

Review on Adoption of Irrigation and Its Impact on Household Livelihood in Ethiopia

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Abstract: Agriculture remains the mainstay of the Ethiopian economy. However, in the country, traditional rain fed smallholder farmers dominates the agricultural sector. Thus, Ethiopia has a huge potential of water resources. Nevertheless, there is a vast gap between the irrigated area (only about 10% of the total cultivated land) and irrigation potential in the country. In Ethiopia, still about 97% of food crops are produced by traditional rain-fed agriculture. Thus, the agricultural production activity is highly depends on seasonally rain-fed farming practice. Moreover, the adoption of irrigation and its impact on household livelihood which can be used as the major policy issue have not been well reviewed earlier. Therefore, the objective of this review is to identify the factors affecting the adoption of irrigation, and its impact on household livelihoods. The review indicated that age of household head, sex of household head, total livestock unit, land size, education level, family size, market distance from the farmer's residence, access to a water source and off farm job participation are significant determinants of adoption of irrigation. Institutional factors like credit service, participation in community leadership, access to agricultural input and extension service are also significant determinant factors. Since the adoption of irrigation practice has significant impact in improving household livelihoods, actions should be taken by the farmer's, extension agents, stakeholders and generally by the Ethiopian government to make a huge improvement on the irrigation farming in the country.

Keywords: Adoption, Agriculture, Ethiopia, Impact, Irrigation, Livelihood

1. Introduction

Agriculture is a vital part of household livelihood and the economy of developing countries. In terms of contribution to the overall economic growth and development, agriculture is the leading sector in Ethiopia [47]. Thus, it accounts for about 36.7% of the nation's GDP, 81.1% of exports, and 80% of the labor force [39]. Even though it has a potential role, in Africa, agriculture is characterized by "low-input/low-output" practices were the main farming approach is subsistence-oriented rain fed agriculture [7]. From the total cultivated part, area under irrigation is only about 6 percent [24]. Particularly, in Ethiopia the dominant farming strategy is rain fed agriculture.

In Ethiopia, chronic food insecurity is familiar because of degradation of natural resources, poverty, and weak institutions. Moreover, low market performance and inconsistent policies have led the country to the food insecurity [54]. In addition, high population growth in the

country creates pressure on limited and fragile land resource. As a consequence, environmental damage probably happens which leads to unsustainable resource exploitation [50]. Moreover, in the arid and semi-arid land parts of Ethiopia, urgent food security aid is facing due to the frequent effects of drought, water scarcity, vulnerability and unpredictable rainfall [13]. In most parts of Ethiopia, as a consequence of the amount and distribution of rainfall, the rain-fed agriculture production has been highly fluctuating [31]. Thus, the irrigation farming strategy plays a great role to endure this challenge and to enhance agricultural production and productivity. This leads to stabilizing household income, and improving the nutritional and health status of the community and overall reducing poverty [25].

Hence, the transformation of the rain fed farming system into the irrigation farming system is essential to minimize the risk of insufficient and uneven distribution of rainfall. Thus, in this manner, the irrigation farming system can enable accelerated and sustainable development in agriculture sector.

Most importantly, irrigation farming secure food security and food self-sufficiency, enhances the production of superior crops and growing of crops more than once in a year [27]. Furthermore, in terms of climate change management, poverty reduction, wealth creation and economic growth, adoption of irrigation development and sustainable water management programs could provide plenty of opportunities. Consequently, it reduces the environmental impact of agricultural expansion to marginal land under rapid population growth [12].

Ethiopia has ample amount of surface water (122 billion meters cube) and groundwater (2.6-2.65 billion meters cube) from the 12 river basins. It indicates that the physically available water per person per year is about 1575 meter cube which is relatively large volume [10]. Even though the country has ample amount of water resources, the agriculture sector does not yet fully benefit from it. To overcome this gap the Government of Ethiopia (GoE) and its development partners have been taken several initiatives to diversify the agricultural system of the country [47].

Starting the last decade, both government and non-government organizations in Ethiopia have been initiating and implementing irrigation projects. However, still in Ethiopia, nearly 97% of food crops is produced by the rain fed farming system, while the rest 3% is from an irrigation farming system [22]. The country irrigated area is only about 10% of the total cultivated land [40]. This indicates in Ethiopia, between the potential and portions of land under irrigation, there is a substantial gap. Even though there is a high ambition for irrigation development, deliveries have failed to meet many of the irrigation targets in Ethiopia [11].

Moreover, there is no adequate and well reviewed information on the factors affecting the adoption of irrigation and its impacts on household livelihood for responsible bodies. The knowledge of role of irrigation is significant for farmers, government and nongovernmental organizations to improve the development of irrigation schemes in Ethiopia. Therefore, the objective of this review is to identify the factors determines the adoption of irrigation and to assess the impact of irrigation on the farm household livelihood in Ethiopia.

2. Literature Review

2.1. Definition and Basic Concept

Adoption: The process by which an individual person or a given organization identifies and implements a new technology is called adoption [38]. The process of adoption begins with the awareness about the technology. Subsequently, the formations of an attitude were followed by the decision to adopt or not adopt the technology. After that, the intention to implement the technology and lastly the implementation of the innovation ensued [46, 16].

Irrigation: defined as a method of applying water to the soil purposefully to meet the water needs of growing plants

[18]. Thus, it is an intentional human action to apply water to the soil for growing crops, especially to endure the shortage of rainfall during dry seasons [45]. This action is a profession as well as a science [19].

Livelihood: can be defined as the various activities and resources that let people to live. In a few words, the livelihood is a 'means of making a living' [23]. It comprises the activities required for a means of living, the capabilities, and assets for a living. Considering the natural resource base, it can be sustainable when it can survive the stress and shocks and maintain its capabilities and assets, both now and in the future [17].

Impact: can be defined as a long-term effect produced by a development intervention directly or indirectly, intentional or unintentional, which may yield a positive or negative result [43]. Thus, the intervention might be a small project implementation, a large programme, a collection of development activities, or a policy alteration [44].

Small scale irrigation: It is a type of irrigation that smallholder farmers' can operate and maintain effectively typically on small plots by using a given level of technology. In small-scale irrigation, farmers' involvement is essential in the design process, and decisions making about its boundaries. Generally, the layout of the canals, and the position of outlets and bridges are farmer managed [48].

2.2. Factors Affecting Households' Decision to Adopt Irrigation

In Ethiopia, to alleviate poverty and enhance food security, irrigation is considered as a significant strategy. To transform the country agriculture from the rain fed farming system, irrigation system is an essential strategy [29]. Hence, it is understood that farmers' decision to adopt or reject irrigation at any time is influenced by a variety of factors. For ease of grouping, [36] categorized the variables identified as having a significant relationship with adoption as demographic, socioeconomic, and institutional factors.

2.2.1. Demographic Factors

According to the [53] study on the impact of small scale irrigation on household income by using probit model, found that age is positively associated with the adoption of small scale irrigation. Similarly, Hadush Hailu [28] also found the age of the household head has positive effects on the participation of micro irrigation. However, these results against the study of Eliyas Assefa [21], Kidanemariam *et al* [32], and Beyan *et al* [15], that indicated the negative relationship between age and adoption of irrigation. Hence, the reason behind is that, initially, when the age increase, the probability of the participation of irrigation could increase. 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 household head remains controversial.

Concerning the determinants of small-scale irrigation practice and its contribution to household farm income, [6] conducted studies in Arba Minch Zuria Woreda, Southern Ethiopia, by using logistic regression model. This study

identified that sex of household head' has significant and positive effects on the adoption of irrigation. In line with this finding, the study by Abdi *et al* [1], and Tadesse *et al* [49] reported that male headed households have more chance to adopt the irrigation farming than their counterparts. This is due to cultural biases where female-headed households have limited resource access and males have more exposure to other social and economic activities.

2.2.2. Socio-Economic Factors

According to Abdissa *et al* [2] study on 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. The study by [1, 19] is also in agreement with this result. In essence, combining large livestock population with the field cultivation may possibly create the difficulty of management. Due to that, total livestock unit possibly will have a negative association with the adoption of irrigation farming. Distinctively, in the participation of small scale irrigation, numbers of oxen are one of the important factors to the rural farm household's that forgotten by most researchers. However, the study by [3] reflected on number of oxen and noted that it has significant and positive effects participation in irrigation. Since ox is the most important animals used for farming purpose, high numbers of oxen could help household to farm its' own land and also can rent in and share in other lands for farming.

Family size is also an important characteristic influencing the adoption behavior of farmers. By using logit model to reveal factor influences household's participation in micro irrigation, [28] found that family size has positive association with the likelihood of irrigation participation. The findings reported by [34, 49] and [21] mainly focused on the size of an active household engaged in agricultural labor force. This finding stated that active household size has a significant positive effect on the participation of irrigation. Due to the reason of, irrigation is mostly labor intensive; household heads with larger family size can more probably have more labor to engage in irrigation farming.

By using the logit model, [14] studied the small-scale irrigation technology impacts on the nutritional wellbeing of children in the Amhara region, Ethiopia. The result shows that the size of land holdings has a positive effect on the likelihoods of adopting irrigation technology. This is in line with the study conducted by [37, 2]. Thus, holding large size of land creates better opportunity to participate in irrigation and probably assist utilization of land extended to the riverbank. In addition, instead of total land holding, [3] focused on the size of irrigable land as a determinant of irrigation participation. The authors point out that the large size of irrigable land has a positive relationship with the probability of adoption of irrigation. Thus, the accessibility of irrigable land encourages the farmers to participate in irrigation farming practice.

Regarding to the small scale irrigation impact on household welfare, Anwar Alamin [9] conducted study on the

Laelay Dayu Irrigation Scheme, Alamata District, Tigray. The author point out that level of education was significantly and positively influences irrigation participation. Many studies reported positive effects of level of education on irrigation participation [14, 19, 34]. Thus, there is a strong link between education and knowledge and the ability to understand irrigation technology. Therefore, the better the education, the better know how have the people, and the better they would behave the capacity, and capability to implement the irrigation technology.

Moreover, off-farm job participation is another important factor that can affect the irrigation participation. According to [21] study conducted on small scale irrigation impact on farmer's livelihood; the case of mekdela woreda, Ethiopia, the result of the binary logit model show that off-farm job participation was negatively associated with the probability of irrigation participation. Thus, farmers occupied in off-farm job are less likely to adopt irrigation technology. This is due to off-farm job participation may restrict the allocation of labor to farm activities. However, it's against the study conducted by [28] that indicated, participation in non-farm activities positively affects the adoption of micro irrigation. As a consequence, it may create additional income for farmers, which enhance the purchase of necessary inputs of irrigation technology. Despite the fact that it deserves further study to compromise contradiction.

2.2.3. Institutional Factors

Credit is an institutional factor that can facilitate farm households to purchase the needed agricultural inputs. The study by [49] on the Adoption and impacts of an irrigation technology, by using a logit model, revealed credit access was positively associated with the irrigation participation. This is in agreement with the finding of [37, 2]. Essentially, it indicates access to credit service enables farmers to afford input and labour costs which might encourage them to decide on irrigation participation.

Moreover, extension service is another essential factor which determines the adoption of technology by enabling farmers to access information via communications and more opportunities to participate in demonstration tests. In view of that, [32] on the study of micro-irrigation impact on households' welfare in the northern part of Ethiopia found that extension service has a positive association with the probability of adoption of irrigation. Since the household information about the irrigation technology, highly depend on the extension service, this variable is one of the important determining factors for the household whether to participate or not in irrigation farming. Many authors, for instance, [4, 28, 6] and [2] have reported a positive relationship between extension services and irrigation adoption. Most importantly, extension service enhances the farmers to get training on the irrigation technology in particular and generally on all aspects of the modern agricultural technology.

On the topic of the impact of adopting motor pump technology on smallholder farmers' income, the study by [37] revealed that the household head participation in community

leadership positively affects the adoption of irrigation farming. This result is in agreement with the study of [15, 3]. Hence, participation in community leadership assists farmers to share their knowledge related to irrigation technologies among the social participants and enable to get information from local administrations.

Furthermore, for producers, market distance is an important factor which has a substantial effect on the reduction of transportation cost. In view of that, [21] stated market distance is significantly and negatively affect the adoption irrigation farming. In essence, the probability of Participation in irrigation farming will be decreased when distant to market increase. This result is in agreement with the study by [28, 1]. Hence, if the market is far, transportation costs are high. As a result, the probability of access to market information is low. This leads farmers choose to sell their product with cheaper price at farm area and/or consume for themselves as well. In addition, the study by [15] point out that weather road distance is also an essential variable to the adoption of irrigation. The study indicated that, like market distance, weather road distance is also negatively associated with the probability of irrigation participation. The reason is that farmers may probably fail to get their product to the market due to difficulty in access to transportation service in such areas, which is likely to discourage the farmers to participate in irrigation.

According to [33] study, proximity of household residence to water source is a key determinant of participation in irrigation farming. The results stated that household's residence distance from water sources is negatively related to the probability of participation in irrigation. Many studies, for instance, [2, 19, 15] and [6] have reported a negative relationship between the distance of a household's residence to water sources and participation of irrigation. Essentially, to access the irrigation scheme, households nearby to the water sources do not incur much cost. As a consequence, they might quickly decide to participate in the irrigation farming.

Most importantly, [1] on the studies of impact of boset-fentalle irrigation on the income of agro pastoralist; by using the logit model revealed that access to agricultural input positively affect the probability of participation in irrigation. Also, [34] noted that fertilizer uses and improved seeds are positively affect probability of household participation in irrigation program. Hence, farm input uses actually increase the agricultural productivity, which might encourage farmers to participate in irrigation farming.

2.3. The Impacts of Irrigation

Adoption of irrigation and other agricultural water management practices has significant impacts on the households in terms of wealth creation and food security as well as a positive developmental impact on the general economy [5]. As mentioned in numerous studies, adoption of irrigation has a positive and significant role in household livelihood.

A study by [8] indicated that on average, households using traditional irrigation and occupied in participatory small-

scale irrigation development programme had higher crop yields. This enables participant farmers to exercise the crop diversification. Similarly, [34, 41] stated that food and nutrition status and the overall benefits of local farmers highly improved through the irrigation dam project.

According to the previous studies [42, 51, 6] and [20], to increase farm household income, access to irrigation is an essential mechanism. Moreover, to reduce the dependence on food aid, and overall, to improve the rural economy, irrigation has a significant impact. Similarly, [33, 30, 52] noted that irrigation access possibly increased mean annual household income. According to these findings, the opportunity for crop intensity and diversification could be increased through irrigation access. Above all, this possibly will lead farmers to increase crop income. Moreover, households who adopt irrigation farming have more opportunity to harvest more than two times of high value crops that increased their annual production. As a consequence, adopters of irrigation farming have more income compared to non adopters' households from the sale of crops. Most importantly, the same findings point out that by providing feed during the dry seasons, irrigation practice also plays a significant role to improve the livestock productivity.

Also [38] mentioned that in draught mitigation measures and improvement of household food security, irrigation development plays an important role. Concerning the smallholders' irrigation practices and issues of community management, the findings noted the household income in particular and generally, their livelihoods could be improved through utilizing irrigation farming. Moreover, in terms of households' poverty reduction, [4] found that the treadle pump irrigation adoption has an important contribution. Similarly, [26] and [2] reported that in terms of boosting agricultural production, irrigation farming has a positive and significant impact. In essence, irrigation approach is a highly recommended to enhance food security of the rural farmers.

Mostly, through increased productivity and food availability, irrigation interventions can improve nutritional outcomes and households diet [35]. In addition, the study by [49, 28] indicated that participation of irrigation has significantly contributed to the farmers in terms of productivity, and employment creation. In reality, the adopters of irrigation farming's are more likely to employ more labour as compared to non-adopters. This might be an indicator of the multidimensional role irrigation technology in terms of generating employment opportunities.

In addition to impact on income, and agricultural productivity, irrigation also has a positive and significant impact on the fixed asset formation [1, 32, 52]. Furthermore, focusing on the household welfare, the study by [9] concludes that the irrigation adopters' household life standard is better than non adopters. Thus, the finding stated that irrigation participation enhance households to practice crop diversification, to increase farming intensity, to minimize crop failure and overall to enhance productivity and farm

income. In perspective of poverty reduction, the same author stated that the severity of poverty were significantly higher for the non adopters of irrigation. Thus, irrigation intervention significantly contributes in poverty reduction.

3. Conclusion and Recommendation

The essence of the review is to thoroughly examine various factors determines the adoption of irrigation by smallholder farmers. The result of the review point out that, distance to weather road, number of total livestock units, distance of household residence to water sources, and distance to market are negatively associated with the adoption of irrigation. Further, the review had shown sex of household head, family size, land size, educational level, access to credit, access to extension service, participation in community leadership and access to input confirms the positive significant effects on the adoption of irrigation. The effects of age and off farm job participation in adoption of irrigation farming are contradicted.

The adoption of irrigation has significant impacts on household livelihood indicators such as household income and asset formation, nutrition, food security, poverty reduction, employment creation, agricultural productivity, opportunity for crop intensity and diversification. This implies that to improve the livelihood of rural household promoting irrigation programs is an important strategy.

The following actions should be taken by the decision maker to solve problems of inadequate use of irrigation technology and thereby to improve rural household livelihoods.

- 1) The review recommended that efforts should be made by the Ethiopian government to extend road infrastructure, and to facilitate marketing service for smallholder farmers through market linkage.
- 2) Introducing irrigation farming should be supported with a continuous training or technical backup on how to manage and utilize the irrigation material. Thus, the concerned body should be working to strengthen the extension agent capacity and enhance access to education.
- 3) Irrigation farming needs access of agricultural inputs and suitable materials. Therefore, it is crucial for policy makers to ensure that smallholder farmers are able to have access to credit in order to purchase necessary agricultural input which improve their adoption level of irrigation farming.
- 4) Access to water source, new employment opportunities, and increased income may encourage women's participation in irrigation. Therefore, the government of Ethiopia and non government organization should try to encourage and increase women's participation via more research to better understand how irrigation programs may be designed.

Declaration of Conflicts of Interest

The authors declare that they have no competing interests.

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