 1.93. This indicates that individuals of one sex are approximately 1.93 times more likely to participate compared to individuals of the other sex, holding all other variables constant. One avenue for discussion could be examining cultural norms and expectations related to gender roles, which might influence individuals' willingness or ability to participate in the activity under study. Additionally, exploring potential barriers or facilitators specific to each sex could shed further light on the observed difference in participation rates. Factors such as access to resources, societal support systems, and institutional policies may vary between sexes and impact their likelihood of participation. Furthermore, considering the implications of this finding is crucial for understanding and addressing any disparities that may exist. For instance, if one sex is consistently underrepresented in participation, it could have implications for program effectiveness, resource allocation, and overall inclusivity.

This result indicates that education plays a significant role in determining participation rates. With a coefficient of 0.2595 and an odds ratio of 1.30, we can interpret that for every one-unit increase in education level, the odds of participation increase by approximately 30%. Higher levels of education often correlate with greater access to resources, opportunities, and social networks. Individuals with more education may possess enhanced skills, knowledge, and confidence, which can empower them to engage actively in various activities. Furthermore, education serves as a pathway to socioeconomic advancement, with higher levels of education typically associated with better employment prospects and higher income levels. This socioeconomic advantage can further facilitate participation by providing individuals with the means to invest time and resources into activities they find meaningful or enjoyable. However, it's important to acknowledge that disparities

in education access and attainment exist, which can contribute to inequalities in participation opportunities. Factors such as socioeconomic background, geographical location, and systemic barriers can influence access to quality education, thereby impacting individuals' ability to participate fully in society. Therefore, efforts to promote equal access to education for all individuals are crucial for fostering more inclusive and equitable participation opportunities. By addressing barriers to education and promoting lifelong learning initiatives, societies can empower individuals to actively engage in activities that contribute to personal fulfillment, community development, and societal progress.

With a coefficient of 0.0160 and an odds ratio of 1.02, we can interpret that experience has a slight positive effect on participation. However, the associated odds ratio suggests that the impact is minimal, with only a marginal increase in the odds of participation. This suggests that although individuals with more experience may be slightly more likely to participate, the difference in participation rates between individuals with varying levels of experience may not be substantial. It's important to consider the potential reasons for this minimal impact of experience on participation. Experience may contribute to participation by providing individuals with valuable skills, knowledge, and confidence that make them more inclined to engage in the activity under study. However, other factors, such as education, socioeconomic status, and personal motivations, may play more significant roles in determining participation rates. Furthermore, the marginal increase in the odds of participation associated with experience suggests that while it may have some influence, it is not the sole or primary determinant of participation. Therefore, efforts to promote participation should consider a holistic approach that addresses various factors influencing individuals' likelihood of engaging in the activity. Additionally, exploring the interaction between experience and other factors, such as education and socioeconomic status, could provide further insights into their combined effect on participation rates. Understanding how these factors intersect and influence participation can inform targeted interventions and policies aimed at promoting more inclusive and equitable participation opportunities for all individuals.

With a coefficient of 1.0190 and an odds ratio of 2.77, we can interpret that social status has a significant positive effect on participation. Specifically, individuals with higher social status are about 2.77 times more likely to participate compared to those with lower social status. Social status encompasses various factors, including income, occupation, education, and social connections, all of which can influence individuals' access to resources, opportunities, and social networks. Individuals with higher social status often have greater financial resources, access to influential networks, and opportunities for personal and professional development. These advantages can facilitate their participation in activities that may require financial investments, social connections, or specialized skills. Moreover, social status is closely linked to broader societal structures and power dynamics, with historically marginalized groups often experiencing barriers to accessing and participating in activities on an equal footing. Therefore, disparities in social status can contribute to inequalities in participation opportunities, perpetuating cycles of disadvantage and exclusion. Addressing disparities in social status requires systemic interventions aimed at promoting equity and social justice. Efforts to reduce income inequality, improve access to education and employment opportunities, and foster inclusive social networks can help level the playing field and create more equitable participation opportunities for all individuals. Furthermore, recognizing the impact of social status on participation underscores the importance of creating environments that value diversity, inclusion, and equal opportunity. By promoting social policies and practices that prioritize equity and justice, societies can work towards ensuring that everyone has the opportunity to participate and contribute to their communities.

With a coefficient of -0.0682 and an odds ratio of 0.93, we can interpret that family size has a negative relationship with participation. However, the associated odds ratio suggests that the impact is minimal, with a negligible decrease in the odds of participation for each additional unit of family size. This implies that while larger family sizes may be associated with slightly lower odds of participation, the difference in participation rates between families of varying sizes may not be significant. It's essential to consider the potential reasons for this negative relationship between family size and participation. Larger family sizes may entail greater caregiving responsibilities, time commitments, and financial constraints, which can limit individuals' ability to participate in activities outside of their familial obligations. Moreover, the minimal decrease in the odds of participation associated with family size suggests that while it may have some influence, it is not the sole or primary determinant of participation. Other factors, such as socioeconomic status, education, and personal motivations, may play more significant roles in shaping individuals' likelihood of engaging in activities. Furthermore, exploring the interaction between family size and other factors, such as household income and access to support networks, could provide further insights into their combined effect on participation rates. Understanding how these factors intersect and influence participation can inform targeted interventions and policies aimed at promoting more inclusive and equitable participation opportunities for all individuals, regardless of family size.

With a coefficient of -0.6129 and an odds ratio of 0.54, we can interpret that cultivated area has a negative impact on participation. Specifically, individuals with larger cultivated areas are about 0.54 times less likely to participate compared to those with smaller cultivated areas. Cultivated area reflects the extent of agricultural activities and land use, which can impact individuals' time, resources, and priorities. Individuals with larger cultivated areas may face greater demands on their time and energy related to agricultural work, which can limit their availability and capacity to participate in other activities. Additionally, larger cultivated areas may be associated with rural or agricultural livelihoods, where access to infrastructure, services, and opportunities for leisure or recreational activities may be limited. Moreover, the negative impact of cultivated area on participation underscores the complex relationship between livelihoods, land use, and social engagement.

Agricultural activities are often integral to rural economies and livelihoods, yet they can also pose challenges in terms of balancing work, family responsibilities, and participation in community or social activities. Addressing barriers to participation related to cultivated area requires holistic approaches that consider the interconnectedness of livelihoods, land use, and social dynamics. Efforts to improve access to agricultural resources, support sustainable farming practices, and enhance rural infrastructure and services can help create conditions that enable individuals to participate more fully in community life. Furthermore, recognizing the impact of cultivated area on participation underscores the importance of promoting diverse and inclusive participation opportunities that accommodate the needs and priorities of individuals engaged in agricultural activities. By fostering environments that value and support rural livelihoods and community engagement, societies can work towards ensuring that everyone has the opportunity to participate and contribute to their communities.

These results shed light on the significant impact of livestock ownership on participation rates. Livestock Holding, its coefficient of 1.2600 and odds ratio of 3.53 indicate a strong positive relationship with participation. This suggests that individuals with higher livestock holdings are approximately 3.53 times more likely to participate compared to those with lower livestock holdings. Livestock ownership can provide individuals with valuable assets, income opportunities, and social capital, which may enable them to engage more actively in various activities. Moving on to Oxen Owned, its coefficient of 0.4682 and odds ratio of 1.60 demonstrate a positive relationship with participation as well. For each additional unit of oxen owned, the odds of participation increase by approximately 60%. Oxen are often essential assets in agricultural and rural livelihoods, playing crucial roles in tasks such as plowing fields and transporting goods. Therefore, individuals with more oxen may have greater capacity and resources to participate in activities beyond their immediate agricultural responsibilities. Livestock and oxen are not just economic assets but also hold cultural and social significance in many communities. Therefore, their ownership can influence individuals' social status, access to resources, and opportunities for participation in community activities. Furthermore, addressing barriers to livestock ownership and oxen ownership, such as access to markets, veterinary services, and financial resources, can help promote more inclusive participation opportunities for all individuals, regardless of their livestock holdings.

Soil Fertility Status, its coefficient of 0.3677 suggests a positive impact on participation, indicating that higher soil fertility status is associated with increased participation. However, the odds ratio of 1.44 implies a moderate increase in the odds of participation for each unit increase in soil fertility status. This suggests that while soil fertility status does positively influence participation, the effect size may not be substantial. Moving on to Market Distance, its coefficient of -0.0352 implies a negative effect on participation, indicating that greater distances to markets are associated with decreased participation. The odds ratio of 0.97 suggests a minimal decrease in the odds of participation for each unit increase in market distance. This indicates that while market distance does negatively influence participation, the impact is relatively small. Credit shows a coefficient of -0.3173, indicating a negative relationship with participation. This suggests that individuals with access to credit are less likely to participate compared to those without. The odds ratio of 0.73 implies a moderate decrease in the odds of participation for individuals with access to credit. This indicates that while credit access does negatively influence participation, the effect size is moderate. For example, while soil fertility status may influence agricultural productivity and livelihoods, its impact on participation may be mediated by factors such as access to markets, agricultural extension services, and social networks. Similarly, market distance may reflect broader structural challenges related to infrastructure, transportation, and access to markets, which can affect individuals' ability to engage in economic, social, and recreational activities. Moreover, access to credit can be both a facilitator and a barrier to participation, depending on factors such as interest rates, repayment terms, and individuals' financial literacy and risk tolerance.

Extension coefficient of 0.0040 implies a slight positive effect on participation, suggesting that access to extension services may contribute to increased participation. However, the associated odds ratio of 1.00 indicates that the impact is minimal, with no significant change in the odds of participation. This suggests that while extension services may play a role in promoting participation, their influence may be limited in magnitude. Irrigation Distance, its coefficient of -0.7471 and odds ratio of 0.47 indicate a significant negative relationship with participation. Individuals located further away from irrigation sources are approximately 0.47 times less likely to participate compared to those closer to irrigation sources. This highlights the importance of proximity to irrigation infrastructure in shaping participation rates, particularly in agricultural activities where access to water is crucial for productivity and livelihoods. Extension services play a vital role in disseminating information, training, and resources to farmers, which can enhance their agricultural practices and productivity. However, factors such as the quality, accessibility, and relevance of extension services may influence their effectiveness in promoting participation. Similarly, irrigation infrastructure plays a critical role in determining agricultural productivity, water availability, and crop yields. Individuals located further away from irrigation sources may face greater challenges in accessing water for irrigation, which can impact their ability to engage in agricultural activities and participate in related opportunities. Addressing barriers related to extension services and irrigation infrastructure requires coordinated efforts to improve access, quality, and relevance. Investments in extension programs, infrastructure development, and technology adoption can help bridge gaps and empower individuals to participate more fully in agricultural activities and community life.

The provided statistics offer a comprehensive overview of the logistic regression model's performance and significance in predicting participation based on the specified independent variables. Firstly, the Likelihood Ratio chi2 (LR chi2) statistic,

with a value of 106.80, signifies that the model is statistically significant overall. This indicates that the combination of independent variables included in the model collectively contributes to explaining the variation in the dependent variable, participation. The Pseudo R-squared (Pseudo R2) value of 0.4052 provides insight into the goodness of fit of the model. This metric suggests that approximately 40.52% of the variance in participation can be explained by the independent variables considered in the model. While Pseudo R2 is not directly comparable to R-squared in linear regression, it serves as a useful measure of the model's explanatory power in logistic regression settings. The probability associated with LR chi2 (Prob > chi2) being 0.0000 indicates a high level of statistical significance. A value lower than the conventional threshold of 0.05 suggests that the model's results are unlikely to have occurred by chance alone. This reinforces the confidence in the model's ability to predict participation based on the selected independent variables. The log likelihood value of -85.223 represents the maximized value of the likelihood function given the estimated parameters of the model. This value is utilized in model comparison and inference, with higher values indicating better fit to the data. Lastly, the number of observations (Numb ons), which is 400 in this case, reflects the size of the dataset used for the logistic regression analysis. A larger sample size generally increases the reliability and generalizability of the model's findings.

Table 1: Logistic Regression Results

Participation	Coeff	Odds ratio	SD	Z
Cons	-1.4852		1.5177	-0.98
Sex	0.6551	1.93	0.4600	1.42
Education	0.2595	1.30	0.0732	3.54***
Experience	0.0160	1.02	0.0285	0.56
Social status	1.0190	2.77	0.4291	2.37**
Family size	-0.0682	0.93	0.1254	-0.54
Cultivated area	-0.6129	0.54	0.1553	-3.95***
Livestock holding	1.2600	3.53	0.2791	4.51***
Oxen owned	0.4682	1.60	0.2250	2.08**
Soil fertility status	0.3677	1.44	0.4671	0.79
Market distance	-0.0352	0.97	0.0674	-0.52
Credit	-0.3173	0.73	0.5665	-0.56
Extension	0.0040	1.00	0.00167	0.24
Irrigation dist	-0.7471	0.47	0.1750	-4.27***
LR $chi^2(13)$ = 106.80		Pseudo R^2 = 0.4052		
Prob > chi^2 = 0.0000		Log likelihood = -85.223		
Numb ons=400				

Table 2 presents the outcomes of a balancing test for covariates in an observational study, aimed at evaluating the similarity in the distribution of various variables between the treated and control groups before and after matching. Each row in the table corresponds to a different covariate included in the analysis, while the columns provide key statistics for assessing balance. Before matching, notable differences in means between the treated and control groups are evident, as indicated by the t-test %bias values. For instance, variables such as SEXH and EDUCHH exhibit considerable differences in means between the two groups, suggesting potential imbalance. This imbalance is further corroborated by the significant t-test statistics and associated p-values, indicating statistically significant differences in means before matching. However, after matching, there is a substantial reduction in the absolute difference in means between the treated and control groups, as reflected in the %reduct values. This reduction suggests improved balance achieved through the matching process. Additionally, the bias values after matching are notably smaller, indicating that the means between the treated and control groups are now much closer to each other, signifying improved balance. Furthermore, the t-statistic and corresponding p-values after matching assess the statistical significance of the difference in means between the treated and control groups. In cases where the p-values are non-significant, it suggests that the difference in means is not statistically significant after matching, indicating successful balancing of the covariates between the two groups.

Before matching, there are noticeable differences in the means of covariates between the treated and control groups, as indicated by the %bias and t-test values. For instance, variables like CULTSIZE, LIVESTOC, and OXNUMB exhibit substantial differences in means between the two groups, suggesting potential imbalance. However, after matching, there is a considerable reduction in the absolute difference in means between the treated and control groups, as demonstrated by the %reduct values. This reduction suggests that the matching process has effectively improved balance between the groups for most covariates. Additionally, the bias values after matching are much smaller, indicating that the means between the treated and control groups are now closer to each other. Furthermore, the t-statistic and corresponding p-values after matching assess the statistical significance of the difference in means between the treated and control groups. In cases where the p-values are non-significant, it suggests that the difference in means is not statistically significant after matching,

indicating successful balancing of the covariates between the two groups. In addition to understanding the statistical results, it's essential to consider the specific variables being examined in this balancing test for covariates. For instance, CULTSIZE likely represents the size of cultivated land, while LIVESTOC and OXNUMB may indicate livestock holding and the number of oxen owned, respectively. These variables offer insight into the characteristics of individuals in the study population and their potential impact on treatment outcomes. Overall, the results of the balancing test suggest that the matching process has effectively reduced the imbalance between the treated and control groups, resulting in a more comparable distribution of covariates. This enhanced balance increases confidence in the validity of the observational study's findings and strengthens the credibility of the conclusions drawn from the analysis.

Table 2: Balancing Test for Covariate

		Mean			%reduct	t-test	
Variable	Sample	Treated	Control	%bias	Bias	t	p>t
_pscore	Unmatched	.7287	.27124	186.8		13.21	0.000
	Matched	.49545	.488	2.9	98.5	0.15	0.882
SEXH	Unmatched	.77	.63	30.8		2.17	0.031
	Matched	.69565	.6744	4.7	84.8	0.22	0.829
EDUCHH	Unmatched	5.62	3.91	56.8		4.02	0.000
	Matched	4.7391	4.898	-5.3	90.7	-0.24	0.814
EXPFARM	Unmatched	26.65	25.35	17.1		1.21	0.228
	Matched	26.304	24.72	20.8	-21.5	0.93	0.355
SSO	Unmatched	.73	.54	40.1		2.83	0.005
	Matched	.6521	.6097	9.0	77.6	0.42	0.677
HHSIZE	Unmatched	5.64	5.25	22.6		1.60	0.112
	Matched	5.3261	5.121	11.8	47.5	0.54	0.593
CULTSIZE	Unmatched	3.017	4.109	-76.0		-5.37	0.000
	Matched	3.588	3.545	3.0	96.1	0.15	0.881
LIVESTOC	Unmatched	1.854	1.328	60.7		4.29	0.000
	Matched	1.468	1.508	-4.7	92.3	-0.23	0.820
OXNUMB	Unmatched	1.56	1.28	32.5		2.30	0.023
	Matched	1.478	1.425	6.1	81.2	0.27	0.789
SOILFERT	Unmatched	.77	.74	6.9		0.49	0.624
	Matched	.7391	.7437	-1.1	84.7	-0.05	0.96
MARKTD	Unmatched	10.136	10.64	-16.1		-1.14	0.258
	Matched	10.141	10.27	-4.1	74.4	-0.20	0.841
CREDIT	Unmatched	.14	.18	-10.9		-0.77	0.443
	Matched	.152	.143	2.3	78.4	0.12	0.908
EXTCONTC	Unmatched	25.38	23.94	12.3		0.87	0.387
	Matched	24.13	24.45	-2.7	77.7	-0.13	0.898
IRRID	Unmatched	1.341	3.738	-21.9		-1.55	0.124
	Matched	1.859	1.914	-0.5	97.7	-0.18	0.858

Table 3 presents findings regarding the average treatment effect on the treated (ATT) for two key variables: calorie intake per day and net income. This analysis aims to understand the impact of a specific treatment or intervention on these outcomes compared to a control group. For the variable "Calorie/day," the treated group has an average intake of 3251.16 calories per day, while the control group's average intake is notably lower at 2130.20 calories per day. This results in a substantial difference of 1120.96 calories per day between the treated and control groups. Similarly, for "Net income," the treated group has a significantly higher average net income of 6379.12 compared to 3345.82 for the control group, resulting in a difference of 3033.29. The significant t-statistics (denoted as ***) associated with these differences indicate that they are statistically significant at a high level of confidence. This suggests that the observed differences in calorie intake per day and net income between the treated and control groups are unlikely to have occurred by chance alone. These findings imply that the treatment or intervention under study has a meaningful impact on both calorie intake per day and net income among the treated individuals. Specifically, the treated group shows higher levels of calorie intake and net income compared to the control group. Such insights are crucial for evaluating the effectiveness of interventions and understanding their implications for improving outcomes related to health and economic well-being. Additionally, the standard errors provided in the table offer a measure of uncertainty around the estimated differences. They indicate the precision of the estimates and provide context for understanding the reliability of the observed effects. Overall, the results underscore the importance of considering treatment effects in program evaluation and policy decision-making processes.

Table 3: Average Treatment Effect on Treated

Variables	Sample	Treated	Controls	Difference	S.E	T-stat
Calorie /day	ATT	3251.16	2130.20	1120.96	382.0	2.99***
Net income	ATT	6379.12	3345.82	3033.29	1116.73	2.72***

4. CONCLUSIONS

The objective of this study was to assess the influence of small-scale irrigation on income generation and food security among farm households in the central East Hararghe lowland areas of Oromia, Ethiopia. Data for the analysis were sourced from both primary and secondary sources. The primary data collection involved administering semi-structured questionnaires to 400 households, evenly split between irrigation users and non-users. Additionally, secondary data from various sources were utilized to complement the primary data. Regression analysis was employed to identify factors influencing income generation, while propensity score matching was utilized to evaluate the impact of irrigation on household food security status. The decision to participate in irrigation farming is influenced by various factors such as the education level of the household head, distance to irrigation schemes, cultivated area, livestock holdings, ownership of oxen, and involvement in social organizations. Through propensity score matching, 46 participating households were successfully matched with 95 non-participating households, ensuring similarity in pre-participation characteristics except for the treatment effect. After applying various quality tests, the matched comparisons indicated significant differences in outcomes of interest between treatment and comparison households. The impact estimation results suggest that participation in small-scale irrigation has a notable effect on farm income and food security status. Specifically, households engaged in irrigation practice experienced a 44% increase in calorie intake and a 38% improvement in farm income compared to non-participating households. Furthermore, the results from the Rosenbaum bounding procedure, designed to assess hidden biases due to unobservable selection, indicate the robustness of the estimated treatment effects for significant outcome variables.

REFERENCES

Adank. M. Jeths, M. Belayneh, B. Chaka, S. Lema Z. Damake, T. and Zemede, A. (2008). The costs and benefits of multiple uses of water: The case of Gorogutu woreda of East Haraghe Zone, Oromiya Regional State, Eastern Ethiopia. Working Paper No. 7, Addis Ababa.

Ahmad K. & Ali, A. (2016). Rising Population and Food Insecurity Linkages in Pakistan: Testing Malthusian Population Growth Theory. *International Journal of Economics and Empirical Research (IJEER)*, 4(1), 1-8.

Ahmad, N., & Khan, A. (2021). Food Self-Sufficiency and Food Security: A Holistic Approach. *Journal of Business and Economic Options*, *8*(2).

Kassegn, A., & Endris, E. (2021). Review on livelihood diversification and food security situations in Ethiopia. *Cogent food & agriculture*, *7*(1), 1882135.

Kibatu, T., Tigabu, B., Mamo, M., Tolosa, S., Girma, F., Debebe, N., & Shewarega, M. (2021). On-Farm Management, Processing and Post-Harvest Handling of the Indigenous Enset (Ensete ventricosum (Welw) Cheesman) in Gedeo Zone, Southern Ethiopia. *Ethiopian Journal of Agricultural Sciences*, *31*(2), 73-85.

Naeem, M., & Hameed, F. (2017). Assessing the Impact of Climate Change on Cash and Food Crop Production in Pakistan: Insights and Adaptation Strategies. *Journal of Policy Options*, *4*(2), 27-34.

Qasim, M., & Tariq, M. (2019). Determinants of Food Insecurity: A Comparative Analysis of General and Farmer Households in Pakistan. *Journal of Business and Economic Options*, *6*(4).

Slaymaker, O., Spencer, T., & Embleton-Hamann, C. (2021). Recasting geomorphology as a landscape science. *Geomorphology*, *384*, 107723.

Tesfay, M. (2021). Understanding Food Security: Perspectives on National Self-Sufficiency. *Journal of Business and Economic Options*, *8*(3).

Wassie, S. B. (2020). Natural resource degradation tendencies in Ethiopia: a review. *Environmental systems research*, *9*(1), 1-29.

Yigezu Wendimu, G. (2021). The challenges and prospects of Ethiopian agriculture. *Cogent Food & Agriculture*, *7*(1), 1923619.