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*Corresponding author: Dagninet Asrat, Agri economics, Samara university, Ethiopia.
E-mail: dagninet60@gmail.com

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FOOD SCIENCE & TECHNOLOGY | REVIEW ARTICLE

The determinants of irrigation participation and its impact on the pastoralist and agro-pastoralists income in Ethiopia: A review study

Dagninet Asrat^{1*} and Adugnaw Anteneh¹

Abstract: This review identified factors that determine the decision of a household to participate in irrigation, and its impact on the income of pastoralists and agro-pastoralists. In Ethiopia, agriculture is the basic economic sector in which the country relies for its social and economic development. In Ethiopia, the majority of population directly or indirectly engaged in agriculture where around 95% of the country's agricultural output is produced by smallholder farmers. However, the sector has remained in its rudimentary stage, especially in dry lands of Ethiopia. The recurrent drought is the key factor, causes vulnerability to agro-pastoralists and pastoralists. To alleviate the problem, the government of Ethiopia has taken irrigation agriculture subsector as the main strategies in the overall country's development agenda and gives high priority to irrigation development, including smallholder and large-scale commercial schemes to exploit the untapped resources. Ethiopia is considered as the water tower of Africa. However, currently, only 5% is actually irrigated, which is very low. The basic factors influencing the decision of smallholder farmers to participate in irrigation farming are demographic, socioeconomic and institutional characteristics. Hence, to make considerable

ABOUT THE AUTHOR



Dagninet Asrat

Dagninet Asrat is a full-time lecturer in Department of Agribusiness and Value Chain Management at Samara University, Ethiopia and has MSc in Agricultural Economics from Bahirdar University, Ethiopia. He has taught several courses for agribusiness and value chain management, agricultural economics, natural resource economics and management, and rural development students. And he also has engaged in the supervision of research projects for the students in the same department. His research interests focus on conducting research challenges and the impact of irrigation on climate smart agriculture, status of food security, value chain, market chain etc. with the particular inclination to the sub-Saharan Africa.

PUBLIC INTEREST STATEMENT

Agriculture is the basic economic sector in which the country relies for its social and economic development. In Ethiopia, the majority of population directly or indirectly engaged in agriculture where around 95% of the country's agricultural output is produced by smallholder farmers. However, the sector has remained in its rudimentary stage, especially in dry lands of Ethiopia. Irrigation is one of the agricultural technologies defined as the man-made application of water to guarantee double cropping as well as steady supply of water in areas where rainfall is unreliable. Irrigation agriculture can increase production and income, protects against risks of crop loss due to insufficient rainwater supplies, promotes the use of yield enhancing farm inputs and creates additional employment. These help very poor households to meet the basic needs by improving their overall economic livelihood status that in the long run enables them to move out of the poverty trap.

improvement on the decision to adopt irrigation, actions should be taken by household heads, government of Ethiopia, national and international organizations.

Subjects: Agriculture & Environmental Sciences; Soil Sciences; Environment & Business

Keywords: income; irrigation; impact; agro-pastoralists; pastoralists; Ethiopia

1. Introduction

1.1. Background

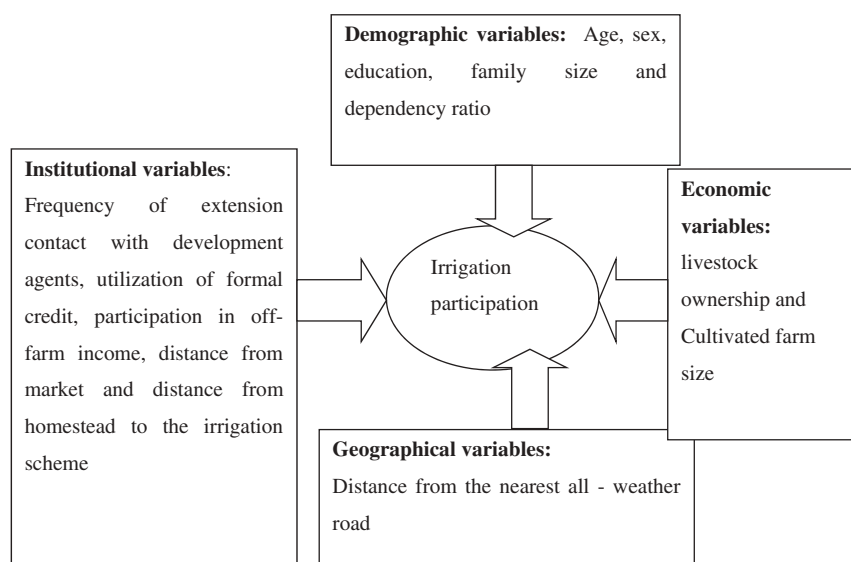
Agriculture still remains the main stay of Ethiopian economy, where around 95% of the country's agricultural output is produced by smallholder farmers (MoA, 2010). Hence, agriculture is the backbone of Ethiopian economy; it contributes 70% of export earnings, 80% of employment and 40.2% of country's gross domestic product (UNDP, 2015). In general, agriculture serves as the primary means for improving the livelihood of smallholder farmers. However, the sector has remained in its rudimentary stage because of environmental degradation, small and fragmented landholding, unchecked population growth (2.4% per annum), high rate of urbanization (5%), limited access to new agricultural technologies, traditional methods of cultivation, high dependence on natural factors and unsatisfactory institutional support services (CSA, 2012; MoFED, 2012). In most dry lands of Ethiopia, the recurrent drought is the key factor that causes vulnerability of agro-pastoralists and pastoralists. According to Duguma (2013), the traditional coping and adaptation strategies of agro-pastoralists and pastoralists in Ethiopia become increasingly insufficient to sustain local livelihoods during drought.

To overcome the challenge, it is crucial to shift and expand irrigation agriculture. According to as cited by Haile and Kasa (2015), irrigation can be defined as an artificial application of water to soil for the purpose of suppling the moisture essential in the plant root zone to prevent stress that may case reduced yield or poor quality of harvest crops. Likewise, irrigation farming increases the income of smallholder farmers at household level in particular and national level at large (MOA, 2011a). It is developed by farmers themselves, nongovernmental organizations (NGOs) or government.

The country is endowed with ample water resources with 12 river basins that provide an estimated annual runoff of 125 billion m³ and 22 natural and artificial lakes, and the ground

**Figure 1. Conceptual frame-
work for determinants of irri-
gation participation.**

Source: Modified from
Mengistie and Kidane (2016).



water potential varies from 2.6 to 13.5 billion m³ per year, which makes an average of 1,575 m³ of physically available water per person per year, a relatively large volume (Makombe et al., 2011; Michael & Seleshi, 2007; MOA, 2011a). Moreover, Ethiopia has at least 5.3 million hectares (5.3 Mha) of irrigation potential; 3.7 Mha from gravity-fed surface water, 1.1 Mha from groundwater and 0.5 Mha from rainwater harvesting (Awulachew & Ayana, 2011; Makombe et al., 2011).

In addition, various studies found that irrigation had a positive and significance influence on smallholder farmers' income (Astatike, 2016; Gebrehiwot, Makina, & Woldu, 2017; Owusu, Namara, & Kuwornu, 2011; Regassa et al., 2015; Zeweld, 2015). However, currently, only 640,000 ha (5%), which includes 128,000 ha from rainwater harvesting, 383,000 ha from small-scale irrigation, and 129,000 ha from medium and large-scale irrigation of cultivable land, is irrigated (Awulachew, Erkossa, & Namara, 2010). This indicates development of irrigation has been facing gaps between designed potential and actual area irrigated and potential and actual yield level obtained as well as perception of rural farm households. The gaps between potential and actual irrigation utilization levels were ambitious potential level (area and yield) set that in reality could not be achieved.

Hence, there is scanty of studies, especially in agro-pastoral and pastoral areas of Ethiopia. Moreover, the available studied documents were not well reviewed and documented as a literature which is a base for future studies in the sector. This knowledge is important in such a way that the people and government who are living today become aware of the contribution of irrigation. And also, help the attention of governmental organizations and NGOs to improve the existing irrigation schemes and further development of irrigation projects and programs in Ethiopia.

1.2. Objective

The overall objective of the review was to identify the determinants of irrigation participation (Figure 1) and its impact on pastoralists and agro-pastoralists income in Ethiopia.

Specifically, the study was trying:

- ✓ To review the factors affecting the decision of households to participate in irrigation farming;
- ✓ To review the impact of irrigation on households' income.

1.3. Methodology

The review was based on intensive reading of published and unpublished materials like books, articles and other scholarly materials.

2. Review of related literature

This part was discussed some concepts and definitions applied in irrigation and income analysis, the determinants of household decision to participate in irrigation farming and the impact of irrigation on households' income in Ethiopia.

2.1. Concepts and definitions

Irrigation is defined as the artificial application of water to arid land and at last rainy period's for growing crops. It is a profession as well as a science. According to Woldeab (2003), irrigation includes range of activities for the supply of water to agricultural crops by artificial means, designed to permit farming in arid regions and to offset the effects of drought in semi-arid regions and even in areas where total seasonal rainfall is adequate on average; it may be poorly distributed during a year and variable from year to year. Institutional arrangements governing the water sector for irrigation are undergoing remarkable changes worldwide. Although the extent of these changes varies by country-specific economic, political and resource realities, they do evince some common patterns and clear trends (Saleth & Dinar, 2000). Such a system of water application needs a functioning set of principles and techniques adopted by humans to create a water flow pattern within the physical structure and the varying needs of the fields.

According to United Nations Development Group (UNDG, 2011), impact is defined as changes in people's lives. This might include changes in knowledge, skill, behavior, health or living conditions for children, adults, families or communities. Such changes are positive or negative long-term effects on identifiable population groups produced by a development intervention, directly or indirectly, intended or unintended.

Income can be defined by different scholars in different perspectives. According to International Labour Organization (ILO, 2004), it refers to receipts, whether monetary or in kind, that are received by the household or by individual members of the household at annual or more frequent intervals but excludes windfall gains and other such irregular and typically one-time receipts. Household income receipts are available for current consumption and do not reduce the net worth of the household through a reduction of its cash, the disposal of its other financial or non-financial assets or an increase in its liabilities. Similarly, statistical national authority (2008) defined disposable household income as the maximum amount that a household or other unit can afford to spend on consumption goods or services during the accounting period without having to finance its expenditures by reducing its cash, by disposing of other financial or nonfinancial assets or by increasing its liabilities.

2.2. Factors affecting pastoral and agro-pastoral households' decision to participate in irrigation

In eastern Africa, pastoral and agro-pastoral farmers have long been regarded as peripheries, especially in economic terms, and also in terms of social and cultural accomplishments (Fre & Tesfagergis, 2013). Because biased perceptions of the "unproductive" uses of pastoralism have become outdated, government policies including Ethiopia still do little to formally recognize or integrate pastoral lands as critical parts of rural livelihood systems and economic development models.

In Ethiopia, most pastoral and agro-pastoral households' income from farming is not enough for the whole-year consumption. Some of the factors can be linked to low food production and productivity there by leading to pervasive poverty (Asenso et al., 2013). Here, the government of Ethiopia has taken irrigation agriculture subsector as the main strategy in the overall country's development agenda and gives high priority for irrigation development to stabilize the household income and further reduces poverty (MOA, 2011a). Moreover, under scarce and imperfect land market, it enables to create more job opportunities for some pastoralists and agro-pastoralists and this contributes for the reduction of rural unemployment.

However, currently in Ethiopia, irrigation subsector is not significantly contributing to the national economy (Tadesse & Bezabih, 2017). According to their reports, the main factors are no consistent and reliable inventory data, lack of agreed reports in common consensus and well-studied documented reports with regards to water and irrigation-related potentials and implementations.

For instance, in pastoral and agro-pastoral areas of Ethiopia, livelihood strategies include charcoal production and fire wood collections; sell of livestock, government support in the form of safety net and their indigenous social support mechanisms; petty trading especially by women; brokering on livestock trade; engagement in contraband trade; searching for daily labor and others (Tadesse, Beyene, Kassa, & Wentzell, 2015). According to their reports, they have a little knowhow about irrigation farming and lack of infrastructure development. Hence, these are the main factors that determine pastoralist and agro-pastoralist farmers to participate in irrigation farming. Similar finding is reported by Owusu et al. (2011) in Ghana; little is however known about the poverty-reducing role of already provided infrastructure against the backdrop of rising quest for more irrigation investments.

Owusu et al. (2011) on their work, the welfare-enhancing role of irrigation in farm households in northern Ghana noted that age square of household head and farm land size were significant and positively correlated with the decision to participate in irrigation. Owusu et al. (2011) in their work

on identifying the factors that determine households' decision to participate in irrigation farming in Ghana noted that age square of household head and farm land size were significant and positively correlated with the decision to participate in irrigation. This is possibly so owing to the fact that older farmers might possess richer farming experience that could be easily harnessed for improved irrigation activity. This equally has implication for farm productivity. Similarly, Abdissa et al. (2012) found that small size of farm land holding was one of the factors that are driving small-holder farmers out of irrigation farming. Individual's own asset base helps both directly and indirectly in livelihood diversification. Asset offers a store of wealth as well as provides an opportunity to invest in alternative enterprises.

Kuwornu and Owusu (2012) investigated the impact of irrigation on households' per capita consumption expenditure in Ghana using endogenous switching regression model (ESR) with sample size of 290 households. Following Lokshin and Sajaia (2004), they estimated simultaneously the selection and both outcome equations by full information maximum likelihood method. The results from ESR model indicate that number of years in school, dependency ratio, size of livestock, frequency of extension, income per capita, land covered by dam and distance from homestead to irrigation scheme significantly determine the decision to participate in irrigation.

Regassa (2015) investigated the determinants of agro-pastoralists' participation in irrigation scheme: the case of Fentalle agro-pastoral district, Oromia regional state, Ethiopia. The combination of multistage, stratified and random sampling techniques was used to collect cross-sectional data from 144 samples, of which 72 were irrigation users and 72 nonusers' households using semi-structured questionnaire. In addition, data were also supported by secondary sources (documents from agricultural and rural development office and Kebele developmental agents' office) in the study area. Logistic regression model was used to assess factors that affect participation in irrigation. The logistic regression model revealed that age, sex, income, input use and participation in cooperative organization have affected irrigation participation significantly and positively. On the other hand, farm experience, distance to the district market and total livestock unit have significantly and negatively affected households' decision to participate in irrigation.

Astatike (2016), on the study of assessing the impact of small-scale irrigation schemes on household income in Bahir Dar Zuria Woreda, Ethiopia by using Heckman selection model (two-staged), identified the factors that affect households to participate in irrigation. The probit model indicated that owning irrigation land, having pumping motor and dissatisfaction with the existing irrigation schemes are the most influencing factors that influence irrigation participation.

2.3. Impact of irrigation on the income of pastoralists and agro-pastoralists

According to Hussain and Hanjra (2004), impact studies differ in terms of geographic coverage, scale of analyses and approach adopted in measuring impacts. Accordingly, different studies adopted various scales of analyses, ranging from household to village, region and national to international levels.

According to previous studies (Gebremedhin and Peden, 2002; Hussain, 2006; Nhundu, Gwata and Mushunje, 2010), irrigation increases agricultural productivity and farm income per hectare. It insulates the national agricultural and economic sector against weather-related shocks and increasing agricultural yield, increasing the area of arable land and increasing cropping intensity (number of cropping per year). And also, Gebrehiwot, Tadesse, Bheemalingeswara and Haile Selassie (2011) found that irrigation increases production, create employment opportunities and improve living conditions of pastoralists and agro-pastoralists. Moreover, it produces export commodities that would earn foreign exchanges, provides raw materials to the local industries, protects the environment from degradation and pollution, and also increases subsurface water levels and recharges groundwater. Similarly, Belay and Bewket (2015) explained that irrigation water is critical to improve food security and rural livelihood results in poverty alleviation through increased production.

Various studies found that irrigation has a positive and significance influence on income (Astatike, 2016; Bacha, Namara, Bogale, & Tesfaye, 2011; Gebrehawaria et al., 2009; Gebrehiwot et al., 2017; Owusu et al., 2011; Regassa, 2015; Zeweld et al., 2015). Moreover, Belay, Totland and Moe (2013) and Mengistie and Kidane (2016) found that irrigation has positive impact on well-being, asset ownership and food security of rural smallholder farm households; there are clear increases in agricultural production through diversification and intensification of crops grown, household income resulting in increased consumption, sources of animal feed, human health improvements, and asset ownership results change in their mode of life, directly or indirectly.

Owusu et al. (2011) on their work of “the welfare-enhancing role of irrigation on farm households in Northern Ghana” using both propensity score matching and ESR model. They interviewed 140 irrigator and 150 non-irrigator households using cross-sectional data. Both propensity score matching and ESR model revealed that in the rural savannah region of Ghana, irrigation significantly improves household welfare via increase in net farm income, and there is more room for enhanced impacts. Finally, they recommend that pro-poor irrigation investment in this region significantly reinforces both regional and national welfare and is thus justified.

Similarly, in Ethiopia, Gebrehawaria et al. (2009) investigated irrigation investment and its impact on household income using regionally representative data in Tigray region by using PSM (Propensity Score Matching). They found that the average income of irrigator households was 50% higher than that of non-irrigator households. They added that farm income significantly and positively influences participation of irrigation, whereas off-farm income is negatively related with access to irrigation.

According to Regassa et al. (2015), the descriptive statics revealed that income from crop production is significant at probability less than 1%; the mean annual income was 20,747.9 ETB for participants and 2,509.7 ETB for nonparticipants. Further, the mean annual income obtained from livestock was 9,666.8 ETB for participants and 6,173.4 ETB for nonparticipant, respectively. After controlling both observable and unobservable bias, propensity score matching model result revealed that average treatment on the treated was 14,559.22 ETB which access to irrigation project gave an income advantage of 44.14%. The result revealed that access to irrigation has intense impact on improving household income. Finally, they recommend that it shall be great and rewarding if policy makers, designers, implementers and any funding agencies with similar interest further capitalize and scale up the project to achieve the development plan and objective.

Bacha et al. (2011) examined the impact of small-scale irrigation on household poverty in central Ethiopia, using propensity score matching and FGT (Foster-Greer-Thorbecke) model. Based on the findings, they reported that land productivity, credit utilization, mean off-farm income, asset ownership, extension support, resilience to poverty and mean food and nonfood consumption expenditures were significantly higher for irrigators than non-irrigators.

Astatike (2016) found that the average income of irrigation users (both rain-fed and irrigation user farmers) was 52% higher than non-irrigation users (only rain-fed farmers). Furthermore, the study identified the main sources of income of both irrigation users and nonusers. Cash crops, vegetables and fruits contribute higher farm income to irrigation users whereas off-farm activities and cereal crops (Maize, Teff and Finger Millet) contribute higher income to non-irrigation users. Finally, he recommended to identify the potential area under irrigation so as to bring higher and more stable income of the society.

Zeweld et al. (2015) investigated adoption of small-scale irrigation and its livelihood impacts in northern Ethiopia using Heckman model with 400 rural households. Their findings confirm the presence of a statistically significant difference in income, overall expenditure, asset accumulation and expenditures on agricultural inputs between the irrigation users and nonuser households. In contrast, no statistically significant differences in food consumption, and expenditure on

education, health and livestock resources were found. Furthermore, as expected, the poverty incidence, depth and severity values were significantly lower for irrigation users compared to nonusers. Overall, they concluded that participation in small-scale irrigation has robust and positive effect on most of the livelihood indices and that an expansion of irrigation schemes is a good strategy in the potential areas of the country.

Gebrehiwot et al. (2017) evaluate the impact of micro irrigation on households' welfare in the northern part of Ethiopia using ESR with 482 rural households sample size. They found a positive and significant impact of irrigation use, income by 8.8% and asset formation by 186% as compared to nonusers.

3. Conclusion and recommendation

3.1. Conclusion

This work has thoroughly reviewed the factors affecting smallholder farmers' decision to use irrigation farming and its impact on the income of smallholder farmers, focused on pastoralist and agro-pastoralists in Ethiopia. In most dry lands of Ethiopia, the recurrent drought is the key factor that causes vulnerability of agro-pastoralists and pastoralists. The traditional coping and adaptation strategies of agro-pastoralists and pastoralists in Ethiopia become increasingly insufficient to sustain local livelihoods during drought. Hence, development of irrigation is the main strategy of the Ethiopian government to use untapped water resources.

The strong significant association to decide the use of irrigation calls for policy measures through developing and strengthening institutions in order to pave the way to solve credit access, extension service and promoting irrigation, which are the better income-generating options. Giving training on the decision to use irrigation points the direction to create access to information and other necessary services like credit for people in the same community.

As the result of the review indicated, in dry lands of Ethiopia where agro-pastoralists and pastoralists are dominant, total livestock unit and irrigation participation are negatively related. Agro-pastoralists and pastoralists having large number of livestock are not motivated to adopt new technologies and want to diversify their farm activities because they waste much of their time at livestock rearing. They also expect that securing their food in the time of drought is an opportunity to bear the risk that may occur. The effect of education on irrigation participation confirms the positive significant role of the variable in consideration for betterment of income diversification. The more household head educated, the higher will be the probability of educating family member and to be familiar with modern technology, which the twenty-first century so badly demands. Distance to the district market and distance from homestead to the irrigation scheme are negatively related to the adoption of irrigation.

As the above literature reviewed, most studies found that irrigation has a positive and significance influence on income. Moreover, in dry land of Ethiopia, the impact of irrigation on income is highly significant because rain-fed agriculture is not mostly practiced. The reviewed document expected to provide inputs for farmers, traders, consumers, investors, governmental organizations and NGOs, researchers, policy makers and others who need this information to make appropriate decisions accordingly.

3.2. Recommendation

To make considerable improvement on the adoption status of irrigation in Ethiopia, the following measures and actions should be taken by household heads, government of Ethiopia, national and international organizations.

- Irrigation needs technical knowhow; households need to read and understand some guiding irrigation materials to obtain, process and use information relevant to the participation of irrigation. Therefore, the concerned body has to work more to increase access to education.

- The desired impacts will be achieved if an effective extension system is in place to guide farmers to understand the issues related to the optimal application of inputs, targeted planting dates and product quality to enable them respond well to market incentives. Hence, the government of Ethiopia should give special attention to strengthen the capabilities of the existing extension system by assigning additional extension agents as well as equipping them with the necessary technologically appropriate equipment such as motor cycles, mobile phones etc.
- Efforts should be made to rehabilitate current infrastructure and district marketing office should strengthen cooperative marketing and develop market linkage.
- Generally, the study suggested that the government of Ethiopia should promote different governmental organizations and NGOs for further development of irrigation schemes, adoption of modern technologies and formulation of farmers' friendly policies.

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Author details

Dagninet Asrat¹

E-mail: dagninet60@gmail.com

ORCID ID: <http://orcid.org/0000-0001-5457-5000>

Adugnaw Anteneh¹

E-mail: adugna.abvm@gmail.com

¹ Department of Agribusiness, Value Chain Management
 Samara University, Samara, Ethiopia.

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