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Impact Analysis of Small Scale Irrigation Schemes on Household Food Security the Case of Sibu Sire District in Western Oromia, Ethiopia

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Abstract

This study was aimed at examining analysing the impact of small scale irrigation on household food security in Sibu Sire district of Western Oromia regional state. Data were collected from 105 irrigation users and 45 non-users. Multi-stage stratified random sampling was applied to select the respondents. Descriptive statistics, Heckman two-stage model and Greer and Thorbecke methods were applied to analyse the data. And the analysis research result implies that 44% of the non-users and 27% of users were food insecure. The result was also revealed that 56% of non-users and 73% of the users were food secured. The model's first stage revealed the significance effects of distance from the water source, size of cultivated land, access to credit service, access to extension, livestock holding and soil fertility factors in irrigation utilization. The second stage of the model discovered that access to irrigation, household size, dependency ratio, size of cultivated land, proximity of the households to a water source, distance from the market, livestock holding, crop pest infestation, and the Inverse Mills ratio are the determinants of household food security. The study analysis concluded that small scale irrigation utilization is one of the viable solutions to secure household food needs in the study area.

Keywords: Impact; Food security; Small scale irrigation farm household; Participation; Hecckman two-stage model

Abbreviations

ETB: Ethiopian Birr; FAO: Food and Agriculture Organization; IWMI: International Water Management Institute; Kcal: Kilo calorie; MEDaC: Ministry of Economic Development and Cooperation; MoWR: Ministry of Water Resources; NGOs: Non-Governmental Organizations; OIDA: Oromia Irrigation Development Authority; OLS: Ordinary Least Square; SSDARDB: Sibu Sire District Agricultural and Rural Development; TLU: Tropical Livestock Unit; WSDP: Water Sector Development Program

Introduction

Background

Ethiopia is the 10th the largest country in Africa with an estimated total land area of 1.115 million km². Ethiopia's population is now surpassing 80 million and is the second populous country in Africa next to Nigeria [1].

Ethiopian economy is based on agriculture that contributes almost 46% of the GDP. Moreover 85% of the export and 80% of the employment opportunities are also depend on this economic sector. Both the industry and services sectors depend strongly on the performance of agriculture, which provides raw materials, generates foreign currency for import of essential inputs and food for the fast growing population.

The agricultural production system is heavily dependent on highly variable rainfall. The farming system is also mainly based on traditional farming system, which has created harmonizes between crop and livestock production for centuries [2].

In countries like Ethiopia where wide spread poverty, low farm productivity and degraded natural resources are key problems, the need to use irrigation water in agricultural system is very vital. The importance of using irrigated agriculture in Ethiopia is because of the fact that rain-fed agricultural is not capable of supplying the desired amount of production to feed the ever increasing population [3,4].

Ethiopian irrigation potential is estimated to 3.7 million hectares [5]. However, so far the country has utilized only 5% of its irrigation potential [6]. The central role of irrigated agriculture within the context of poverty reduction efforts of the country is well understood as it increases the production of agricultural raw materials, exploit land and water resources with enhanced sustainability, reduce dependence on rain based agriculture and its susceptibility to erratic rainfall prevalent in the country and avoid the shattering consequences of periodic drought [7]. As a result, irrigated agriculture currently is a priority in the agricultural transformation and food security strategy of the Ethiopian government. In line with the development policy of the country, regional states and NGOs are promoting small-scale irrigation scheme development so as to increase and stabilize food production in the country.

In Oromia National Regional State, where this study was conducted, a number of irrigation schemes have been constructed by the federal government, the regional governments and international NGO's aimed at providing assured irrigation water supply to users. Among others, the Oromia Irrigation Development Authority-Central Branch Office in collaboration with concerned development organizations has constructed a number of modern small-scale irrigation schemes [8,9].

The focus of this study, Sibu Sire district located in Western Oromia regional state, is one of potential area for the development of irrigation. Recently, in the district the local administration with support from the regional government and international NGOs are fully involved in

the promotion and development of small scale irrigation schemes in the rural part of the district [10]. Currently in addition to the existing traditional small scale irrigation schemes, three improved small scale irrigation schemes, two of them by Oromia regional state. The third scheme is by an international NGO, were constructed and fully implemented.

It is presumed that irrigation water utilization has a huge contribution for household food security. A household is said to be food insecure when its consumption falls to less than 80% of the daily minimum recommended allowance (MRA) of caloric intake for an individual to be active and healthy. The study area, Sibu Sire district, one of the irrigation potential districts of Estern Wollega Zone of Western Oromia region, small-scale irrigation scheme has been chosen as a strategic intervention to address farm household food security.

Regardless of the prospective water resource for irrigation, expansion of irrigation land and increasing the number of users, no attempt has been done to assess the contribution of irrigation water use on food security of farm household in the district.

Thus, this study focused on identifying and quantifying the socio-economic, institutional and other factors determining participation in irrigation water and the effect of small-scale irrigation schemes water utilization on household food security of the study area

Objectives

The general objective of the study is to analyse the impact of irrigation on household food security of the study area.

The specific objectives are:

- To assess factors that affect smallholder farmer decisions to participation in irrigation water use in the district.

- To identify factors that affect household food security of small scale irrigation schemes users and non-users in the study area.

Methodology

Description of the study area

The study area, Sibu Sire district, is located about 270 km west of the capital city of Ethiopia, Addis Ababa. It lies between 8°56'- 9°23'N latitudes and 36°35'- 36°56' E longitudes. The altitude of the district varies from 1336 to 2500 meter above sea level. It has an estimated area of 1,132.51 km. About 74.2% of its surface area belongs to Mid-altitude agro-climate, 7.53% of the land is highland agro-climate and the remaining 18.27% is classified as low land agro-climate. The mean annual temperature and mean annual rain fall is 25^{0}C and 1050 mm, respectively [11].

Agriculture provides the principal share of the source of revenue for the population of the district. Crop production took the lion's share followed by livestock production. The major crops include maize (25.6% of cultivated land), teff (20.5% of cultivated land), sorghum (16.5% of cultivated land), 'Nuog' (13% of cultivated land) followed by Finger millet (12.3% of cultivated land). The remaining percent of the cultivable land is covered by minor crops such as vegetables, roots and tubers and some perennial crops [12].

The district is endowed with 37 rivers providing water for both traditional and modern small scale irrigation schemes. This study was carried out on tow improved small scale irrigation schemes called Indris and Jalelle small scale irrigation schemes, located westward of the Sire, district's town. These irrigation schemes have the capacity to

develop 100 ha of land supporting about 200 households.

Sampling design and data collection methods

Sample size and sampling technique: This study applied a multi-stage sampling technique to select sample households. In the first stage, out of the 19 district's farmer associations the two namely 'Cheri Jarso' and 'Cheffe Jalalle' have been selected purposely because of availability and accessibility of irrigation schemes. In the next stage, two improved irrigation schemes were purposely selected from irrigation schemes operating in the districts based on proximity to main road and better performance of the schemes. In the third stage, the households in the two selected PAs were stratified into irrigation users and non-users. Finally, a total of 150 sample households of which 105 irrigation user households and 45 non irrigation users were selected randomly using probability proportional to size sampling technique.

Methods of data collection: In this study both primary and secondary data were used. The primary data were collected from sample farm households using a semi structured questionnaire within time frame of December, 2015 to April, 2015 by enumerators selected from rural development agents. All data collection activities were conducted under close supervision of the researcher. Supplementary secondary data were collected from published and unpublished source documents.

Data analysis techniques

Measuring household food security: Method was applied to quantity food poverty line using the cost of calorie.

$$\ln X_i = a + bC_i \tag{1}$$

Where Ci is calorie consumption and Xj food expenditure variable

The food poverty line Z is the estimated cost of acquiring the recommended daily allowance (RDA) of calories per adult equivalent.

$$Z = e^{(a+Rb)} \tag{2}$$

Where a and b are the coefficient estimates from equation (1) and R is recommended daily allowance of calories per adult equivalent.

Econometric analysis: The wider range of influence and complexity in the transmission mechanism of technology interventions on the wellbeing of the society and the ecology has posed methodological difficulties on impact assessment researches. According to Tafese , small scale irrigation scheme water use decision and its impact on household food security is also influenced by an interwoven and interacting set of socioeconomic, institutional and other related characteristics of the farmers' operational environment Heckman two-step procedures is the appropriate tool to capture unobservable factors which could affect the outcome of the interventions.

Heckman two stage analysis: Heckman two stage model is one of the tools widely used by economists to test and control sample selection biases [13]. The first stage of the model attempts to capture the factors governing membership in a program and is also used to construct a selectivity term known as the Mill's ratio which is added to the second stage equation often referred as the outcome equation.

This study, therefore, employed Heckman's two-step procedure to investigate the impact of small scale irrigation on household food security in Sibu Sire district.

Specification of the Heckman two-step procedure: The model is specified as follows [14]:

$$D_i^* = \sum_{k-1}^{k} y_k z_{ik} + u_i \qquad (3)$$

Where:

- X_{is} are variables that determine household food security

- C_i are household food security

- β_s are the coefficients

- Z_{ik} are variables that determine the decision to participate in the irrigation scheme

- u_i are disturbance terms.

$$C_i = \sum_{s-1}^{s} \beta_s X_{is} + \varepsilon_i \quad \text{Observed only if } D_i^* \ 0 \qquad (4)$$

- D_i^* are represents latent variables

- y_k are the coefficients

- ε_i are disturbance terms.

Inverse Mills ratio is related to the conditional probability that an individual household would decide to use irrigation water is determined by:

$$\lambda(-\gamma Z) = \frac{\varphi(-\gamma Z)}{(1 - \phi(-\gamma Z))} \qquad (5)$$

Where λ is inverse Mills ratio, φ and Φ are density and cumulative distribution function, respectively of the standard normal distribution.

The selection control factor ($\lambda(-Z\gamma)$) reflects the effect of all the unmeasured characteristics related to the small scale irrigation water use decisions. In the outcome equation λ is included as an independent variable in the OLS estimates to measures the influence of small scale irrigation use on household food security.

The model is specified as:

$$C_i = X\beta + \sigma_{eu} \lambda(-yz) + v_i \qquad (6)$$

Where v_i is the distributed error term uncorrelated with $X\beta$ and $\lambda(-\gamma z)$

Therefore, in Heckman's two-stage model the decision to participate in irrigation and the impact of the irrigation schemes on the food security of households can be simultaneously modelled.

Definition of variables and working hypothesis: Once the analytical procedures and their requirements are known, it is necessary to identify the potential variables and describe their measurements [15]. Accordingly, the key variables expected to have influence on small scale irrigation water-use participation and the impacts of small scale irrigation on household food security are explained below.

Dependent variables: In this study there are two dependent variables, one shows household participation to use small-scale irrigation water and the other is the impact of irrigation on household food security.

Participation Decision in irrigation (Y_1): This is the dependent variable of the first stage of the Heckman two-step procedure. This variable is a dummy variable given a value of 1 if the household participates in the irrigation scheme and 0 otherwise.

Household food security (Y_2): This variable is the second dependent variable of the outcome equation of the model. Represents annual food expenditure of the household per adult equivalent measured in local currency, Ethiopian Birr. It is continuous variable.

Definitions of explanatory variables

Based on the review of different literatures the following potential explanatory variables were considered to examine their effect on farmers' decision to participate in small scale irrigation water utilization and the impact of participation on household food security.

The variables incorporated in the analysis were sex of the household head, age of the household head, education level of the household, household family size, distance from market centre, access to extension service, crop pest infestation, soil fertility status, distance from the water source, access to credit service, dependency ratio, size of cultivated land and livestock holding.

Result and Discussion

Measuring household food security

In this study food expenditure, data were collected on a monthly basis, however, in order to calculate the food expenditure, the data was scaled up to yearly basis. Method employed in this study revealed that the estimated cost of acquiring the calorie recommended daily allowance that is 2,200 kcal per adult equivalent per day was Ethiopian Birr 1,533. It was the minimum food expenditure per adult equivalent per annum required to meet basic needs (calorie recommended daily allowance).

Based on their food expenditure per adult equivalent, the analysis result showed that 56% of non-users and 73 per cent of the users were food secured. Generally out of the 150 sample households 67% were food secure while 33% were food insecure.

Empirical result of model

After statistically confirming the overall fitness of the model for the data under consideration, LIMDEP version 8 was used for the econometric analysis of the model.

The output for the participation equation shows six variables significantly determining the decision to participate in irrigation water utilization (Table 1). These are Proximity of the households to a water source (NEAWAT), size of cultivated land (SIZLAD), access to credit service (ACCRED), access to extension (ACCEXT), livestock holding (LIVEST) and households' perception of soil fertility status (SOIFER).

Proximity of the households to a water source: was found significantly and negatively influencing the decision to participate in irrigation water utilization (Table 1). The negative relationship signifies that households residing closer to irrigation water source have higher chance to participate in irrigation schemes than those situated at far distance. In the study area most of irrigation beneficiary households are not only located closer to irrigation water sources but also with better experience in irrigation farming than those located at far distance. The marginal effect describes that when a household became far from water source by 1 kilometre, the possibility of partaking in irrigation scheme decreases by 22.3%.

Access to credit: It was positively and significantly (5% probability level) associated with household's decision to participate in small scale irrigation. The positive sign indicates that access to credit service might encourage households to decide in irrigation participation as it enables them to afford input and labour costs of their farm activity. Other

Variables	Coefficients	Marginal Effects	P-value
Constant	-1.472	-0.335	-
DISMAR	0.023	0.005	0.6059 NS
DEPRAT	0.1	0.1	0.3753 NS
AGEHHD	-0.012	-0.003	0.4947 NS
SEXHHD	-0.104	-0.025	0.8317 NS
LEVEDU	0.037	0.037	0.2875 NS
FAMSIZ	0.109	0.025	0.2236 NS
SIZLAD	0.427	0.097	0.025**
LIVSTO	-0.102	-0.023	0.041**
NEAWAT	-0.975	-0.223	0.000*
SOIFER	0.471	0.12	0.072***
ACCRED	0.57	0.094	0.037**
ACCEXT	0.79	0.181	0.022**
CROPES	0.559	0.127	0.1153 NS
Dependent variable	PARTICIP (participation decision)		
Weighting Variable	One		
Number of Observations	150		
Log-likelihood function	-43.22751		
Restricted log likelihood	-91.62965		
Chi squared	96.80427		
Degree of freedom	14		
Predicted Success	Users= 89%, success=87%	non-users=85%, overall	
Significance level	0.0000000		

Note: ***, ** and * show level of significance at 1%, 5% and 10% probability level, NS=Not significant.

Table 1: Maximum likelihood, Estimation result for the first stage of Heckman and Binary Probit model.

things being held constant, the marginal effect suggest that the chance to participate in irrigation is higher by 9.4% for households with access to credit as compared to those do not have access to credit.

Livestock holding: It was negatively and significantly affecting the decision to participate in small scale irrigation schemes. The likely reason for the negative relationship could be livestock ownership is a quality of wealthier households. Households with larger livestock herd send their family members to school which jeopardize the family's capacity manage irrigation farming activities. In fear of shortage of labour actively participating in irrigation farming, the households may not decide to participate in irrigation water utilization. However further investigation will be needed concerning the relationship of the two variables. The marginal effect indicates that increase in one TLU, the possibility of participating in irrigation decreases by 2.3%. This survey result, however, contradict [16-18].

Size of cultivated land: It was positively associated with the decision to participate in irrigation at the 5% significance level. Households with larger cultivated land also own more plots spatially distributed over various locations providing opportunities to exploit the agricultural potential of the area. Moreover households with larger land holing are more likely to occupy land extended to the river-bank which creates better opportunity to participate in irrigation. All other factors held constant, a unit increase in cultivated land size, increases the probability of irrigation water utilization by 9.7%. This result is also in contradiction with the survey result of Shiyani et al. [19]. The reason for the contradiction might be site specific potential factors that could affect the relationship. Any ways, it deserves further study to compromise contradiction.

Soil fertility status: This variable was significant at 10% probability level. It has a positive relationship with participation decision in irrigation. The regression analysis shows that soil fertility status has an influence on participation in irrigation. Households with fertile land could produce better yield, in addition to this opportunity, when the households are given access to use irrigation, the output may increase by a significant amount both for household consumption and for sale. This situation encourages them to participate in irrigation. The current survey result showed similar result with the study conducted by Koundouri et al. [20]. The marginal effect also confirms that better soil fertility status increases the household's chance of participation in irrigation by 12%.

Access to extension service: This variable had significant positive consequences on farmers' partaking in irrigation at 5% probability level. Extension service is one of the major sources of information to use farm technologies. It is through extension services that the farmers get training on advantages, practice and characteristics of all aspect of modern agricultural technologies such as irrigation, improved seeds, cultural practices and other agricultural technologies that improve household production, productivity and farm income.

Therefore, farmers who have better access to extension services have better awareness and are more likely to use irrigation water than those who do not have access [21-23]. The marginal effect of this variable also reveals that probability of using irrigation increases by 18% as farmers have access to extension service.

In the second stage of Heckman two stage/outcome equation/ of the model, eight variables were found significantly influencing household food security (Table 2). These are: access to irrigation (PARTCI), household size (FAMSIZ), dependency ratio (DEPRATI), size of cultivated land (CUTLAN), Distance from the water source (NEAWAT), distance from the market (DISMAR), livestock holding

Variables	Marginal Effect	P-Value
CONSTANT	31767	0.0000*
PARTIC	1631	0.0005*
DISMAR	-35.00	0.0248**
DPRATI	-656.0	0.0235**
AGEHH	-0.11	0.9862 NS
SEXHH	-2440	0.1695 NS
LEVEDU	24.40	0.4100 NS
FAMSIZ	-401.0	0.000*
SIZLAD	136.0	0.0298**
LIVSTO	41.00	0.0123**
NEAWAT	165.0	0.0752***
SOILFER	-54.00	0.6163 NS
ACCRED	-65.36	0.5780 NS
ACCEXT	19.00	0.6151 NS
CROPES	-268.0	0.0402**
IMR	-578.0	0.0441**

Dependent variable =ADEEXP (Household consumption expenditure per adult equivalent pre- year)
No. of observations=150
Log-L=-1181
Restricted (b=0) Log -L=-1273
R-squared=0.708061
Rho=0.04796
Prob.value=0.00000
Adjusted R²=0.66795

Note: ***, ** and * show level of significance at 1percent, 5percent and 10percent probability level, NS=Not significant
Source: Model output, 2008.

Table 2: Estimation result of the outcome equation and its marginal effect.

(LIVSTO), crop pest infestation (CROPES), and the Inverse Mills ratio (LAMBDA).

Inverse Mills ratio (Lambda) term: was significant at 5% probability level indicating the presence of selectivity bias. The negative sign suggests that the disturbance terms in the participation and outcome equations are negatively correlated. The significant result showed that there are unobserved determine factors of household participate in irrigation other than those variables contained within in the model. These factors are likely to be negatively associated with household food security.

Access to irrigation: As expected access to irrigation was found to have positive and significant (1% probability level) impact on household food security (Table 2). It contributed to household food security at least in three ways. First, access to irrigation enabled households to utilize farm resources (land, labour and oxen) more efficiently during off-season that otherwise would have underutilized. Second, access to irrigation enabled irrigation users increase cropping intensity (grow crops more than once in a year) thereby not only increased output but also contributed to stabilize consumption. Third, it helped farmers to be engaged in high value crops production that could be marketed in the off season when prices are at their peak. The coefficient of the variable confirmed that the food consumption expenditure for irrigation user households exceeded by ETB 1631 than non-user households, confirming a better food security status of irrigation users [24-27].

Household family size: Household size was negatively and significantly (1% probability level) related with household food security suggesting the larger the family size the higher the possibility of a household to be food insecure (Table 2). Large family size, especially whose members are more of inactive labor force, increases the number of dependent family members which causes shortage of labor force to perform agricultural activities and this in return decrease the supply of enough food for a household and its members. Moreover those households who depend on limited productive resources will face food insecurity by increasing family size. Land scarcity and degradation of cultivable land are the current common problems of the study area. The coefficient of the variable indicated that as the household size increases by one adult equivalent, to keep the household food secure the income should increase by ETB 401 [28,29].

Dependency ratio: This variable was negatively and significantly (5% probability level) related with household food security status of the study area. The result indicated that an increase in family size, whose members are more of inactive labour force, increases the number of dependent family members. The increase in dependent family members causes shortage of labour force to accomplish agricultural activities including irrigation farming. This condition of the family in return decreases the supply of enough food for household members. Consequently the households' ability to be food secured becomes less [30].

Size of cultivated land: The analysis result showed that this variable has positive sign and it was significant at 5% probability level (Table 2). In the study area households holding larger cultivated land produce relatively sufficient amount of crop by their own or through different contractual agreements such as share cropping and the like. More-over, the larger land holders have plots extended to the river-bank. As a result the households have an opportunity to produce additional crops using irrigation water in off-season period. This implied that households with larger land holding could produce sufficient amount of crops that ensures households' food security. The coefficient of the variable showed that as the household owned one more hectare of land,

food consumption expenditure per adult equivalent increases by ETB 136 that enhances household food security [31].

Livestock holding: Livestock are important sources of income, food and draft power for crop cultivation. As hypothesized, livestock size was positively and significantly (associated with the probability of being food secure in the study area. In the study area livestock production is the major source of farm households' income next to crop production. The households with more livestock produce more milk, milk products and meat for direct consumption of their family which enable the owners to be more food secured. Besides, holding more livestock enables the farm households to have better chance to earn more income from the sale of the livestock that could be invested in purchasing food for the family during food shortage months. Moreover, income from livestock sale could be invested in purchasing productive farm inputs that increase food production, and able in ensuring household food security. The result indicates that, other things held constant, as livestock size increased by one TLU the household food expenditure increased by ETB 41.

Distance from the water source: was found to be a significant determinant of household food security. It is positively linked to household food security and significant at 10% probability level. This positive and significant relationship tells us that as households become closer to the irrigation scheme, food security status improves significantly. The possible justification could be in the study area households closer to irrigation water source are more experienced in irrigation farming. Such experience helps them to recognize market oriented crops and the peak time to produce the crops. More over their proximity to irrigation farm enable them to manage properly their crop with minimum cost. As a result much better income could be earned from irrigation farming. Consequently household food security is improved. The coefficient of the variable also confirms that when a household is closer to the scheme by one kilometer, the food consumption expenditure increases by ETB 165.

Distance from the market: It was negatively and significantly influenced household food security at 5% probability level. The marginal value of this variable suggests that for one kilometer distance from a market a household resides from the base mean level, food consumption expenditure decreases by ETB 35. Households residing far from market centers incur high marketing and transportation costs while producing and marketing farm products. In the study area, farmers' sale horticultural crops produced under irrigation at farm-get at substantially lower prices due to the high marketing costs and inconveniences involved in transporting perishable products over long distance. High transaction costs also limit farmers attempt to efficiently utilize irrigation water that otherwise had been used to boost production. Earlier study by Yilma (2005), however, reported a significant and positive impact of market distance to household food security suggesting the need for further investigation of this variable in future studies.

Crop pest infestation: Crop pests are important biological factors limiting crop production and causing food deficit in the study area. Crop infestation was significantly (at 5% probability level) and negatively influenced household food security. This might be due to the fact that the study area has ranges of altitudes which favour the occurrence of some insects and diseases that cause failures of crops. As a result crop pests in the study area are the cause of quality and quantity loss of crops harvested from both rain-fed and irrigation farm. Particularly quality loss caused by pests affect the feed quality and market price of the crops. The aggregate effect of quality and quantity

loss caused by pests could be manifested in household food insecurity. Therefore, households faced with crop pest infestation had less resistant to food insecurity than those households not affected by the problem. The coefficient of the variable shows that household food expenditure decreases by ETB 268 as the household faces such problem [32].

Conclusion and Policy Implications

Conclusion

Crop failures due to dry spells and extended droughts are not uncommon in Ethiopia. Such vulnerability and sustained food supply deficiency cannot be solved with the rain-fed agriculture that has dominated crop production in this country. And it is the experience of a number of food secure countries to use irrigation technology in order to improve the productivity and production of the agricultural sector. Nowadays, Ethiopian government, NGOs and international organizations have understood the very important contribution of irrigation to agricultural production and have devoted a lot of resources for the development of the sector. Irrigation development has a great advantage because of its higher yield potential per unit area. However, in most small scale irrigation schemes in general and in the study area in particular the interwoven environmental, socio-economical, technological and other potential factor affect the productivity and in consequence the contribution of small scale irrigation in household food insecurity alleviation.

Results from food security measurement revealed that 73% of irrigation users and 56% of the non-users are found to be food secure. The Heckman two-step procedure was to analyse the effects of different explanatory variables on farmers' participation decision in small-scale irrigation water use, and the impact of irrigation water use on household food security. In the first stage of the Heckman two-step procedure proximity of the households to a water source, size of cultivated land, access to credit service, access to extension, livestock holding and soil fertility were found to determine participation in irrigation. In the selection /outcome/ equation of the model, access to irrigation, dependency ratio, household size, size of cultivated land, distance from the water source, distance from the market, livestock holding and crop pest infestation were found to have effect on household food security.

In conclusion, the study revealed participation in irrigation is found to be a significant determinant of household food security. Participation in irrigation helps the households to generate additional income and diversification of household food consumption. This effect of irrigation water utilization has direct bearing on household food security. Therefore, increasing efficiency of the existing small scale irrigation schemes and designing and implementing the new schemes leads to sustainable production that could change the life of the rural poor.

Finally, as this study is the pioneer in assessing the 'impact of small scale irrigation schemes on household food security' of the study area, the result of the study might serve as the entry point for further investigation on the contribution of small scale irrigation on household food security. Therefore, conducting further investigation on the problem area by considering additional socio-economic, environmental and institutional factors of the study area could contribute more in raising the performance of small scale irrigation schemes on household food security.

Policy implications

Based on the findings of the study, the following points are suggested to be considered as strategic elements in order to promote farmers participation in small-scale irrigation scheme utilization and the impact of the limited irrigation water utilization on household food security. The study revealed that distance from the water source was significant determinant of participation decision and food security of the household. This implies that the closer the household to the water source, the higher is the probability of participation decision and the better is household food security. Therefore, the construction of small scale irrigation schemes should consider the distance between the water source and villages for a better use of the schemes by households.

Livestock holding is another important factor determining negatively participation decision but positively household food security of the study area. The negative influence of livestock holding on the decision to participate might have arisen from the shortage of labour faced the households. However, with further extension service and introduction of farming techniques that would enable farmers to integrate crop farming with livestock production and management could improve the possibility of household participation in irrigation which ultimately improves household food security.

The size of cultivated land and farmers' perception of soil fertility status positively and significantly influenced both the participation decision and household food security revealing participation decision and household sustenance security are directly related with size of cultivated land and soil fertility status. However, land in the study area is scarce to expand because of the increasing population. Therefore provision of extension on land use and soil fertility management techniques could encourage the farm households to properly use their land and meet food demand of their family members through participation in irrigation utilization.

Access to extension service was associated positively and significantly with the probability of participating in irrigation water use. Therefore, exposing farmers to new market driven crop varieties, providing training on irrigated agriculture, arranging visits to other better irrigation schemes so as to expose farmers to other better practices would contribute to utilization of the scheme.

Access to credit service has also positively and significantly influenced participation decision of households in irrigation. Thus, timely provision of credit services and closer follow-up for proper utilization and timely repayment could raise the benefit of credit service in farm activity.

Participation in irrigation is found to be a significant determinant of household food security. Participation in irrigation helps the households to generate additional income and diversification of household food consumption. This effect of irrigation water utilization has direct bearing on household food security. Therefore, increasing efficiency of the existing small scale irrigation schemes and designing and implementing the new schemes leads to sustainable production that could change the life of the rural poor.

Household size and dependency ratio are found to influence negatively household food security status of the study area. This implies that households with larger household size especially with high dependency ratio could not be able to meet the minimum daily requirement. Therefore, the introduction of appropriate family planning strategy and training on diversification of livelihood strategies would be indispensable to have healthy and productive family.

Distance from the market centre is also found to be negatively affecting household food security. Therefore, rural road construction

and provision of transportation facility could connect those farmers at distant to the market centre could lessen their marketing cost and the loss of perishable farm products. Moreover, striving to create market linkage for their farm product could raise farm income by minimizing their marketing cost.

Crop pest infestation is one of the important factors negatively and significantly related to household food security. This implies that farmers with problem of crop pest infestations are more likely to be food insecure than those who don't have the problem.

Therefore, extending appropriate crop protection mechanisms to the farmers could reduce the yield loss caused by crop pest infestation. In addition to this selection and distribution of insect and disease resistant crop varieties could maintain the production potential of the study area.

Finally, as this study is the pioneer in assessing the 'impact of small scale irrigation schemes on household food security' of the study area, the result of the study might serve as the entry point for further investigation on the contribution of small scale irrigation on household food security. Therefore, conducting further investigation on the problem area by considering additional socio-economic, environmental and institutional factors of the study area could contribute more in raising the performance of small scale irrigation schemes on household food security.

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