Ethiopian Journal of Development Research Vol. 32, No. 2, October 2010

Rural Poverty and Inequality in Ethiopia: Does Access to Small-scale Irrigation Make a Difference?

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Abstract

The underlying causes of rural poverty are many in Ethiopia. However, the persistent fluctuation in the amount and distribution of rainfall is considered as a major contributing factor. Cognizant of this reality, the successive Ethiopian governments, NGOs and farmers have made considerable investments in small-scale irrigation systems. Based on data obtained from a survey of 1,024 farmers drawn from four major regional states of Ethiopia, this article analyzes the efficacy of these investments in reducing poverty. The Foster, Greer and Thorbecke poverty indices were used to compare the incidence, depth and severity of poverty among groups of farmers defined by relevant policy variables including access to irrigation. Logistic regression model was fitted to explore the correlates of rural poverty. The main conclusion of the study is that poverty is affected more by the intensity of irrigation use than mere access to irrigation and there seems to be an economy of scale in the poverty-irrigation nexus.

Keywords: rural poverty, small-scale irrigation, inequality, Ethiopia

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Introduction

Rural Ethiopia is home to millions of poor and food insecure people. Despite the appreciable efforts made to reduce poverty in the country over the past several decades, farmers, herders and other rural people remain poor. Small-scale farmers and herders, who comprise the largest group of poor people, live in a shock-prone environment.

The underlying causes of rural poverty in Ethiopia are numerous and complex and at minimum include the following factors:

- Wide fluctuations in agricultural productivity and production in tune with the amount and distribution of rainfall (World Bank, 2006);
- Low agricultural productivity (Gebre-Selassie, 2004);
- Limited access of the majority of rural households to support services and basic social and economic infrastructure such as transport and communication networks, credit facilities, health and educational facilities, veterinary services, safe drinking water supply, quality extension services, etc. (Fellner, 2000);
- Inefficient agricultural marketing system (Eleni, 2001);
- Land degradation due to rampant deforestation and unfavorable agricultural practices (Bekele and Holden, 2000);
- Fragmented and declining landholding (Gebre-Selassie, 2004); and
- Lack of participation by rural poor people in decisions that affect their livelihoods (Harbeson, 1978).

However, the persistent fluctuation in the amount and distribution of rainfall is considered to be a major contributing factor to rural poverty. Agricultural production, which is the source of livelihood for eight out of ten Ethiopians, is extremely vulnerable to the amount and distribution of rainfall received in any given year. The unmitigated hydrological variability costs the economy more than one-third of its growth potential.

To avert the problem of rainfall uncertainty and risk, the successive Ethiopian governments and farmers have made investments in small, medium, and large scale irrigation schemes (Kloos, 1991; Seleshi *et al.*, 2007; Solomon, 2006; Wolfgang, 1979). The effect of drought is not confined to the agricultural sector. It significantly cripples the performance of the overall economy of Ethiopia due to the fundamental agrarian nature of the economy that heavily relies on the natural rainfall pattern. Oftentimes, Ethiopia is ravaged by droughts, leading to dramatic decline in economic growth. The persistent correlation between rainfall and GDP growth is striking and troubling. The effects of hydrological variability on agricultural production and productivity are transmitted through input, price, and income effects onto the broader economy, and are exacerbated by lack of adequate hydraulic infrastructure to mitigate variability and market infrastructure that could mitigate economic impacts by facilitating trade between deficit and surplus regions of the country. World Bank (2006) has indicated that the Ethiopian economy is taken hostage by uncertain rainfall pattern. The development of irrigated agriculture is seen by many as the way out of the problem. It eases Ethiopia's dependence on the annual availability of rainfall (UNPD, 2006). Based on this conviction, several small-scale irrigation projects have been developed with prime objective of alleviating rural poverty and enhancing household food security. But little empirical analyses have been done to confirm whether irrigation investment has achieved its stated objectives. The limited available studies were qualitative in nature (Tucker and Leulseged Yirga, 2010; RiPPLE, 2010).

Objectives

This paper has three main objectives:

a. To analyze the state of poverty and inequality among sample farm households with and without access to irrigation;
b. To assess the effect of other farm-household socio-economic and demographic characteristics on poverty; and
c. To analyze the relative impact of access to irrigation and other household specific socioeconomic and demographic variables on poverty.

Data and Methodology

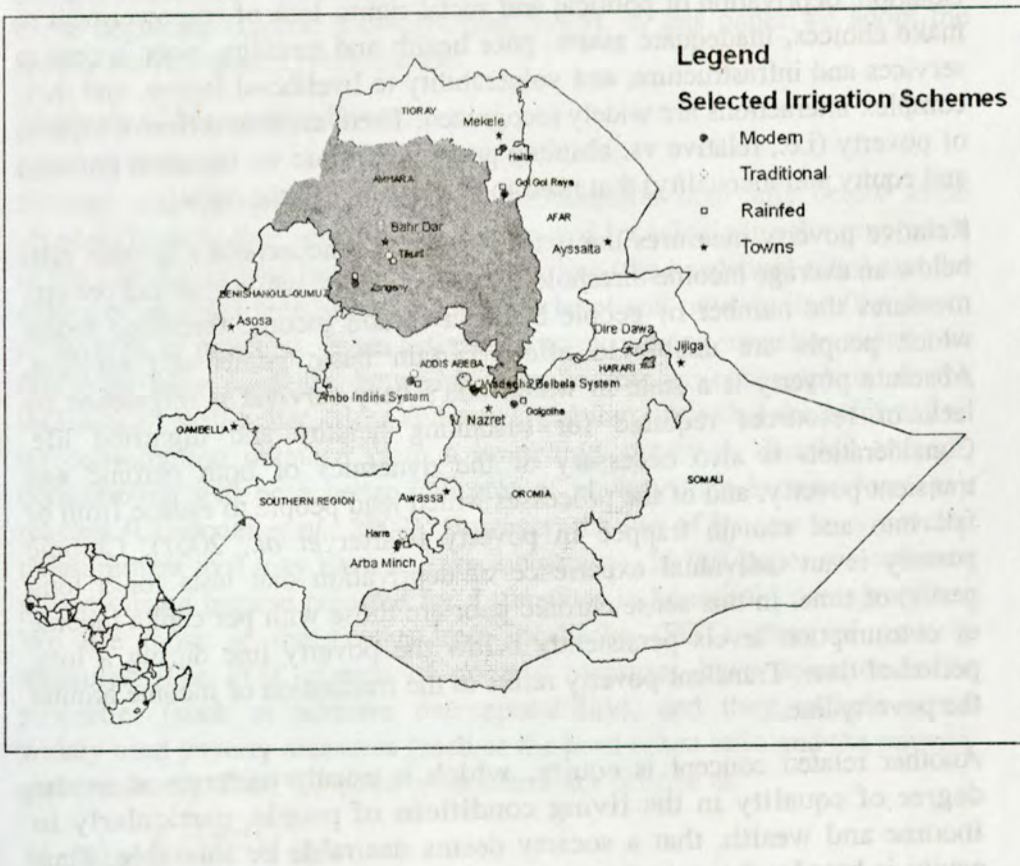
Data Sources

This paper is based on a database generated by the project "Impact of Irrigation on Poverty and Environment (IIPE)" funded by the Austrian Development Agency (ADA) and implemented by International Water Management Institute (IWMI) and Institut fuer Oekologischen Landbau Universitaet fuer Bodenkultur (BOKU), Austria, in collaboration with other Ethiopian and Austrian institutions. Other institutions involved in the implementation of the project are Ethiopian Institute of Agricultural Research (EIAR), Arba Minch University (AMU), Haramaya University (HU), ARC Sibersdorf Research with further cooperation from the Ethiopian Ministry of Water Resources, Ministry of Agriculture and Rural Development (MoARD) and Regional Bureaus for Water and Agriculture.

Sampling Procedure and Sample Size

The survey was done in four major regional states of Ethiopia: Oromia, Amhara, Tigray, and Southern Nations Nationalities and Peoples State (SNNPS).These regions are home to the lion's share of small-scale irrigation schemes developed so far in Ethiopia (Seleshi *et al.*, 2007). A multi-stage stratified sampling design was adopted to select the irrigation schemes and farm households for the study from a database of irrigation schemes developed with the framework of the IIPE project. First, the small-scale irrigation schemes in the four regional states were stratified into three traditional agro-ecological groups: *Kolla*, *Woinadega*, and *Dega*. Second, the small-scale irrigation schemes within each of the agro-ecological stratum were further stratified into traditional and modern irrigation schemes. In total 11 small-scale irrigation schemes (7 modern schemes and 4 traditional schemes) were selected (Figure 1). For comparison purposes, adjacent villages with no access to irrigation were also sampled. In cases where the selected irrigation schemes were in close proximity, only one control rain-fed village was selected. Third, simple random sample of farm-households were selected from each of the sampled irrigation schemes and rain-fed villages. All in all, 1024 farming households consisting of 382 modern scheme irrigators, 245 traditional scheme irrigators and 397 purely rain-fed farmers were selected. Fourth, all of the plots or fields operated by sample farmers during 2005/2006 cropping season were studied. The sample households operated a total of 4,953 plots. A household operated on average five plots indicating the extent of fragmentation of farm land in Ethiopia. Of the total 4,953 plots covered by the survey, 25 percent (1,250 plots) were under traditional irrigation, 43 percent (2,137 plots) were under modern irrigation while the remaining 32 percent (1,566 plots) were under rain-fed agriculture.

Figure 1. Location of sample irrigation schemes



Study Approaches and Conceptual Issues

Clarification of Concepts

Before addressing the rural poverty and irrigation nexus, it is important to clarify the meaning of poverty as there is great variation in the manner in which it is defined and measured (May, 2001). Over the last 25 years, the understanding of poverty has advanced and become more holistic. In the past, it has been understood almost exclusively as inadequacy of income, consumption and wealth but now multiple dimensions of poverty such as isolation, deprivation of political and social rights, lack of empowerment to make choices, inadequate assets, poor health and mobility, poor access to services and infrastructure, and vulnerability to livelihood failure, and their complex interactions are widely recognized. There are also different aspects of poverty (i.e., relative vs. absolute poverty, chronic vs. transient poverty, and equity and inequality) that need to be explained at the outset.

Relative poverty measures the extent to which a household's income falls below an average income threshold for the economy, while absolute poverty measures the number of people below a certain income threshold below which people are unable to afford certain basic goods and services. Absolute poverty is a state in which one's very survival is threatened by lack of resources required for sustaining healthy and dignified life. Consideration is also necessary of the dynamics of both chronic and transient poverty, and of the processes which lead people to escape from or fall into and remain trapped in poverty (Carter *et al.,* 2007). Chronic poverty is an individual experience of deprivation that lasts for a long period of time. In this sense chronic poor are those with per capita income or consumption levels persistently below the poverty line during a long period of time. Transient poverty refers to the fluctuation of income around the poverty line.

Another related concept is equity, which is usually understood as the degree of equality in the living conditions of people, particularly in income and wealth, that a society deems desirable or tolerable. Thus equity is broader than poverty and is defined over the whole distribution, not only below a certain poverty line. The meaning of equity encapsulates ethical concepts and statistical dispersion, and encompasses both relative and absolute poverty.

Hence, ideally an assessment of the effect of investment in irrigation on rural poverty must consider impacts on these varied dimensions of poverty and their interactions. For example, it must consider whether changes are in absolute or relative terms, and whether they are long lasting or transient. Similarly, it must encompass the other dimensions of poverty beyond income, consumption and wealth. Nevertheless, while recognizing that poverty is a multidimensional phenomenon consisting of material, mental, political, and communal and other aspects, the material dimensions of poverty expressed in monetary values is too important an aspect of poverty to be neglected (Lipton and Ravallion, 1995). In this paper we adopt the money metric based poverty indices.

Methods of Measuring Poverty

Poverty Indices

Poverty may be defined as private consumption that falls below some absolute poverty line, which is best measured by calculating the proportion of the population who fall below a poverty line (the headcount ratio) and the extent of shortfall between actual income level and poverty line (the depth or severity of poverty). When estimating poverty using monetary measures, one may have a choice between using income or consumption as the indicator of well-being. Most analysts argue that, provided the information on consumption obtained from a household survey is detailed enough, consumption will be a better indicator of poverty than income for many reasons (Coudouel *et al.,* 2002). However, the use of income as a poverty measurement tool may have its own advantages. In this paper we estimate poverty using income adjusted for differences in household demographics. We use those in the Foster-Greer-Thorbecke (FGT) class of poverty measures. The FGT classes of poverty measures have some desirable properties (such as additive decomposability), and they include some widely used poverty measures (such as the head-count ratio and the poverty gap measures). The FGT poverty measures are defined as

$$P(z;\alpha)=\int_0^1\left(\frac{g(p;z)}{z}\right)^{\alpha}dp$$

Where z denotes the poverty line, and α is a nonnegative parameter indicating the degree of sensitivity of the poverty measure to inequality among the poor. It is usually referred to as poverty aversion parameter. Higher values of the parameter indicate greater sensitivity of the poverty measure to inequality among the poor. The relevant values of α are 0, 1 and 2.

At $\alpha=0$, equation 1 measures poverty incidence or poverty headcount ratio, which indicates the share of the population whose income or consumption is below the poverty line, i.e., the share of the population that cannot afford to access basic basket of goods and services. It simply shows the proportion of a population that is in poverty. At $\alpha=1$, equation 1 measures depth of poverty (poverty gap). This provides information regarding how far off poor households are from the poverty line. This index captures the mean aggregate income or consumption shortfall relative to the poverty line across the whole poor population. It is obtained by adding up all the shortfalls of the poor (assuming that the non-poor have a shortfall of zero) and dividing the total by the number of poor population. In other words, it estimates the total resources needed to bring all the poor to the level of the poverty line divided by the number of individuals in the population. The poverty gap can be used as a measure of the minimum amount of resources necessary to eradicate poverty. It is the amount of resources that one would have to transfer to the poor under perfect targeting (i.e., each poor person getting exactly the amount he/she needs to be lifted out of poverty) to bring them all out of poverty (Coudouel *et al.*, 2002).At $\alpha = 2$, equation 1 measures poverty severity or squared poverty gap. This takes into account not only the distance separating the poor from the poverty line (the poverty gap), but also the inequality among the poor. That is, a higher weight is placed on those households further away from the poverty line. These indices were calculated using software known as Distributive Analysis - Version 4.4 (Duclos *et al.*, 2006).

Inequality Indices

To assess the income inequality among the different farm household groups, we calculate the Gini coefficient of inequality and Deciles Ratios. Gini coefficient is the most commonly used measure of inequality. The coefficient varies between 0 and 1. Zero indicates complete equality, while 1 indicates complete inequality (i.e., one person has all the income and all others have none). The deciles dispersion ratio is the ratio of average consumption or income of the richest 10 percent of the population divided by the average income of the bottom 10 percent. This ratio is readily interpretable by expressing the income of the rich as multiples of that of the poor.

In summary the analysis of poverty and inequality followed four steps. First, we had chosen household income as a welfare measure and this was adjusted for the size and composition of the household. Second, a poverty line is set at 1,075 Birr (1USD = 9.07 Birr in 2006), a level of welfare corresponding to some minimum acceptable standard of living in Ethiopia (MOFED, 2006). Third, after identifying the poor, poverty measures such as poverty gap and squared poverty gap were estimated. Lastly, we constructed poverty profiles showing how poverty varies over population subgroups differentiated by access to resources (i.e., farm land, livestock, and irrigation), and household characteristics (i.e., level of education and family size). The poverty profiling is particularly important as what matters most to many policymakers is not so much the precise location of the poverty line, but the implied poverty comparison across subgroups or across time.

Multivariate Analysis

Descriptive analysis or exploring relationships between variables without holding the effect of other factors constant may potentially obscure the relationship between poverty and a single factor of interest due to correlations among key variables. Consequently, it is useful to analyze the impact of the relevant variables on poverty holding all other factors constant. This implies the need to separate the effects of correlates. We approach this problem through the application of multivariate analysis. The simplest method of analyzing the correlates of poverty is to use regression analysis to see the effect on poverty of a specific variable while holding constant all other variables. In these regressions, the logarithm of consumption or income (possibly divided by the poverty line) is typically used as the left hand variable (Qiuqiong *et al.,* 2005). An alternative framework transforms the continuous income variable into binary variable using poverty line as a cutoff value (Anyanwu, 2005). The resulting dummy variable indicates whether a household is poor (i.e., the household's income is less than the poverty line) or non-poor (i.e., the household's income is more than the poverty line). In this paper we follow the latter approach. The right-hand explanatory variables span a large array of possible poverty correlates, such as education of different household members, number of income earners, household composition and size, and geographic location. The specific explanatory variables considered in the model were household heads' personal characteristics (age, gender, educational achievement, etc.), household demographic characteristics (household size and its square), household wealth (farm size and livestock holding), the nature of farming system (share of grains in the total cultivated area and size of irrigated area), and location (zones to which the household belong). See Table 8 for details of the variables included in the model. The dependent variable is a discrete variable which takes a value equal to 0 for non-poor, if a household had per capita income equal to or more than 1,075 Birr and 1 for poor if a household had a per capita income less than 1,075 Birr (which is considered here as a poverty line).

In the model, the response variable is binary, taking only two values, 1 if the rural household is poor, 0 if not. The probability of being poor depends on a set of variables listed above and denoted as X so that:

$$\text{Prob}(Y=1)=F(\beta' x)$$
$$\text{Prob}(Y=0)=1-F(\beta' x)$$

Using the logistic distribution we have:

$$\text{Prob}(Y=1)=(e^{\beta' x}/1+e^{\beta' x})=\Lambda(\beta' x)$$

Where Λ represents the logistic cumulative distributions function. Then the probability model is the expression:

$$E[y/x]=0[1-F(\beta' x)]+1[F(\beta' x)]$$

Since the logistic model is not linear, the marginal effects of each independent variable on the dependent variable are not constant but are dependent on the values of other independent variables. Thus, to analyze the effects of the independent variables upon the probability of being poor, we calculated the conditional probabilities for each sample household. Once the conditional probabilities are calculated for each sample household, the partial effects of the continuous individual variables on household poverty can be calculated using:

$$\frac{\partial \Lambda(\beta' X_i)}{\partial X_i} = \Lambda(\beta' X_i)[1 - \Lambda(\beta' X_i)]$$

The partial effects of the discrete variables will be calculated by taking the difference of the mean probabilities estimated for respective discrete variables at values 0 and 1. Alternatively, we present the change of the odds ratios as the dependant variables change. The odds ratio is defined as the ratio of the probability of being poor divided by the probability of not being poor. This is computed as the exponents of the logit coefficients (e^{β}) and can be expressed in percentage as [100(e^{β}-1)].

Descriptive Results

Household Income Distribution

The income distribution differentiated by access to irrigation and irrigation use intensity is shown in Table 1. A close scrutiny of the table shows the following interesting results:

- The mean per capita income of rain-fed farmers is below the poverty line. Interestingly also the mean per capita income values up to the eighth income deciles is lower than the assumed poverty line. But, the mean per capita income for irrigators and the overall sample is higher than the poverty line;
- The gap between mean per capita income and poverty line widens in proportion to the size of irrigated area;
- Comparison of the mean per capita income for the richest 10% of irrigators and non-irrigators shows that the mean per capita income for the former is almost double that of the latter group. The income difference widens with the size of irrigated area;
- Comparison of the per capita income for the lower 10% of income distribution for irrigators and non-irrigators shows that the per capita income for the irrigators is three times that of non-irrigators. This difference is also influenced by the size of cultivated area;
- The gap in mean per capita income between poor and non-poor households is substantial irrespective of access to irrigation;

- Even though the mean per capita income of poor people with access to irrigation is higher than that of the poor without access to irrigation, the difference seems to be insignificant;
- The Gini index of income inequality values suggests that income inequality is higher among households with access to irrigation as compared to those with no access. The values for the deciles ratios also indicate that income inequality is lower among the rain-fed farmers.

Table 1. Distribution of per capita income by income deciles for irrigators and non-irrigators

Deciles	Rain-fed	Irrigation by size in *Timmad*					Overall mean
		<1	1-2	>2-4	>4	Irrigators	
First	38.5	90.8	80.4	116.5	233.4	114.5	72.6
Second	166.8	274.6	242.6	362.9	520.0	331.0	236.4
Third	285.6	385.5	466.7	538.9	708.2	503.0	391.0
Fourth	401.6	509.3	584.3	658.8	960.2	648.2	526.8
Fifth	514.2	673.4	813.8	864.0	1268.3	850.9	651.5
Sixth	617.0	827.0	1035.8	1270.1	1641.1	1127.9	842.0
Seventh	774.2	1112.8	1245.2	1766.1	2295.2	1507.0	1099.5
Eighth	984.5	1481.8	1729.0	2506.7	3294.9	2067.9	1542.5
Ninth	1379.2	2033.6	2374.8	3889.2	4796.6	3231.7	2425.7
Tenth	4152.5	6395.6	7447.2	9352.3	10212.0	8736.3	7096.5
Mean	930.7	1369.6	1613.7	2230.9	2492.7	1908.3	1487.3
Poverty line	1075	1075	1075	1075	1075	1075	1075
poor	486.2	503.4	527.0	525.2	602.9	498.5	492.8
non-poor	2688.4	2980.4	3123.2	3998.4	3718.5	3497.1	3290.5
% poor	77.1	66.3	58.9	53.9	41.8	58.5	65.7
Gini coefficient	0.499	0.507	0.515	0.537	0.503	0.546	0.547
Deciles ratio	11.6	14.8	20.1	22.6	16.4	26.9	20.7

Poverty Profile

Rural Poverty and Irrigation

Table 2 shows the incidence, depth and severity of poverty by access to irrigation, irrigation typology, and extent of irrigated area owned by those who have access to irrigation. As expected, the poverty incidence, depth and severity values are lower for farmers that have access to irrigation. While the interpretation of the incidence values is straight forward (i.e., it indicates the proportion of poor people in the sample), that of the depth and severity is not. The depth of poverty for irrigators is about 0.322 as compared to 0.425 for those without access to irrigation. The interpretation is that the per capita income of farmers with access to irrigation needed to be increased on average by 32.2% to lift their per capita income level to the poverty line or alternatively to move them out of absolute poverty, while the income of rain-fed poor farmers should be increased by 42.5% to lift them out of poverty. The higher poverty severity value for rain-fed poor farmers also indicates that inequality among the poor rain-fed farmers is higher when compared to irrigating poor farmers. Similar interpretations hold for tables 3 through 6 as well.

We noted that the incidence of poverty among the sample households is still higher irrespective of access to irrigation indicating the seriousness of rural poverty in Ethiopia. When comparing irrigation scheme types, the poverty situation is worse among irrigators benefiting from traditional schemes. Poverty indices are also responsive to the size of irrigated area. Poverty incidence for households owning less than 1 *timmad*[i] of irrigated land is about 65.8%, which decreases to 40.3% for those owning more than 4 *timmad* of irrigated land.

Table 2.The effect of irrigation on incidence, depth and severity of poverty

Variables	Incidence ($\alpha = 0$)		Depth ($\alpha = 1$)		Severity ($\alpha = 2$)	
	value	SD	Value	SD	Value	SD
Access to irrigation						
Irrigators	0.585	0.0197	0.322	0.0140	0.226	0.0125
Non-irrigators	0.771	0.0211	0.425	0.0161	0.283	0.0144
Irrigation scheme type						
Traditional Schemes	0.661	0.0303	0.404	0.0234	0.297	0.0216
Modern Schemes	0.537	0.0255	0.270	0.0169	0.181	0.0148
Size of irrigation area						
No irrigation	0.792	0.0191	0.466	0.0160	0.333	0.0154
<1 *timmad*	0.658	0.0374	0.351	0.0259	0.230	0.0220
1-2 *timmad*	0.586	0.0436	0.299	0.0298	0.203	0.0254
>2-4 *timmad*	0.524	0.0390	0.268	0.0246	0.171	0.0209
>4 *timmad*	0.403	0.0450	0.177	0.0246	0.104	0.0181

It is true that the exact magnitude of the calculated poverty incidence, depth and severity values is influenced by the level of the chosen poverty line.

This is particularly true when one considers the fact that the different regions of Ethiopia are expected to differ in the magnitude of poverty line due to several reasons (Coudouel *et al.,* 2002). To avoid the potential bias that might be created due to the use of inappropriate poverty line, we have plotted a graph depicting the relationship between all the realized per capita income and the corresponding poverty incidence values. The results are shown in figures 2 and 3. Figure 2 shows that baring the results for the extreme low values of per capita income, at all of the realized per capita income (plausible poverty lines); the poverty incidence is consistently higher among farmers with no access to irrigation. The vertical line indicates the assumed poverty line (1,075 Birr).Figure 3 shows poverty incidence for different irrigated area categories. The figure indicates that poverty incidence is very responsive to the size of irrigated area.

Figure 2. Poverty incidence curves for irrigators and non-irrigators under different poverty line assumptions

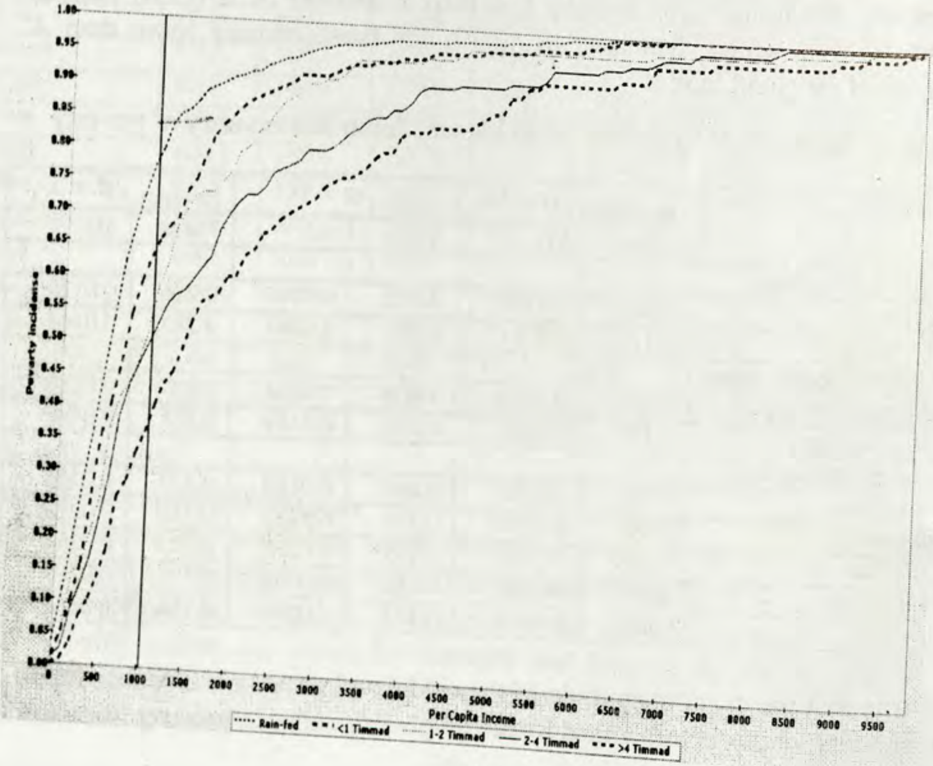
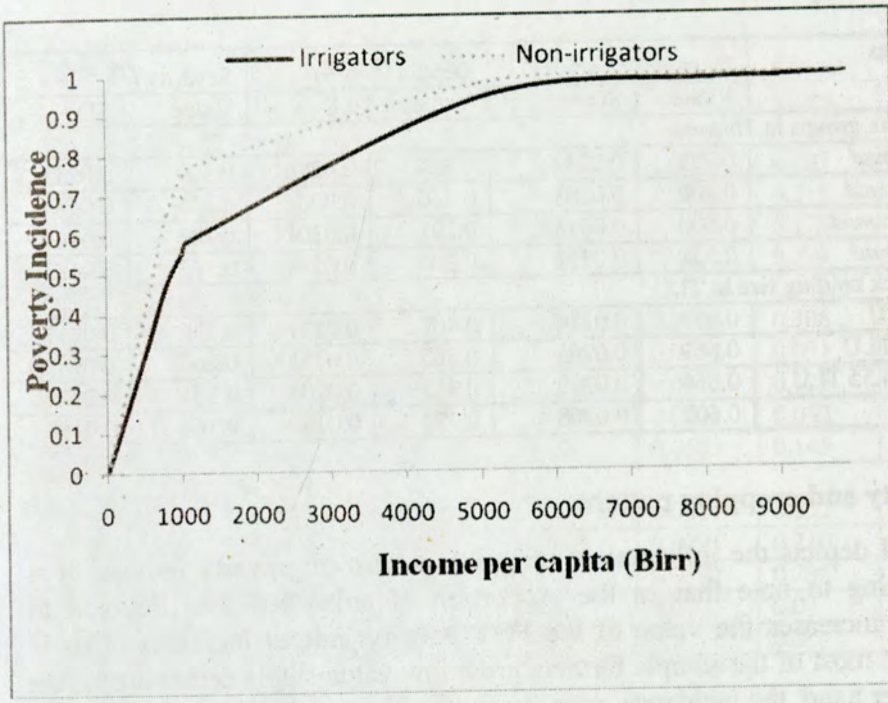


Figure 3. Poverty incidence by different irrigated area size classes



Poverty, Farm Size and Livestock Holding

The effect of farm size and livestock holding on the incidence, depth and severity of poverty is shown in Table 3. The incidence depth and severity of poverty among farmers in the higher farm size category is significantly lower. However, it should be noted that the room for expanding farm size is limited in most parts of Ethiopia due to population pressure. Any farther expansion is possible only in fragile lands or important natural resources enclaves. Poverty incidence is lower among farmers with highest livestock holding.

Table 3. The effect of farm size and livestock holding on poverty incidence, depth and severity

Variables	Incidence ($\alpha = 0$)		Depth ($\alpha = 1$)		Severity ($\alpha = 2$)	
	Value	SD	Value	SD	Value	SD
Farm size groups in *Timmad*						
<3 *Timmad*	0.789	0.0249	0.524	0.0216	0.400	0.0211
3-5 *Timmad*	0.700	0.0288	0.360	0.0204	0.235	0.0181
>5-8 *Timmad*	0.600	0.0313	0.291	0.0201	0.183	0.0164
>8 *Timmad*	0.531	0.0312	0.260	0.0194	0.163	0.0157
Livestock holding size in TLU						
<0.7 TLU	0.657	0.0230	0.407	0.0231	0.299	0.0217
0.7-2.6 TLU	0.669	0.0295	0.383	0.0212	0.260	0.0182
>2.6 to 4.55 TLU	0.654	0.0299	0.353	0.0205	0.231	0.0172
>4.55	0.607	0.0308	0.272	0.0190	0.164	0.0155

Poverty and cropping pattern

Table 4 depicts the influence of cropping pattern on poverty indices. It is interesting to note that as the proportion of cultivated area devoted to cereals increases the value of the FGT poverty indices increases. This is because most of the sample farmers grow low value staple cereal crops. On the other hand, the incidence, severity and depth of poverty are significantly lower among farmers whose substantial proportion of cultivated area is devoted to vegetables and root crops. This suggests that poverty among smallholders can be reduced through diversifying crop production by including high value crops such as vegetables. However, it is also important to note that most of the farmers who grow vegetables and root crops had access to irrigation.

Table 4. The effect of cropping pattern on poverty incidence, depth and severity

Variables	Incidence ($\alpha = 0$)		Depth ($\alpha = 1$)		Severity ($\alpha = 2$)	
	Value	SD	Value	SD	Value	SD
Crop area shares: cereals						
<0.25	0.575	0.0319	0.385	0.0257	0.307	0.0239
0.25-0.50	0.630	0.0290	0.334	0.0196	0.218	0.0170
0.50-0.75	0.641	0.0303	0.290	0.0190	0.175	0.0152
0.75-1.0	0.780	0.0259	0.441	0.0203	0.299	0.0185
Crop area shares: vegetables						
No vegetables	0.766	0.0158	0.440	0.0126	0.308	0.0117
<0.25	0.455	0.0399	0.178	0.0195	0.091	0.0130
0.25-0.50	0.368	0.0495	0.179	0.0313	0.125	0.0291
0.50-0.75	0.263	0.1011	0.096	0.0528	0.062	0.0440
0.75-1.0	0.258	0.0786	0.181	0.0603	0.145	0.0537
Crop area share: root crops						
No root crops	0.661	0.0161	0.366	0.0117	0.252	0.0105
<0.25	0.645	0.0435	0.329	0.0291	0.210	0.0239
0.25-0.50	0.667	0.0786	0.411	0.0592	0.295	0.0518
0.50-0.75	0.0	0.0	0.0	0.0	0.0	0.0
0.75-1.0	0.0	0.0	0.0	0.0	0.0	0.0
Crop area shares: fruits						
No fruits	0.671	0.0176	0.351	0.0120	0.233	0.0109
<0.25	0.523	0.0377	0.296	0.0257	0.203	0.0217
0.25-0.50	0.738	0.0480	0.471	0.0383	0.345	0.0351
0.50-0.75	0.625	0.1211	0.398	0.0930	0.297	0.0855
0.75-1.0	0.903	0.0531	0.668	0.0647	0.675	0.0672

Poverty and Household Demographic and Socioeconomic Characteristics

Table 6 presents the state of poverty among sample farmers by their demographic and socioeconomic characteristics. Education had a profound effect on poverty. In fact, no poor person with post secondary education has been identified. Poverty is also highly associated with household size. The poverty incidence is almost 90% among households having 10 members or more. Contrary to our expectation, the poverty incidence is relatively lower among female headed households. Poverty incidence is also lower among younger farm households.

Table 6. Household socioeconomic and demographic characteristics

Variables	Incidence ($\alpha = 0$)		Depth ($\alpha = 1$)		Severity ($\alpha = 2$)	
	value	SD	Value	SD	Value	SD
Education						
No education	0.677	0.0186	0.364	0.0132	0.243	0.0114
Elementary	0.649	0.0295	0.356	0.0209	0.241	0.0182
Secondary	0.539	0.0465	0.295	0.0333	0.215	0.0311
Post-secondary	0.0	NA	0.0	NA	0.0	NA
Household Size						
1 person	0.348	0.0703	0.177	0.0445	0.122	0.0390
2-4 persons	0.529	0.0278	0.277	0.0181	0.183	0.0153
5-9 persons	0.727	0.0183	0.399	0.0139	0.275	0.0126
10 + persons	0.885	0.0408	0.581	0.0401	0.435	0.0411
Gender						
Male	0.664	0.0162	0.368	0.0118	0.254	0.0105
Female	0.626	0.0370	0.330	0.0257	0.221	0.0220
Household age group						
15 through 24	0.561	0.0658	0.301	0.0463	0.212	0.0419
25 through 34	0.592	0.0347	0.310	0.0239	0.211	0.0215
35 through 44	0.665	0.0292	0.359	0.0412	0.245	0.0187
45 through 54	0.710	0.0320	0.315	0.0225	0.315	0.0225
55 through 64	0.680	0.0381	0.359	0.0268	0.236	0.0232
65 through 74	0.686	0.0460	0.358	0.0322	0.233	0.0278
75 +	0.646	0.0691	0.364	0.0491	0.248	0.0430

Analytical Results

The logistic regression analysis is fitted to strengthen and clarify the descriptive results of the preceding descriptive sections. Before presenting the model results we give a brief description of the variables included in the model (see Table 7). There is significant association between poverty and access to irrigation. Irrigating households have also significantly higher farm size, family size, and years of schooling. They also devote significantly lower area to the cultivation of food grains than the non-irrigators. The proportion of female headed households is relatively higher among farmers without access to irrigation.

Table 7. Description of variables included in the logit regression model

Variables	Irrigators	Non-irrigators	statistic
Proportion of poor (Y=1=poor, 0 other wise) (%)	56.8	76.6	41.578***
Proportion of female (%) (X1)	14.8	19.6	4.051*
Zones (Number) (X2)			
North Omo	55	55	NA
Arsi	109	30	NA
Awi	55	53	NA
Raya Azebo/Southern Tigray	107	100	NA
East Shewa	108	57	NA
West Shewa	110	55	NA
West Gojam	83	47	NA
Irrigated area (Timmad) (X3)	3.02	NA	NA
Farm Size (Timmad) (X4)	6.87	5.90	8.321***
Area share of grains (%) (X5)	64.33	91.21	234.085***
Livestock holding in TLU (X6)	3.78	4.20	2.708
Family Size (number) (X7)	5.63	5.34	3.569*
Age of household head (years) (X8)	45.99	44.84	1.386
Years of schooling (X9)	2.34	1.65	11.389***

Note: NA=Not Applicable

The model results are summarized in Table 8. The likelihood ratio χ^2 statistic is used to test the dependence of rural poverty on the variables included in the model. Under the null hypothesis (Ho) where we have only one parameter, which is the intercept (β_o), the value of the restricted log likelihood function is -666.39, while under the alternative hypothesis (H_1) where we have all the parameters, the value of the unrestricted log likelihood function is -453.64. The model χ^2 statistic is highly significant, indicating that the log odds of household poverty are related to the model variables. With regard to the predictive efficiency of the model, of the 1,024 sample households included in the model, 822 or 80.3% are correctly predicted.

The results of the parameter estimates of determinants of poverty generally agree with the descriptive results of the preceding sections. Of the twelve variables included in the model, nine were found to have a significant impact on poverty. Increases in farm size, irrigated area and years of schooling significantly reduce the probability of being poor; while increases in family size and area share of food grains in the total cultivated area significantly increases the probability of being poor. The relationship between poverty and family size is non-linear. Family size increases the probability of being poor up to a certain point beyond which any successive addition of a family member contributes to the reduction of poverty. This confirms the usual inverse U relationship between poverty and family size (World Bank, 1991; 1996; Cortes, 1997; Szekely, 1998; Gang *et al.*, 2004). Livestock holding size, which is usually regarded as a measure of wealth had the expected sign but not statistically significant. Contrary to our expectation female headed households had lower chance of being poor as compared to male headed households. Concerning location effects, the probability of being poor for sample households from North Omo and West Shewa is significantly higher, whereas the probability of being poor for households from East Shewa and Raya Azebo zones is significantly lower.

We assessed the magnitude of the effect of changes in statistically significant and policy relevant variables on household poverty based on the partial effects of the respective variables on conditional probabilities (Table 9). The partial effects of continuous variables were calculated using equation 5, while those of the discrete variables were calculated by taking the difference between the mean probabilities estimated at the respective values (0 and 1) of the discrete variables. The partial effects thus calculated from the logistic model show the effect of change in an individual variable on the probability of being poor when all other exogenous variables are held constant.

Table 8. Parameter estimates of determinants of poverty model

Variables	Estimate [a]	SE	e^{β}	$100(e^{\beta}-1)$
Constant	-1.018	0.913	0.361	-63.9
Size of irrigated area	-0.354***	0.117	0.702	-29.8
Area share of grains cultivation	1.942***	0.433	6.970	597
Irrigated area-by-area share of grain	0.291*	0.156	1.338	33.8
Farm size	-0.202***	0.026	0.817	-18.3
Livestock holding in TLU	-0.039	0.025	0.961	-3.9
Family size	0.724***	0.146	2.064	106.4
Square of family size	-0.022*	0.012	0.979	-2.1
Age of household head	-0.050	0.035	0.951	-4.9
Square of age of household head	0.001	0.000	1.001	0.1
Level of education of HH head	-0.116***	0.032	0.890	-11
Sex of the household head(=Male)	0.438*	0.246	1.549	54.9
Zones:				
North Omo	2.248***	0.440	9.470	847
Arsi	0.663*	0.378	1.940	94
Awi	-0.161	0.353	0.852	-14.8
Raya Azebo/Southern Tigray	-0.569*	0.296	0.566	-43.4
East Shewa	-1.353***	0.309	0.258	-74.2
West Shewa	1.107***	0.357	3.026	202.6
West Gojam (reference)				

Note:
Restricted log likelihood value [Log (L0)] =-666.3848
Unrestricted log likelihood value [Log (L1)] =-453.6428
Log likelihood value ($\chi^2_{(df=9)}$) $= -2[\log(L0) - (-\log(L_1))] = 425.4841$ ***
% of correct prediction=80.3
Number of observation=1024
[a] The parameters were estimated using maximum likelihood methods. They are un-weighted.
***Statistically significant at p<0.01; **statistically significant at p<0.05; *statistically significant at p<0.1.

In logit model analysis, it is marginal effect values and elasticities that have direct economic interpretation - not the estimated coefficients. Looking at the marginal effect and elasticity values presented in Table 9, the irrigation variable comes third or after area share of grains and family size variables in quantitative importance with respect to poverty reduction. Rural poverty is highly responsive to the cropping pattern. A unit increase in the proportion of area of grain crops increases the probability of being poor by 0.41% or a 1% increase in the proportion of area devoted to grain crops increases the probability of being poor by 0!44%. This implies that changing the crop mix managed by farmers towards high value crops such as vegetables would have a profound effect on rural poverty. Irrigation technology facilitates the cropping pattern shift process. A one *timmad* increase in an irrigated area would reduce the probability of being poor by 0.075%. In other words, a 1% increase in irrigated area would reduce the probability of being poor by 0.2%. Increasing the household member by one person would increase the probability of being poor by 0.15%. Alternatively a 1% increase in the family size would increase the probability of being poor by 1.21%. Another significant policy relevant variable is years of schooling. A unit increase in year of schooling decreases the probability of being poor by 0.0245.

Table 9. Marginal effects of the significant variables

Determinants	Marginal effects	Elasticity
Irrigated area in *timmad*	-0.0747	-0.20
Area share of grain crops	0.4089	0.44
Farm size in *timmad*	-0.0426	-0.40
Family size	0.1526	1.21
Years of schooling	-0.0245	-0.07
Gender (Male)	0.0865	0.02
Zones		
North Omo	0.3113	0.06
Arsi	0.1240	0.02
Awi	-0.0346	-0.01
Raya Azebo	-0.1268	-0.04
East Shewa	-0.3156	-0.07
West Shewa	0.1948	0.05

The interesting results contained in Table 10 can be graphically depicted. Poverty is more responsive to the size of irrigated area than mere access to irrigation (See panel a and b of Figure 4). In Ethiopia due mainly to the demand for irrigated land exceeding the supply and due also partly to the egalitarian policies followed for rural development, the irrigated land is rationed. In an effort to reach many people the irrigated plots distributed to farmers are often far below an economic size that is sufficient to warrant the full engagement of farmers in irrigated production business. Consequently, irrigated farming is considered as a second best option by farmers.

As has already been demonstrated, rural poverty is also very responsive to cropping pattern changes (see panel c and d of Figure 4). Reductions in area share of food grains and increases in the area share of high value crops such as vegetables significantly reduce rural poverty. Two major variables that allow the change to high value crops are access to irrigation and proximity to the demand centers thus allowing easy marketing. Panel E and F in Figure 4 show that poverty is highly related to family size and level of education of the household head.

Figure 4. A graphical illustration of the effect of irrigation, cropping pattern, household size, and education on rural poverty

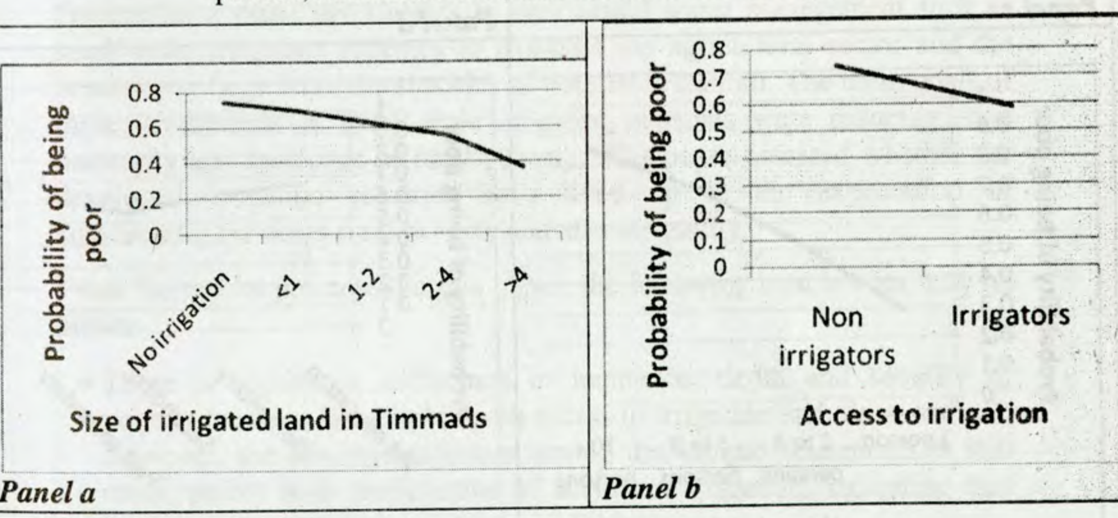
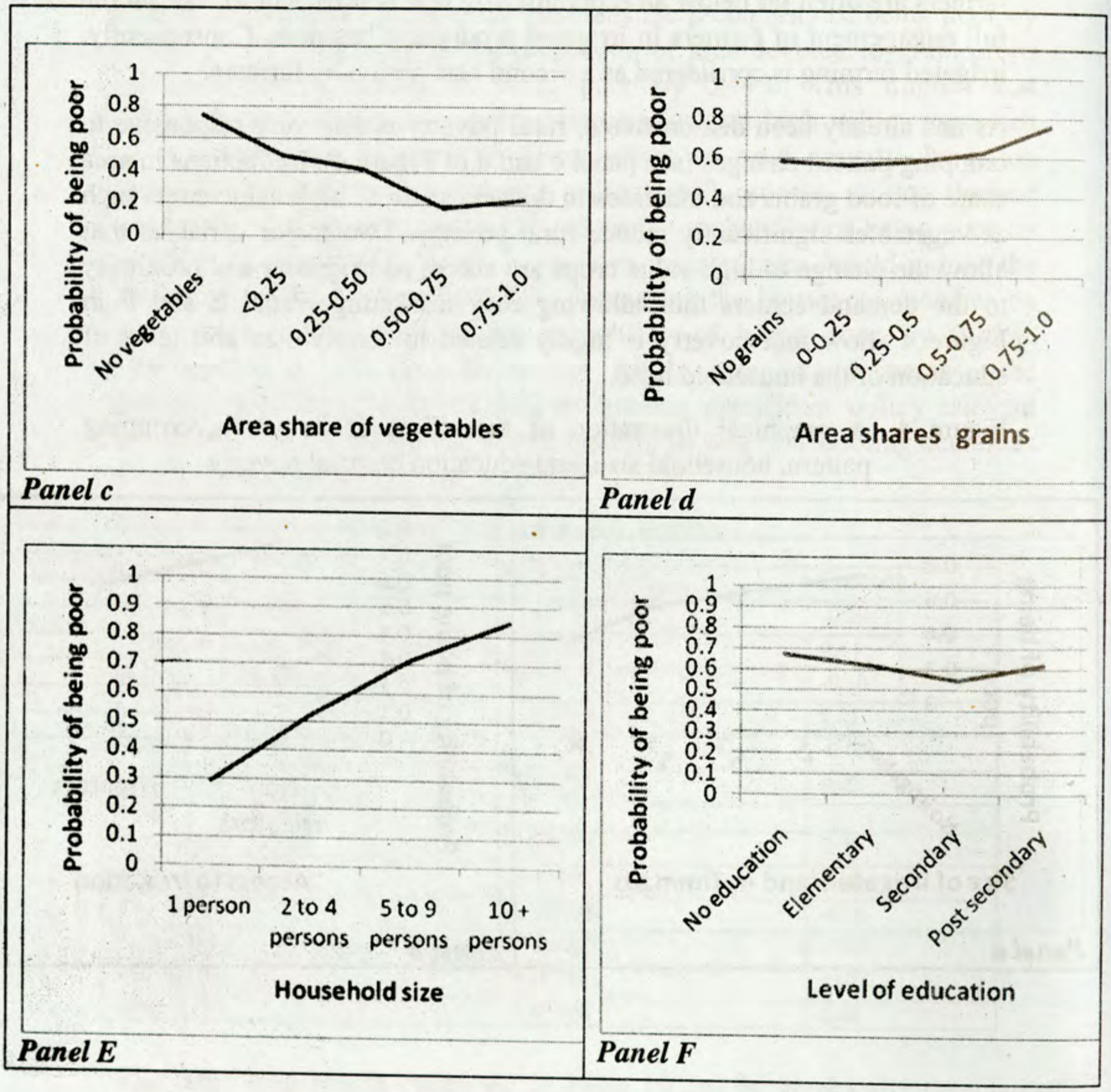


Figure 4 … cont'd



Conclusions and policy implications

In Ethiopia agriculture and even the performance of macro-economy is taken hostage by the amount and distribution of rainfall. The unreliable rainfall pattern in many parts of the country forced the farming population to adopt a risk-averse behavior, the behavior that limits the capacity of farmers to innovate and adopt farming technologies with potential of boosting yield and income. For instance, the successive Ethiopian governments have tried to enhance the productivity of agriculture through modest investments in agricultural research and extension, mainly focused on seed and fertilizer technologies. Several evaluation studies of these programs have underlined that the seed and fertilizer technologies were mostly successful in areas endowed with relatively ample moisture (Byerlee *et al.*, 2007). It was based on this revelation that the government, NGOs and farmers have made investments in agricultural water management such as small-scale irrigation schemes to extricate the agricultural sector and the economy at large from the shackles of unreliable rainfall. The main goals of these investments in small-scale irrigation schemes were reducing food insecurity and incidence of rural poverty. This paper assessed whether the developed irrigation schemes have lived up to the expectation of significantly reducing rural poverty and also inequality.

From the results presented in this paper, the following conclusions may be drawn:

- There is significant difference in incidence, depth and severity of poverty between households with access to irrigation and those without. However, the poverty incidence among the sample households is still unacceptably high irrespective of access to irrigation, indicating that poverty is deeply entrenched in rural Ethiopia.
- Poverty indices are responsive to irrigation typology and irrigation use intensity. Among the two irrigation typologies studied, the poverty situation is relatively milder among modern irrigation scheme users.
- Poverty indices were found also to be responsive to the irrigation intensity as measured by the size of irrigated area. Poverty incidence is significantly lower among households with higher irrigated area size. Due to demand outstripping the limited supply of irrigation service and due to considerations for equity, irrigation plots are rationed in Ethiopia.

The limited differentiation observed in the size of irrigated land among sample farmers is due to the prevalence of informal irrigable land markets or informal land rental contracts. This calls for an investigation to determine a minimum economically viable irrigated area that needed to be allotted to a household for sustained poverty and food insecurity reduction.

- Poverty incidence is also related to the cropping pattern, indicating that mere access to irrigation would not bring the desired results. Poverty situation is more sever among farmers devoting significant proportion of their cropping land to food grains (cereals, oil seeds and pulses) irrespective of access to irrigation. Vegetable growers are better off in terms of poverty situation. The implication is that irrigation project planners should consider the crop mix in future irrigation development plans.
- Income inequality among households with access to irrigation is worse than that of those without access. The implication is that even though accesses to irrigation move up the mean income, farmers have different capacity in making better use of the available irrigation water and therefore irrigation widens the income gap. However, the main policy concern in Ethiopia is reducing absolute poverty at this moment.
- Finally, our study confirms that while the income inequalities among households without access to irrigation are lower, it was found that inequality among rain-fed poor farmers is higher than those with access to irrigation.

Acknowledgments

This study is part of a comprehensive study on the impacts of irrigation on poverty and environment run between 2004 and 2007 in Ethiopia implemented by the International Water Management Institute (IWMI) with support from the Austrian government.

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Endnote

[i] A *timmad* is a local measure of cultivated area approximately about 0.25 ha. However, there is variation from region to region depending on factors such as topography, soil type, the capacity of oxen and length of working hours in a day.