



The Impact of Small Scale Irrigation on the Income and Food Security Among Small-Scale Farmers in Ethiopia: A Review

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Abstract: Irrigation in Ethiopia is perceived as a key approach to minimize poverty, food insecurity, and rising income. Irrigation has various positive and harmful effects on the country as a whole. Based on the studies conducted in Ethiopia, the reviewer is intended to review the impact of small-scale irrigation on smallholder farmers' income, food security, and health condition in Ethiopia. Different documents carried out in Ethiopia were reviewed as the source. The income of the smallholder farmers was improved positively and significantly due to practicing small-scale irrigation as reviewed. The occurrence of waterborne diseases including malaria, schistosomiasis, cholera, bilharzia, typhoid, diarrhea, and bacterial dysentery within the irrigation practicing system was significantly higher than in the rain-fed practicing system. Therefore, initiating private investment in delivering inputs, manufacturing, distributing, and maintaining irrigation technologies should be expected from local, woreda, zonal, and national level administration as well as other private bodies. Building strong capacity in information management, technical capacity, and know-how at national, regional, zonal, and woreda levels on planning, implementation, monitoring, and evaluation viewpoint related to irrigation management to improve irrigation practice among users have to be required.

Keywords: Income, Malaria, Impact, Irrigation

1. Introduction

Agriculture is the main focus area for many developing countries including Ethiopia to ensure food security, improve income, create employment, and serve as an input for other sectors. The agricultural sector provides a significant role in Ethiopia's economy while the economy of Ethiopia was increased by 6.1% in 2020. Agriculture's sector contribution to GDP has fallen over but larger than 70% of the labor force was working in this sector [2]. However, the sector is still over-involved with inadequate agricultural innovation and practiced by large smallholder farmers by using the only rain-fed farming system which results in low output. Ethiopia has a total of 16187 and 37903 (in terms of 1000 hectares) arable and agricultural land in 2018 respectively [15].

Practicing irrigation in Ethiopia is the most imperative way to lessen poverty, food insecurity and take pressure off the dependence on the rain-fed farming system [22]. In 2016,

from the total cultivated smallholder land close to 2.7 million hectares were irrigated [36]. Practicing irrigation is important for compensating for low rainfall, increasing production and productivity, multiple cropping per year, increasing cultivable land, and boosting economic growth [49].

Different kinds of literature have been conducted in Ethiopia using household and cross-sectional data to evaluate household welfare and small-scale irrigation relationship. For example, there is an 8.8 percent income difference between micro-irrigation beneficiaries and non-beneficiaries [32]. According to different scholars, there is an increment in the income of small-scale farmers in Ethiopia because they are used small-scale irrigation [1, 6, 42, 51].

Food security of the small-scale farmers was improved significantly in Ethiopia since they practiced small-scale irrigation [4, 21, 43]. The use of small-scale irrigation also causes water-borne diseases like malaria, hepatitis, cholera, typhoid, guinea worm, schistosomiasis, sleeping sickness, yellow fever, etc, and increases the occurrence of water-

borne diseases around the community [8, 11, 30]. Many studies were focused more on the improvement of farm income, and poverty reduction, but few kinds of literature tried to include harmful impacts on health. The overall goal of this review is to make available information on small-scale irrigation's direct and indirect impact on smallholder users in different parts of Ethiopia.

1.1. Objective

This review paper is intended to make public information about small-scale irrigation's impact on smallholder farmers' income, food security, and health in Ethiopia.

1.2. Data Collection and Interpretation Method

The studies conducted in different parts of Ethiopia at different times by different researchers were reviewed to

collect necessary data that could supplement the study. The gathered data was organized and justified. The reviewer supports the consistency and difference of separate authors and made his understanding.

2. Definition and Methods of Irrigation

Irrigation is the method of providing water to the land using the man-made process for fulfilling the amount of water required by the crops for growth as shown by [40]. It is the unnatural procedure of applying water to fertile land using systematically verified ways and applying it [20].

Methods of Irrigation Systems

Irrigation systems are different based on how the water is spread all over the land [10]. A few types of irrigation were included below:

Table 1. Irrigation Methods.

Types	Definition
Surface irrigation	Water is distributed over and across the land by gravity.
Localized irrigation	Water is distributed under low pressure, through a piped network and applied to each plant
Drip irrigation	Water is delivered at or near the root of plants.
Sprinkler irrigation	Water is distributed by overhead high-pressure sprinklers or guns from a central location in the field or sprinklers on moving platforms.
Center pivot irrigation	Water is distributed by a system of sprinklers that move on wheeled towers in a circular pattern.
Manual irrigation	Water is distributed across land through manual labor and watering cans.

2.1. Benefit of Irrigation

Irrigation provides numerous benefits for the user's [46]. The basic motive for irrigation is to provide water for the plant to meet full vapor transpiration. It is required when rainfall deficient has occurred in terms of space and time in certain environments. But the application of irrigation is also useful for improving food production, supplementing natural precipitation when rainfall is not enough, increasing crop yields and quality in many countries comprising Ethiopia.

The use of irrigation allows farmers to grow high-value crops twice or more all over the year that will improve their diet [46].

2.2. The Area Under Irrigation in Ethiopia

The overall water requirement will rise quickly in the next centuries globally. The overall farmland was 20% and about 40% of food was produced by irrigation globally [14]. The prospect essentiality of the water by all sectors will vary from 25 to 40 percent to be recycled for maximizing productivity and employment activities [47].

Still no formal understandable record that confirms the whole area underneath irrigation in Ethiopia. Wide-ranging and integrated water management and optimal exploitation of available water are important for improving the living standard, food independence, and food security of the citizens by establishing water resource management [36]. As depicted by Ethiopia's Ministry of Agriculture about 1.2 million hectares of land were proposed to be irrigated and over 120 million quintals were estimated to be harvested

until September 2020. A total of 2.1 million farmers and around 300,000 women would be involved in irrigation [48]. There is an increment in the total area allocated for irrigation in Ethiopia from 290 thousand hectares in 1999 to 858 thousand hectares at a mean yearly rate of 5.95% in 2018 [50]. There is also an annual rise in total irrigated land in Ethiopia from the 2007-2018 production seasons. Annually total irrigated land in 2007 was 523 000 hectares but there is 335 000 hectares increment from 2007-2018 which resulted in 858 000 hectares of total irrigated land in Ethiopia.

Table 2. Total irrigated land in Ethiopia.

Year	Irrigated total area in 1000 hectares
2018	858
2017	858
2016	858
2015	858
2014	800
2013	760
2012	720
2011	680
2010	640
2009	600
2008	562
2007	523

Source: FAOSTAT 2021.

2.3. Indicators and Status of Food Security in Ethiopia

Food security in Ethiopia is varied due to factors like desert locust infestation, poor rainfall, conflict, climate change, high food prices, and the COVID-19 while 8.5

million are highly food insecure people [29]. Food security is measured by dietary energy supply using the number of calories from food available for human consumption [28]. The overall average dietary energy supply has increased from 2716 kcal/cap/day in 1999–2001 to 2904 kcal/cap/day in 2015–17 [14]. Food security can also be explained by dietary diversity to measure distinctive food categories eaten at a certain time [27].

Lack of enough food consumption causes health trouble and represents the numbers of underfeeding (PoU) [15]. In 2019, undernourishment occurrence was 19.7%. The pervasiveness of undernourishment cut down slowly from 39.2% during 2005 to 19.7% within 2019. In 2018,

expenditure on food per capita was \$257.4. In 2014, about \$210.3 was spent on food per capita whereas in 2018 was \$257.4 [50]. Food security is also computed by the convenience of food and high food convenience is connected with a relatively low incidence of malnutrition and a low incidence of serious food insecurity.

Agricultural food production is affected by conflicts, climate change, and politics and initiates the increment of hungry people in the world. Food supply variability in terms of kilocalories per capita per day in 2000 was 22 and increased to 39 in 2017. Another food security indicator is food production variability in terms of dollars per capita which was 5.8 in 2000 and 5.8 in 2017 in Ethiopia.

Table 3. Food security indicators of Ethiopia.

Year	Prevalence of undernourishment (%) /3-year average	Number of people undernourished (million) /3-year average	Average dietary energy supply adequacy (%) /3-year average	Per capita food supply variability /kcal/cap/day	Per capita food production variability (thousand dollar per capita)
2000-2002	47.1	32.1	86	22	5.8
2001-2003	44.3	31.1	87	21	4
2002-2004	42.7	30.8	88	20	2.6
2003-2005	39.2	29.1	89	19	2.4
2004-2006	37.2	28.4	90	15	2.4
2005-2007	35.8	28.1	91	13	2.5
2006-2008	35.3	28.5	92	25	1.9
2007-2009	33.9	28.1	93	25	2.4
2008-2010	31.8	27.1	94	30	2.5
2009-2011	30.7	26.9	95	30	2.6
2010-2012	30.1	27.1	96	27	3.6
2011-2013	29.9	27.8	96	16	3.6
2012-2014	27.5	26.2	98	14	3.2
2013-2015	24.8	24.3	100	14	2.9
2014-2016	21.5	21.7	103	27	2.5
2015-2017	20.6	21.3	104	35	5.8
2016-2018	19.9	21.1	105	37	-
2017-2019	19.7	21.5	105	39	-

The price of food determines the households spent on food and non-food expenditures [34]. Food consumption expenditure refers to the monetary value of acquired food, purchased and non-purchased, including non-alcoholic and alcoholic beverages as well as food expenses on away from home consumption in bars, restaurants, food courts, work canteens, street vendors, etc [14]. In 2018, expenditures spent on food for Ethiopia were 56.62%. There is an increment in expenditure on food per capita in Ethiopia from 2013-2018 and it increased from 193.8 in 2013 to 257.4 in 2018. Expenditure spend on food in 2018 was 257.4 and there is an increment from 2013 which indicates 193.9 [50].

Table 4. Expenditure on food per capita.

Year	Expenditure on food per capita	Expenditures spent on food
2018	257.4	56.62
2017	254.9	56.54
2016	257.9	56.78
2015	236.7	54.70
2014	210.3	54.24
2013	193.9	53.89

Source: Knoema (2021).

2.4. Small Scale Irrigation Impact on Smallholder Farmers Income

Studies conducted in different parts of the world including Ethiopia confirmed that there is an increase in production and productivity, initiation in crop diversification, and encouragement of the farmers to use improved varieties because of the small-scale irrigation practice. Practicing irrigation is more economically vital if the production is concentrated on high-value crops [37].

According to the study done by [1] depicted that the income of irrigation practicing households is more by ETB 9423.37 than non-practicing households on average. As shown by [46] after controlling for pre-intervention differences, the income is increased positively and significantly by ETB 1870.71 via PSM model. There is ETB 13341.782 and ETB 13392.02 difference between participants and non-participants households applying different matching algorithms of Propensity Score Matching (PSM) model [25].

The micro-irrigation practice improved household income positively and significantly applying the Propensity Score matching model and ETB 19,474.8 growth on the average for irrigation participating farm households [35]. The income of

the household would be increased if farm households shift from non-irrigation farming systems to irrigation farming systems by ETB 16,016.29 per year per hectare applying the Tobit model [26]. The households who were involved in irrigation practice obtained higher gross income than non-users households in different parts of Ethiopia [3, 6, 7, 44, 46]. A better changeability relating to income previous to and following irrigation is described by [12]. There was a 12,630 ETB income difference between users and non-users as a result of small-scale irrigation participation.

A total of 175 users and non-user respondents were applied by the PSM model in the study done by [41]. However, the result is compatible with other previous studies. Data were gathered from 180 samples of households to find the effect of irrigation on the user of households [23]. Therefore, the result of the study signifies there is an ETB 3353 per year increase in the income of irrigation using households. The reviewer agreed that using irrigation has improved the income of the user smallholder farmers positively and significantly in different parts of Ethiopia. Therefore it is important to initiate the farmers to participate in small scale irrigation by facilitating necessary inputs, creating awareness on how to use irrigation technologies, identifying factors affecting their participation in irrigation, facilitating credit services for the farmers to obtain inputs at the right time, and season to produce different crops.

2.5. Irrigation Impact on Smallholder Farmers Food Security

Several studies confirmed that the food security of smallholder farmers was significantly influenced by small-scale irrigation. Food security is a condition for the people to fulfill their food preference and need to build energetic and strong life by having the right of entry to sufficient, reliable, and healthy food, and for all persons [16].

Women are the most affected and exposed group of the community to a moderate and severe level of food insecurity in the world [16]. In 2017, the food security indicator is about 39 kcal/cap/day which is increased by 2 kcal/cap/day (denote 37 kcal/cap/day in 2016). In other ways, it is about 2.5 in terms of 1000 dollars in 2015 whereas from 2016-2019 was around 105% in Ethiopia [15]. Close to 58.5% of people were living in poverty in Ethiopia [17]. The food security of several million people in Africa including Ethiopia is hindered by different factors [18].

The study done on the food security of small-scale farmers described that treatment group households obtained ETB 2556.8 more than control group spending by an adult per year. This implies irrigation users have improved food consumption expenditure than non-users because irrigation practices enable the farmers to get more farm income from growing crops more than once a year and help them to overcome the problems of deficiency of food availability [38].

Irrigation users consumed more energy of 529 kilocalories than non-users and user households have a better food consumption score than irrigation non-users by 3.69 on Walmara district, Finfinnee surrounding Oromia special zone

using PSM model [19]. Cross-sectional data were collected from a total of 294 households by [43].

Most of the irrigation practicing households improved their food security than non-practicing households using the data were collected from 200 samples of the household [45]. There is a momentous distinction amongst the food security of the users [13]. This indicated that about 65% of irrigation beneficiaries were food secured and only 29% of non-beneficiaries were food secured. Irrigation practicing households have improved food security at the family level [24]. However, only 28.6% of non-user were food secured and 80.8% have improved food security.

As indicated in the different literature, the use of small-scale irrigation decreased the prevalence of food insecurity among the user's households in different parts. The reviewer supported the arguments that practicing irrigation improved users' food security status positively and significantly than non-users. Therefore the use of irrigation improved the food security of the user's households in terms of both daily calorie intake and household food consumption score positively and significantly if the pre-intervention difference is controlled.

2.6. Negative Impact of Small Scale Irrigation on Health

Additionally, irrigation has also a negative socio-economic impact on the household, community, and country. As mentioned by different literature, irrigation can upset the problem of water-borne diseases. The negative impact of irrigation on the user's health results from the use of corresponding inputs for the products [33]. The occurrence of disease transmitted by water started after irrigation dam installation [39]. Irrigation initiates water-born infection transmitted through water-borne, fecal-orally methods, swept with water, host living in water and insect-borne parasites are diseases caused by irrigation use [9].

Agroecosystem with rain-fed farming system received low malaria disease event than irrigation practicing agroecosystem. The study informed that irrigation practicing areas were infected by malaria throughout the year than non-irrigation practicing areas [30]. Irrigated practicing areas are more influenced by Anopheles species disease than non-irrigated areas in all seasons on the study done by [11]. The occurrence of diseases like pests, insects, and mosquitoes was increased in the community based on the study by [5]. The use of irrigation increases the cost of medication and decreases the labor forces in the Central Tigray regional state of Ethiopia and also increases children and adult death by 25% and decreases active labor forced used for agricultural production by 35% in this area. The grounds of malaria disease spread is the expansion of mosquito breeding in the area due to the use of irrigation in Simret as depicted by [8, 11].

The establishment of irrigation increased both potentially dangerous mosquitoes and the number of sick people.

The occurrence of malaria in irrigated villages was six times greater than non irrigated village's monthly [31]. The reviewer argued that the use of small-scale irrigation accelerates the frequency of water-borne diseases in different

parts of Ethiopia. Therefore it is important to incorporate health-related policies and strategies during and after the establishment of small-scale irrigation at local, regional, and national levels.

3. Conclusions and Recommendations

Based on the different reviewed literature, both positive and negative impacts of small-scale irrigations on the user smallholder farmers were reviewed. As reviewed in the above section, the use of small-scale irrigation in Ethiopia enabled smallholder farmers to expand cropping and to produce different crops over once per year.

A large number of smallholder farmers in Ethiopia practiced rainfall-dependent crop production with low production and productivity however small-scale irrigation is perceived as the most important strategy to improve income, food security and turn down poverty. Based on the review, participating in irrigation has a direct impact on the smallholder farmers' income. The participant farmers in the irrigation improved their food security as publicized by different authors. The use of small-scale irrigation also stimulates the occurrence of water-borne disease breakdown like malaria all over the place of the users. As presented in the above sections, different authors agreed and revealed his/her result by using a different methodology. Therefore, this review aims to incorporate the arguments and disagreements of different authors.

Corresponding to the review, the resulting indication is recommended.

Irrigation advancement is an imperative investment area in the country. Encouraging investment in irrigation is momentous to boost the size of land. Therefore, initiating private investment to involve in the irrigation sector by creating the right and proper conditions that support their participation in delivering inputs, manufacturing, distributing, maintaining irrigation technologies, facilitating training, workshop, and fields to the users at the right time and quantity should be needed.

The establishment and implementation of small-scale irrigation need the coordination of different stockholders' knowledge and skills. However, without strong human, technical, conceptual, and diagnostic management skills it is impossible to bring expected results among users. For that reason, building strong capacity in information management, technical capacity, and know-how among government and non-government institutions at national, regional, zonal, and woreda levels on planning, implementation, monitoring, and evaluation viewpoint related to irrigation management is a very important aspect to bring the expected result.

The establishment and expansion of small-scale irrigation should be lined up with local, regional, and national levels health policy, plan, and strategy for prevention, control, and elimination of malaria and other diseases on the users. The expansion and enhancement of the irrigation technology to the users should be needed because it improved the income of smallholder farmers significantly. Conducting more

research on the socio-economic and environmental impact of small-scale irrigation is essential because it reduces poverty, food insecurity; boosts income, and also the amount produced by the farmers.

Conflict of Interest

The authors declare that they have no competing interests.

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