Full Length Research Paper

Effect of small-scale irrigation on the income of rural farm households: The case of Laelay Maichew District, Central Tigray, Ethiopia

Kinfe Asayehegn[1]*, Chilot Yirga[2] and Sundara Rajan[3]

[1]Institute of Environment, Gender and Development Studies, Awassa College of Agriculture, Hawassa University, Ethiopia.
[2]Ethiopian Institute of Agricultural Research (EIAR), Ethiopia.
[3]Department of Rural Development and Agricultural Extension, Harapmaya University, Ethiopia.

Agricultural intensification is presumed to be a necessary pre-condition for the development of the agricultural sector in Ethiopia. To this end, various government and non-governmental organizations (NGOs), among others, initiated small-scale irrigation schemes throughout the country including the Tigray region. Despite these efforts, however, smallholder farmers particularly in the study area are found to be reluctant to participate in small-scale irrigation schemes. This study therefore, assessed the factors that affect smallholder farmers' participation in small-scale irrigation of the study area. A two-stage sampling procedure was used to first select peasant associations and then sample respondents. Descriptive statistics and binary probit estimation were used to estimate the determinants of small-scale irrigation participation. The analysis revealed that income, gender, access to market information and health condition of households were found to be important determinants for participating in small scale irrigation schemes. Hence, improving rural farm households' access to market information and health services, are likely to improve participation in irrigation schemes thereby improving of small holder farmers income.

Key words: Ethiopia, income, irrigation, rural farm households, small-scale.

INTRODUCTION

Ethiopia is an agrarian country where around 95% of the country's agricultural output is produced by smallholder farmers (MoARD, 2010). The contribution of agriculture to national GDP (50%), employment (85%), export earnings (90%), and supply of industrial raw materials (70%) has remained high (World Bank, 2010). Although the country is endowed with three main resources namely land, water and labor for production, agriculture in the country is mostly small- scale, rainfall dependent, traditional and subsistence farming with limited access to technology and institutional support services. Hence, the ability of the nation to address food and nutritional insecurity, poverty, and to stimulate and sustain national economic growth and development is highly dependent on the

performance of agriculture. Yet achieving higher and sustained agricultural productivity growth remains one of the greatest challenges facing the nation (Belay and Degnet, 2004; Spielman et al., 2010).

Irrigation contributes to livelihood improvement through increased income, food security, employment and poverty reduction. To this end, Hussain and Hanjira (2004) confirmed a strong direct and indirect linkage between irrigation and poverty. Direct linkages operate through localized and household level effects, whereas indirect linkages operate through aggregate or sub-national and national level impacts. Irrigation benefits the poor through higher production, higher yields, lower risk of crop failure, and higher and year-round farm and non-farm employment. Irrigation enables smallholders to adopt more diversified cropping patterns, and to switch from low-value staple production to high-value market-oriented production. Increased production makes food available

*Corresponding author. E-mail: kinfe85@gmail.com.

and affordable for the poor. Since irrigation investments leads to production and supply shifts, indirect linkages operate through regional and national level and have a strong positive effect on the national economy. Similar study from Gambia revealed that irriga-tion provided smallholder farmers the chance for increasing income that was reflected on increased expenditure, investment in productive and household assets, saving and trade (Webb, 1991). In India poverty head count ranges from 18 to 53% in irrigated and 21 to 66% in rain fed areas and poverty incidence is 20 to 30% lower in most irriga-ted areas compared to rain fed areas. Incidence of chronic poverty is 5% lower for irrigated areas in Sri Lanka (Pakistan) than adjoining rain fed areas (Hussain and Hanjra, 2004).

Besides its positive effect, irrigation utilization decision comprises different determinant factors. Some of the fact-ors facilitate for utilization decision while others not yet. Hence, a study carried out by Desta (2004) and Tafesse (2007) on impact of community-managed irriga-tion on farm production efficiency and household income in Oromia National Regional State, Ethiopia found that education of the household head, livestock ownership, access to irrigation technology, amount of credit received, age of household head, distance from market, participation in extension package program, years of irrigation experience, total income of house-holds, access of the household to improved seed and farm size were the significant determinants of household decision on irri-gation utilization. This was also confirmed by Takele (2007) that in addition to the afore-mentioned factors dependency ratio, active labor force, sex of household head, insect and pest infestation, training received, and ownership of radio are found significant in determining the decision of small-scale irrigation utilize-tion.

The study area is one of the most land-degraded states of Ethiopia. Crop production in the region has failed to keep pace with population growth due to recurrent droughts, environmental degradation and wars, including the most recent conflict with Eritrea (Ersado, 2005). In response to severe environmental degradation and population-resource imbalance, the regional government of Tigray has initiated a major rural development program called Sustainable Agricultural and Environmental Reha-bilitation of Tigray (SAERT), through which several small-scale dams have been, constructed (Ersado et al., 2004). Farm households within the peasant association, which had rain-fed land, were given equal opportunity to own irrigated land. However, some farm households dis-regarded to possess parcels in the irrigable section of the peasant association at will due to different factors. Moreover, most studies in Ethiopia focus on technical aspects of irrigation schemes, and very little is known for the socio-economic factors that have implications on

irrigation participation (Van Den Burg and Ruben, 2006). Therefore, this research is aimed at primarily identifying, analyzing, and documenting the socio-economic and institutional factors affecting household level irrigation utilization that contributes its part to the existing body of knowledge. Secondly, it provides a base for policy ma-kers through the comparisons of positive and negative effect of irrigation with respect to similar areas in specific. Thirdly, it provides directions for further research, extension and development schemes that will benefit the scheme beneficiaries.

METHODOLOGY

Sample and sampling design

A two stage sampling procedure was followed to first select peasant associations and then sample households. In the first stage, three peasant associations where the three micro-dams found were selected purposively. Before selecting household heads to be included in the sample, the sampling frame was stratified into irrigation water user and nonuser households. The stratum of irrigation user consists of households who own, rented/shared in/out or gifted in land for direct utilization. The second stratum referred to hereafter as non-users is composed of households who neither owned irrigated land nor involved in irrigation farming. In the second stage, 130 farm households consisting of 65 irrigation users and 65 nonusers were selected from the identified list using simple random sampling technique taking into account probability proportional to size of the identified households in each of the three selected peasant associations.

Data collection and analysis

A structured interview schedule supported by personal observations of physical features and informal discussion with key informants was used to collect primary data. In addition to primary data, secondary data were collected from the District Offices of Irrigation Development (DOID) and District Offices of Rural and Agricultural development (DORAD)

Initially, the research had two objectives. However, for this paper the second objective is excluded and is organized and presented in other way with a similar analysis method. Descriptive statistics (mean, frequency, percentage and standard deviation) and binary probit were used to analyze the collected data. The statistical significance of the variables in the descriptive part was tested for both dummy and continuous variables using chi-square and t-test, respectively.

There are various ways of estimating the parameters of dichotomous qualitative response regression models. Thus, include LPM, binary probit and logit models. All these models have in common the fact that they are models in which the dependent variable is a discrete outcome such as Yes or No decision (Maddala, 1997). The most widely used discrete response models are probit (which is associated with cumulative normal distribution) and logit model (which is assume cumulative logistic probability function). In these models, the probabilities are bound between 1 if the household is user of irrigation and 0 otherwise and they fit well to non linear relationship between the probabilities and the explanatory variables. However, Maddala 1983 and Gujarati 1995

have noted that, in most applications the cumulative normal distributions (binary probit) and logistic function (logit) is quite similar, the difference being that the logistic function has slightly fatter tails. Hence, there is no compelling reason to choose one over the other and the choice is dependent upon personal preference and experience. Therefore, due to such circumstances, this study used binary probit model to analyze the factors affecting small-scale irrigation utilization.

RESULTS AND DISCUSSION

Socio-demographic characteristics of the households

Gender of the household heads regardless of the age group is an important variable influencing the participation decision in irrigation. The total sample of the study is composed of 20% female headed households while the portion of female headed households who are irrigation users is reduced to 12%. Discussion with sample households revealed that male-headed house-holds hardly faced labor shortage for irrigation as well as rain-fed farming due to physical, technological, socio-cultural and psychological fitness of farm instrument to males than females. Similarly, education plays a key role for household decision in technology adoption. It creates awareness and helps for better innovation and invention. The study revealed that 40% of the users and 60.8% of the nonusers of small-scale irrigation are illiterate. It is also found that the number of irrigation users who completed nine years of schooling and above is twice as compared to nonusers.

The average household size for the users and nonusers of small-scale irrigation is found to be 6.43 and 5.15, respectively (Table 1). This result is statistically significant suggesting labor availability is an important factor influencing households' decision to participate in small-scale irrigation schemes. The result also revealed, as active family labor or work force of a household in adult equivalent increases, the total income of the household increases, which in turn contributed to improved well-being, further providing an evidence for the importance of labor availability in influencing the participation decision of households in small-scale irrigation.

Irrigation labor force is the amount of labor needed for irrigation activities. Similarly, rain-fed labor is the labor required for rain-fed activities. Irrigated and rain-fed agriculture requires diverse labor force both in quantity and technical quality. Evidences from the study as stated in Table 2, demonstrated 44.6% of the users of small-scale irrigation faced labor shortage for irrigation activities while 30.9% of the users and 24.6% of the nonusers faced labor shortage for rain-fed activities. Farm households who faced labor shortage employ different

mechanisms to acquire additional labor required for accomplishing farm activities. A total of 76.9 and 23.1% of the irrigation users, which faced labor shortage, acquired additional labor through hiring and labor exchange mechanisms, respectively. Likewise, 77 and 23% of the labor deficient irrigation users used hired and exchange labor, respectively, to solve the problem of labor shortage for rain-fed farming. Similarly, a total of 24.6 and 75.4% of the labor deficient irrigation nonusers used hired and exchange labor for rain-fed farm activities. It worthy of note that 35.4% of the casual labor employed in irrigation farming were source from the nonusers of irrigation within the kebele/Woreda whereas 64.6% move toward from nearby kebele/Woreda that are very little in irrigation sources. This proves irrigation intensifies labor and is preeminent strategy of employment in countries like Ethiopia with elevated population growth rates.

Irrigation user households also compared the labor consumption ratio of irrigated farming to rain-fed farming, which accounts 12.3, 70.8, 15.4 and 1.5% as equal, two times, three times and four times respectively. The farm households replied from the point of view of their activities and economy. Equal and three or four times ratio is for the farm families specialized on cereal and vegetable crops respectively and two times is from the farm households which diversified on cereal and vegetable crops. This replies that the labor consumption for vegetable farming is double as compared with cereal crops.

Resource ownership and farm experience

Resource ownership and farm experience have a pro-found effect on the participation decision-making behavior of farm households. The variables experience in rain-fed farming and rain-fed land holding pertain to both users and nonusers of small-scale irrigation while the variables irrigation experience and irrigable land holding pertain to users only. Both irrigation user and non-user households of the area have an average land size of 1.1 and 0.627 ha respectively. The survey revealed that 10.8% of the users of irrigation do not own rain-fed land at all rather than irrigated land. On the other hand, of the total respondents, 4.6% of the users and 7.7% of the nonusers do not owned any parcel of land but always use sharecropping arrangements. Findings of the survey revealed that 58.5% of the users and 17% of the nonusers shared in land, while 16.9% of the users and 24.6% of the nonusers shared out their own land. This shows that irrigation users are better practice land shared in than nonusers are. The land shortage and searching for additional land is the motivating factor for shared in (Table 2).

Table 1. Distribution of respondents by demographic characteristics.

Sex	User		Nonuser		Total		χ2
	N	%	N	%	N	%	
Female	8	12.3	18	27.7	26	20	
Male	57	87.7	47	72.3	104	80	3.894**
	Mean	SD	Mean	SD	Mean	SD	T-value
Education (years)	2.26	2.917	1.49	2.646	1.88	2.801	1.575
Family size	6.43	2.038	5.15	1.946	5.79	2.086	3.653***
Family labor	3.71	1.665	2.57	1.468	3.14	1.665	4.135***

*** and ** statistically significant at less than 1and 5% probability level respectively.

Table 2. Distribution of respondents based on land ownership and farm experience.

	Users		Nonusers	
	Frequency	Percent	Frequency	Percent
Shared in	38	58.5	11	17
Shared out	11	16.99	16	24.6
Reasons for not using irrigation				
Land shortage			17	26.2
Limited information			21	32.4
Have fertile rain-fed land			27	41.4

Land holding in ha	User	Nonuser	Total	T-value
	Mean	Mean	Mean	
Total cultivated land	1.1	0.627	0.856	5.826***
Irrigable land	0.5	0.000	0.247	13.531***
Rain-fed land	0.6	0.627	0.608	0.546
Farm experience in years				
Rain-fed	33.37	29.68	31.52	1.706**
Irrigation	11.86	0.000	5.93	14.757***

*** and** statistically significant at 1 and 5% probability level respectively.

Irrigation non-user households which have equal opportunity with the users, have different reasons for rejecting irrigation utilization. Some of them are due to lack of farmland at the time of redistribution while others are due to information gap and lack of awareness on irrigation. Farmers' expectation of the rain-fed land they owned is too fertile and can produce better is the other reason that motivates the rejection of irrigation utilization. With regard to farm experience of the households, findings compared that 55.4% of the irrigation users and 35.4% of the irrigation nonusers have more than 30 years of rain-fed farm experience, respectively. Likewise, 55.4 and 1.5% of the users of small-scale irrigation have 12 and more than 30 years of irrigation experience respectively. The t-test on rain-fed experience between users and nonusers of irrigation showed that there is a significant difference between irrigation user and non-user households at 5% level (Table 2).

Income distribution and inequalities of the households

Some of the households specialized in primarily irrigation dependent livelihoods while others base their livelihood on a diverse range of livelihood activities but out of irrigation. There are also households which diversify their livelihood as irrigation dependent and irrigation indepen-dent. Specifically for income and activities, households diversify to different sources. On-farm income (such as

income from irrigated crop, rain-fed crop or livestock production/rearing), off-farm income (such as trading of agricultural products), and non-farm income (such as non-farm employment, non-farm trade), are the different income portfolios in which the households of the study area diversify their activities. The survey results found that there is a significant difference in mean total household income between irrigation user and non-user livelihoods. It is found that 10.8% of the irrigation users do not have any income from rain-fed crop production other than irrigation products. The results of the survey also compared that the ratio of mean total income of irrigation users to nonusers exceeds by 37.03% and nutritional status and standard of living of the users also increased by the same factor as income.

An entire 63.1% of the users and 67.7% of the nonusers of small-scale irrigation do not participate in any off-farm activities. Thus, households base their livelihood on non-farm and on-farm income portfolios. With regard to livestock production as an on-farm income, irrigation users gain income from livestock 13.8% larger than irrigation nonusers do. Remittance also covers 1.5 and 2.2% of the total income of the users and nonusers of small-scale irrigation respectively (Table 3). Generally, initial income received from non-farm and off-farm activities help farm households to participate in small-scale irrigation through coverage of initial costs such as costs for inputs, draught power e.t.c. However, once the farm families transformed from rain-fed to irrigation livelihoods, it directly minimize their off-farm income due to the load in the labor intensive activity of irrigation.

Social participation and access to infrastructural facilities

Irrigation intensifies input and labor. Credit either in the form of cash or kind from different sources, is an important institutional service to finance poor farmers for input purchase and ultimately to adopt new technologies. However, some farmers have access and utilization to credit while others do not, due to problems related to repayment and down payment in order to get input from formal sources. The survey indicated 78.4% of the non-users and 89.2% of the users of irrigation had utilization to credit although the access is equal to all households without any difference. Credit nonuser households reject credit utilization due to different reasons. The results contended that 7.7% of the users of irrigation, which spurn credit utilization, hardly faced any problem due to their limited need. On the other hand, 6.2 and 7.7% of the nonusers of irrigation eschew credit utilization due to their limited need and fear of failure to pay respectively. It is also found that 4.6% of the nonusers of irrigation reserved from irrigation utilization due to expectations of

high interest rates of the credit. An equal amount 3.1% of the users and nonusers of irrigation restricted themselves from credit utilization due to religion restrictions locally called *haram*.

Rural farm households engage in different positions of informal and formal institutions such as Mahber, Idir, water user association, peasant association and Woreda administration of their locality. The ratio of small-scale irrigation user households to nonuser households who are in different positions of the community exceeds by 47.7%. The main reason for the gigantic difference between irrigation user and nonuser households in their position in the community is due to the access and utilization of information. Information on market prices and channels is one of the important aspects for livelihood improvement of rural farm households. Although information on marketing of irrigation products and agricultural inputs is a determinant factor for producers, only 75.4% of the irrigation users have access to information. As a source of information, 7.7 and 67.7% of them use telephone (fixed or mobile) and person to person information sharing respectively. This shows even in the age of information era, people in such areas still using traditional way of information sources and means.

Probit model

As stated in Table 4, Farm households of the area have different income sources. On-farm income refers to the total income from irrigated and rain-fed crops. Similarly, off-farm income is a type of income, which is derived from sources such as trading of agricultural products. None-farm income on the other hand is a type of income resulted totally out of agriculture and agricultural products. The econometric results confirmed that there is a positive and significant relationship between on-farm income of households and irrigation participation at less than 1% significant level. The positive effect between on-farm household income and participation in irrigation farming suggests that income derived from on-farm activities enables households to pay for farm inputs required for profitable irrigation farming. The marginal effect shows that as on-farm income of households increases by 100 Birr, the probability of a household's participation in small-scale irrigation increases by 1%. However, off-farm income significantly and negatively influenced the likelihood of participation in irrigation-

farming suggesting households engaged in off-farm activities are less likely to participate in irrigation. This negative relationship depicts the likelihood of participation in irrigation would be reduced by 1% for every 100 ETB earned from off-farm activities, as off-farm activities withdraw active labor from participating in irrigation.

Higher market prices of irrigation products are likely to

Table 3. Distribution of respondents based on their mean household income.

Source of income		Users	Nonusers	T-value
	Irrigation	12934.98	0.00	10.169***
	Rain-fed	5225.32	7084.61	-2.878***
On-farm	Irrigation and rain-fed	18160.31	7084.61	7.143***
	Livestock	1864.46	1010.46	3.026***
	Total	20024. 76	8091.07	7.497***
	Expense for crop production	6695.76	2184.64	7.273***
	Net income	12285.92	5878.73	6.065***
Off-farm		746.46	600.30	0.488
Non-farm		2023.07	2572.46	-0.669
Remittance		353.78	249.23	0.412
Property/income		33052.78	14318.91	2.723***
Total income		56200.87	25831.98	4.217***

*** and** statistically significant at less than 1 and 5% probability level respectively.

Table 4. Maximum likelihood estimates of the probit model.

Variable	Coefficients	T-value	Marginal effect
Constant	-4.75882	-2.32099**	-1.5668
Education level	0.012903	0.137887	0.0042
Family labor force	0.168341	0.866935	0.0554
Age of the household head	0.0335619	1.18129	0.0111
On farm income	0.000172252	2.81975***	0.0001
Off arm income	-0.000378195	-1.87574*	-0.0001
Nonfarm income	-0.000149225	-1.26935	0.0001
Remittance	-0.000193725	-0.901888	-0.0001
Property income	7.08725e-006	0.704812	0.0000
Distance from irrigation to market	0.0357116	0.612217	0.0118
Distance from irrigation to home	-0.598272	-3.01655***	-0.1970
Rain-fed land	-1.48404	-1.44643	-0.4886
Total livestock unit	-0.0461839	-0.306553	-0.0152
Sex	1.15819	1.70084*	0.3813
Market information	4.73361	4.18098***	1.5585
Access to credit	-0.460747	-0.589819	-0.1517
Health condition	1.54415	1.98631**	0.5084

Dependent variable	Irrigation participation decision
Weighting variable	ONE
Number of observations	130
Log likelihood function	-19.87096
Restricted log likelihood	-90.10913
Chi-squared	140.4763
Degrees of freedom	16
R-square	0.685043

***, **, and * indicates significant at less than 1, 5, and 10% probability level respectively.

motivate farm households to participate in small-scale irrigation schemes. The marginal effect revealed that the probability of participation in irrigation for a household, with a reasonably good access to market information would by nearly twice than households who do not have access to market information. Similarly, household's residence to water sources is found to have a significant and negative relationship to the probability of participation in small-scale irrigation. The negative sign indicates that the farther water source from a household's residence the lower the likelihood of participation in irrigation farming. Conversely, the nearer a household resides to a water source, the higher the probability of participating in irrigation scheme due to the fact that the opportunity cost of the time lost in travelling to and from an irrigation-farm for households located, a short distance from irrigation schemes would be much lower than households located much farther. Besides, the lower transaction cost households located near water sources enjoy are likely to have a better awareness of the associated agricultural technologies due to their proximity. Keeping other variables constant at their respective mean level, the probability of participating in irrigation for a household increased by 19.7% for as the distance of water source from his/her residence reduces by one kilometer.

Discussion with sample households and key informants revealed that male-headed households hardly faced labor shortage for irrigation as well as rain-fed farming due to physical, technological, socio-cultural and psychological fitness of farm instrument to males than females. Moreover, the income of male-headed households is higher, compared to female-headed households further increasing the comparative advantage of male-headed households to engage in irrigated farming than female-headed households do. The results of the econometric model proved that gender of the household is an important variable influencing the participation decision. The marginal effect of gender indicates the probability of participation in irrigation for a male-headed household increases by 38.13% compared to a female-headed household, given other variables are kept at the average level. In addition to gender, the health status of a household is an important variable influencing participation in program interventions. Disease, disabilities and extra old age affects irrigation participation through reduction of active labor for production and adding expenses for medication. The positive and significant relationship of health status of the household head with participation in small-scale irrigation indicates the probability of a household's participation in irrigation increases by 50.84% for a healthy household head compared to a household with poor health or with some type of disability.

CONCLUSION AND POLICY IMPLICATION

Irrigation intensifies input and labor throughout the year.

It motivates self-employment offsetting fulltime and part time off-farm or non-farm employment, due to efficient utilization of labor. This indicates off-farm income inspires to withdraw active labor force from irrigation activities and placing to off-farm income driving activities reduces irrigation participation of farm households. Farm households that have access to market information are able to compare, the net income from rain-fed and irrigation farming. Moreover, it assists purchasing of the right input at the right time from the right enterprise and supplying of the products to the right customer with a reasonable intermediary cost. However, the gender difference of household heads in irrigation participation indicated female-headed households face shortage of labor and market information, made them rent/shared out their land. Networking of rural farm households with their customers through information sources such as mobile and telephone service is a determinant factor. Accessing of labor saving technologies easily managed by women solves the workforce problem of female-headed house-holds. Special attention for female-headed households considering their gender mainly in criteria of accessing irrigable land facilitates women participation in irrigation. Insuring property ownership of female-headed house-holds through credits and self-help groups is the other mechanism of increasing female-headed house-hold's participation in irrigation.

Access of farm households to irrigated land enables them to diversify their income sources, including cash and food crops, and to make savings. Livestock serve as a source of income for irrigation input purchase and draft power. Wealth status of households also determined by the livestock, they owned mainly oxen. Crop failure risk is minimized if the household owned livestock due to expectations of compensating failed crop through sale of their livestock. Credit is an important institutional service to finance poor farmers for input purchase, able to access draft power and ultimately to adopt new technologies. Saving livestock from sale and land from rent out or shared out, at uncertain seasons is feasible due to credit utilization and double season production. Although increasing the total land size is unfeasible, replacement of the rain-fed land by irrigable land through development of new dams and applying different irrigation technologies is crucial. Due attention to livestock production through introduction of zero grazing systems to make livestock production is friendly with environment, irrigable land and ecology conservation in general is vital. Microfinance institutions are better to provide credit, at reasonable interest rate, and at the right time credit be demanded at places where farm households can access easily.

Household members, who are free of disease, and disabilities, have productive labor for irrigation. The burden of caring and treating sick, disabled or extra old age reduces the active labor for irrigation not only labor of the diseased or disabled individual, but also labor of the other members of the household that leads to dual sentence.

Provision of social services such as health services and road at village level is essential in changing the life and active labor of the farm households. Informal education on health aspects, nutrition, hygiene and sanitation also play role on preventing and curing of disease that leads to better utilization of irrigation.

REFERENCES

Belay K, Degnet A (2004). Challenges Facing Agricultural Extension Agents: A Case Study from South-western Ethiopia. African Development Bank, Blackwell Publishing Ltd, Oxford, UK.

Ersado L, Amacher GS, Alwang J (2004). Productivity and land enhancing technologies in northern Ethiopia: Health, public investments, and sequential adoption. Am. J. Agric. Econ., 86(2): 321-331.

Ersado L (2005). Small Scale Irrigation Dams, Agriculture Production, and Health: Theory and Evidence from Ethiopia. World Bank Policy Research Working Paper 3494. The World Bank: Washington DC.

Gujarati DN (1995). Basic econometrics. 3rd edition, McGraw Hill, Inc., New York.

Hussain I, Hanjra M (2004) Irrigation poverty alleviation: review of the empirical evidence. International Water Management Institute, Colombo, Sri Lanka.

Maddala GS (1983). Limited Dependent and Qualitative Variables in Econometrics. Cambridge University Press, Cambridge.

Maddala GS (1997). Limited Dependent and Quantitative Variables in Econometrics. Cambridge University Press: Cambridge.

MoARD (Ministry of Agriculture and Rural Development) (2010). Ethiopia's Agriculture Sector Policy and Investment Framework: Ten Year Road Map (2010-2020).

Spielman D, Byerlee D, Avid J, Alemu D, Kelemework D (2010). Policies to promote cereal intensification in Ethiopia: The search for appropriate public and private roles, Food Policy, 35: 185-194.

Van Den Burg M, Ruben R (2006). Small-Scale Irrigation and Income Distribution in Ethiopia. J. Develop. Studies: Wageningen University, The Netherlands, 42(5): 868-880.

Webb P (1991). When projects collapse: Irrigation failure in the Gambia from a household perspective. J. Intern. Dev. Inst., Vol. 3(4), Washington D.C.

World Bank (2010). Ethiopian Agricultural Growth Project. Project appraisal document. Addis Ababa: Ethiopia.