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Review Article

Determinants of the Adoption of Small-Scale Irrigation Technology and Its Impact on Household Food Security in Ethiopia: A Review

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Abstract: Agricultural technology is among the most impactful areas of modern technology; it plays a key role in enhancing agricultural yield, reducing poverty, and improving national food security. Agricultural production in Ethiopia is primarily rain-fed and depends on erratic and insufficient rainfall. Moreover, the adoption of small-scale irrigation and its impact on household food security, which can be used as a major policy issue, have not been well reviewed. Therefore, this review paper aims to review the determinants of the adoption of small-scale irrigation and its impact on household food security in Ethiopia. The review indicated that education level, household size, off-farm job participation, farmland size, information access, livestock owners, access to credit, access to water, and extension contact were important variables that positively and significantly influenced the adoption of small-scale irrigation. The adoption of irrigation and other agricultural water management practices has a significant impact on household food security. Since the adoption of small-scale irrigation practices has a significant impact on household food security, actions should be taken by farmers, extension agents, stakeholders, and generally by the Ethiopian government and non-government to make a huge improvement in small-scale irrigation agriculture in the country.

Keywords: Adoption, Agriculture, Food Security, Impact, Small-Scale, Irrigation

1. Introduction

Ethiopia is primarily an agricultural country, with most of its population directly or indirectly engaged in agriculture. Agriculture is the main pillar of Ethiopia's economy, employing 75% of the labor force, accounting for 40% of GDP, and 80% of the national export value [1]. Having a high percentage of the labor-aged population and dependency of 70% of the country's population living in rural areas on agriculture, agriculture is a leading sector. Agricultural technology is among the most impactful areas of modern technology; it plays a key role in enhancing agricultural yield, reducing poverty, and improving national food security [2].

Irrigation plays an important role in stabilizing agricultural production and mitigating the negative effects of fluctuating or inadequate rainfall. It can also increase both yield and cultivation intensity. Irrigated agriculture plays a vital role in global food security and the well-being of much of the world's population, providing approximately 40% of global agricultural output. At the 1996 World Food Summit, the Food and Agriculture Organization (FAO) estimated that 60% of the additional food needed in the future would have to come from irrigated agriculture. In Ethiopia, 5.3 million hectares of land might be used for irrigated agriculture using

surface, ground, and rainfall sources [3, 4].

Although Ethiopia has abundant rainfall and water resources, its agricultural sector has not yet completely benefited from irrigation and water management technology [4]. To overcome this gap, the Government of Ethiopia (GOE) and its development partners have taken several initiatives to diversify the country's agricultural system. Several studies have been conducted by various authors on the adoption of small-scale irrigation technology and its impact on household income separately. However, no well-organized literature review has been performed to assess the determinants of the adoption of small-scale irrigation technology and its impact on household food security in Ethiopia. Therefore, this review paper reviews various sources of information on the factors influencing the adoption of small-scale irrigation technologies and their impact on household food security and proposes several future research studies to assist future researchers.

2. Literature Review

2.1. Basic Concepts and Definition

Irrigation is defined as the artificial application of water to living plants for food production, overcoming the shortage of rainfall, and stabilizing agricultural production and productivity. It is used in areas where rainfall is erratic or where dry seasons or droughts are expected [5]. Small-scale irrigation is a type of irrigation defined as a scheme managed and maintained by individuals, families, communities or local rules or a scheme carried out independently by rural farming households on a small plot of land. Small-scale irrigation is more profitable for farmers, with higher yields and profitability, better food and nutrition security, and resilience to climate shocks. Ethiopia has great potential to expand SSI and has invested heavily in this area in recent years. Small-scale irrigation is a form of irrigation of small fields where farmers have a controlling influence and must participate in the design and decision process, covering an area of less than 200 ha [6].

Food security is defined as a situation that exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life. The concept of food security emerged in the mid-1970s during the international debate on the global food crisis. The focus on food security initially focused primarily on nutrition issues to ensure the availability and, in some cases, price stability of staple foods at the international and national levels. Many development workers understand the concept of household food security as the availability of food in global markets and food production systems in developing countries [7].

Thresholds and distinguish food security from food insecurity situations. Food availability refers to sufficient quantities of food of appropriate quality supplied through domestic production or imports, including food aid. Food access is the state of having sufficient means to buy the right foods for a balanced diet. It is an entitlement or command over the food supplied [8]. The use of food is to provide an adequate diet, clean water, sanitation, and health care to search for a state of nutritional wellbeing. It is about the cultural acceptability of food in local communities. Food's level of shock and other crisis resilience is referred to as its stability. Thus, the concept of food security consists of food and non-food inputs and can be achieved by fulfilling the above four food security elements [9].

2.2. Factors Affecting the Adoption of Small-Scale Irrigation in Ethiopia

Various studies were conducted to determine the factors that led to the adoption of small-scale irrigation in various nations, including Ethiopia. Several factors affect technology adoption, according to an empirical evaluation of the literature on the subject in developing nations. Various factors and their relationships impact how various technologies are adopted throughout place and time. Factors related to socioeconomic, technological, geographical, demographic, and institutional factors are the main variables that affect the adoption of small-scale irrigation. Researchers determined different factors that affect participation in small-scale irrigation by smallholder households using different models and hypothesized different repressors that influence small-scale irrigation adoption [10].

According to Jambo, Alemu [11], determinants of adoption and intensity of adoption of irrigation in Adami Tulu Jido kombolcha district study on employed binary probit model of education level of household head significantly positive, suggests that educated farmers were more likely to engage in irrigation activities than uneducated farmers. Farmers need good information about technology to make the right decisions. Hence, the level of adoption of small scale irrigation may be influenced by the education level of the household head. This result is similar to several studies previously conducted by Belachew [12], who found that educated farmers have more capacity to search for technologies suitable to their production constraints than less educated farmers. Educated farmers may easily process and search information for appropriate technologies to alleviate their production limitations compared with non-educated farmers.

According to the Yihdego and Ghosal [13] study on the impact of small-scale irrigation on household income using the probit model, age is positively associated with the adoption of small-scale irrigation. Similarly, Hadush [14] also found that the age of the household head has a positive effect on participation in small-scale irrigation. However, these results contradict the study of Gebrehiwot, Makina [15], which indicated a negative relationship between age and adoption of irrigation. Hence, the reason behind this is that initially, when the age increases, the probability of the adoption of small-scale irrigation increases. After some period, this relationship might not hold the same when the age of household heads becomes too old. Thus, the sign of age of the household head remains controversial.

Moreover, off-farm job participation is another important factor that can affect irrigation adoption. According to Assefa, Ayalew [16] a study conducted on small-scale irrigation impact on farmers' livelihoods; in the case of Mekdela Woreda, Ethiopia, the result of the binary logit model showed that off-farm job participation was negatively associated with the probability of small scale irrigation adoption. Thus, farmers in off-farm jobs are less likely to adopt irrigation technology. This is because off-farm job participation may restrict the allocation of labor to farm activities. However, this is contrary to Hadush [14], which indicated that participation in off- farm activities positively affect the adoption of small scale irrigation. Consequently, it may create additional income for farmers, which enhances the purchase of necessary inputs of irrigation technology.

According to Abdissa, Tesema [17] in their study on the impact analysis of small scale irrigation schemes on household food security employing the Heckman model, total livestock holding has a significant and negative relationship with the adoption of irrigation schemes. Asrat and Anteneh [18], also agree with this result. In essence, combining a large livestock population with field cultivation may create difficulty in management. Therefore, total livestock units may have a negative association with the adoption of small scale irrigation farming. Distinctively, in the participation of small-scale irrigation, the number of oxen is one of the important factors for rural farm households that are forgotten by most researchers. However, [19] reflected on the number of oxen and noted that it has a significant and positive effect on participation in irrigation. Since ox is the most important animal used for farming purposes, high numbers of oxen could help households to farm their own land and can rent and share in other lands for farming.

According to Mohammed and Shallo [20], a study on the impact of adopting motor pump technology on smallholder farmers' income: Empirical Evidence from Southern Ethiopia using logistic regression estimation of factors driving motor pump adoption found that the size of farm land and participation in local organizations have a significant impact on motor pump adoption. Similarly, Asrat, Anteneh [21] also found that land holding positively and significantly determined the decision to participate in irrigation of both per capita consumption expenditure and income.

Development agent is an institutional factor that can obtain more information on how to use irrigation and better skill and knowledge about irrigation. The study by Zeweld, Hidgot [22] on the adoption of irrigation and its impact on household income in northern Ethiopia, by using the Heckman model access to information, are important factors influencing farmers' decisions to use irrigation similarly, to Legesse, Ayele [23], Impact of Small Scale Irrigation on Household Farm Income and Asset Holding: Evidence from Shebe Dino District, Southern Ethiopia, by using logistic model, found that contact with agricultural development agent is positive relationship with irrigation use indicate that farmers who have more contact with development agent have more information on how to use irrigation than those who have no or less contact. Furthermore, a positive relationship between irrigation use and participation in irrigation use-related training indicates that households that frequently follow training may have better skills and knowledge of the irrigation system.

Numerous studies have shown that household size significantly affects the adoption of agricultural advances. There is a chance that family size will be considered when adopting irrigation technology because the size of the household is probably a proxy for labor supply that could either drive adoption or hinder it. Irrigation in Ethiopia is considered a significant strategy to alleviate poverty and enhance food security. To transform country agriculture from a rain-fed farming system, an irrigation system is an essential strategy. Hence, it is understood that farmers' decisions to adopt or reject irrigation at any time are influenced by various factors. For ease of grouping, categorized the variables identified as having a significant relationship with adoption as demographic, socioeconomic, and institutional factors.

2.3. Impacts of Small-Scale Irrigation on Household Food Security

Adoption of small-scale irrigation and other agricultural water management techniques has a favorable developmental influence on the overall economy as well as a substantial impact on families in terms of wealth creation and food security [18]. Small-scale irrigation is essential to boost agricultural productivity during times of low rainfall, develop land, and reduce dependence on rain farming. Through improved income, food security, addressing social needs, and lowering poverty, it can improve rural communities' quality of life overall. Therefore, small-scale irrigation agriculture is now a priority of the Ethiopian government's agricultural transformation and food security strategy [17].

According to Dawit and Balta [24], regarding the impacts of irrigation on food security, irrigation had a positive impact on the reduction of rainfall dependency and food security in Ethiopia. Various studies have shown that small-scale irrigation has a positive impact on food security. Several studies have confirmed that the food security of smallholder farmers is significantly influenced by small- scale irrigation. Food security is a condition for people to fulfill their food preferences and the need to build an energetic and strong life by having the right to access sufficient, reliable, and healthy food Irrigation usage helps non-irrigated users survive by offering employment opportunities; regular laborers work wholly or partially on irrigation farms.

According to Legesse, Ayele [23] studied the impact of small-scale irrigation on household farm income and asset holding. The author found that participation in irrigation users increased annual household farm income by 19,474.8 birr for participant households compared with non-participant households, which was significant at 1% level. Similarly, it has increased their physical asset holdings, which are measured in the Ethiopian birr valued at 27,502.4-ETB at a 1%

statistical significance level. Therefore, the author concluded that small-scale irrigation has a positive and significant impact on the annual farm income and asset holdings of rural farming households. Adoption of irrigation and other agricultural water management practices has a significant impact on households in terms of wealth creation and food security as well as a positive developmental impact on the general economy.

According to Assefa, Ayalew [16], a study on the impact of small-scale irrigation schemes on farmers' livelihoods in Mekdela Woreda, northeast Ethiopia, employed an endogenous switching regression model to capture the impact of irrigation on farmers' livelihoods and household total income. The model results show that the positive and significant impact of irrigation schemes increased users' total income by 7829 ETB (8.5%) compared with non-users. This shows the significant role of a small-scale irrigation scheme in improving the livelihood conditions of farmers. In reality, adopters of irrigation farming are more likely to employ more labor than non-adopters. This might be an indicator of the multidimensional role of irrigation technology in generating employment opportunities.

According to Haileyesus [25], the Tobit model revealed that age of the household head and crop disease are reported to negatively affect food security, and conversely, access to extension services, land holding size, livestock ownership, and market access are among the factors positively affecting the food security status of households. Irrigation customers invest the money they save on irrigation in various ways. Some irrigation users volunteer in the community, whereas others are more concerned with their children's education. This implies that irrigation users have improved food consumption expenditures than non-users because irrigation practices enable farmers to obtain more farm income from growing crops more than once a year and help them overcome the problems of deficiency of food availability.

According to Domènech [26] irrigation can improve the amount of food available to households through two main pathways. Access to irrigation water can improve the quantity and variety of food we grow. It also enables households to buy more food because the sale of small-scale irrigation technology may increase their income. He also points out that irrigation improves agricultural production in three ways. First, irrigation improves yields by reducing crop losses due to erratic, unreliable, and inadequate rainwater supplies. Second, irrigation allows for multiple plantings, increasing the annual yield. Third, irrigation makes more land available for cultivation in areas where rain-fed production is impossible or marginal.

3. Conclusion

Irrigation as an agricultural intensification method plays a role in increasing agricultural production and productivity. The results of the review show that education level, household size, off-farm job participation, farm land size, information access, livestock owners, access to credit, access to water, and extension contact were important variables that significantly influenced the adoption of small-scale irrigation. By growing better value crops for the market and harvesting more than two harvests per year, irrigation in Ethiopia helps farmers' income, household resilience, and livelihoods against shocks and stressors. In actuality, irrigated farming adopters are more likely to use more labor than non-adopters. This might be a sign of the multifaceted impact irrigation technology has on creating jobs, household income, building assets, improving nutrition and food security, reducing poverty, creating jobs, increasing agricultural productivity, intensifying crop production, and diversifying the agricultural sector.

Irrigation adoption contributes positively and significantly to family food security, as noted in various studies. To help farmers generate additional income, all responsible development partners, including the government and NGOs, should promote small-scale irrigation farming across the country to encourage and provide the necessary support to farmers. The government and other concerned bodies should work on expanding and enhancing its technological development. It also is crucial for policymakers to ensure that smallholder farmers have access to credit to purchase necessary agricultural inputs that improve their adoption level of irrigation farming.

Conflicts of Interest

The authors declare no conflicts of interest.

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