Rural poverty and inequality in Ethiopia: does access to small-scale irrigation make a difference?

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Abstract

Ethiopia is an agrarian society in a land of drought and floods. Agricultural production, which is the source of livelihood for eight out of ten Ethiopians, is extremely vulnerable to climatic conditions. The causes of rural poverty are many including wide fluctuations in agricultural production as a result of drought, ineffective and inefficient agricultural marketing system, under developed transport and communication networks, underdeveloped production technologies, limited access of rural households to support services, environmental degradation and lack of participation by rural poor people in decisions that affect their livelihoods. However, the persistent fluctuation in the amount and distribution of rainfall is considered as a major factor in rural poverty. Cognizant of this reality the successive Ethiopian governments and farmers have made investments in small scale irrigation schemes. This paper aims to assess the efficacy of these investments in reducing poverty based on data obtained from a survey of 1024 farmers drawn from four major regional states of Ethiopia. The Foster, Greer and Thorbecke poverty measures were used to compare the incidence, depth and severity of poverty among groups of farmers defined by relevant policy variables including access to irrigation. In order to explore the correlates of rural poverty and their quantitative significance, logistic regression model was estimated. The main conclusion of the study is that the incidence, depth and severity of poverty is affected more by the intensity of irrigation use (as measured by the size of irrigated area) than mere access to irrigation. Alternatively, there seems to be an economy of scale in the poverty-irrigation relationship.

1. Introduction

Farmers in rural Ethiopia live in a shock-prone environment. Agricultural production, which is the source of livelihood for eight out of ten Ethiopians, is extremely vulnerable to climatic conditions. The causes of rural poverty are many including wide fluctuations in agricultural production as a result of drought, ineffective and inefficient agricultural marketing system, under developed transport and communication networks, underdeveloped production technologies, limited access of rural households to support services, environmental degradation and lack of participation by rural poor people in decisions that affect their livelihoods. However, the persistent fluctuation in the amount and distribution of rainfall is considered as a major factor in rural poverty. Small-scale farmers are the largest group of poor people in Ethiopia. Their average land holdings are smaller, their productivity is low and they are vulnerable to drought and other adverse natural conditions. Cognizant of this reality the successive Ethiopian governments and farmers have made investments in small scale irrigation schemes. Despite efforts to reduce poverty in the country over the past decade, farmers, herders and other rural people remain poor. Poor people in rural areas face an acute lack of basic social and economic infrastructure such as health and educational facilities, veterinary services and access to safe drinking water. Households headed by women are particularly vulnerable. Women are much less likely than men to receive an education or health benefits, or to have a voice in decisions affecting their lives. For them,

poverty means high numbers of infant deaths, undernourished families, lack of education for children and other deprivations (IFAD).

The impact of drought on the overall macro-economy of Ethiopia is very significant. There is very strong correlation between hydrology and Ethiopia's GDP performance. It is widely accepted that the Ethiopian economy is taken hostage to hydrology due to the so far insignificant infrastructural development in the water sector (World Bank, 2006). Oftentimes, Ethiopia is ravaged by droughts, leading to dramatic slow downs in economic growth. The development of water storage facilities which could be used, among other things, to develop irrigation is seen as a way of reducing Ethiopia's dependence on the annual availability of rainfall (UNPD, 2006; World Bank, 2006).

In Ethiopia, the persistent correlation between rainfall and GDP growth is striking and troubling. The effects of hydrological variability emanate from the direct impacts of rainfall on the landscape, agricultural output, water-intensive industry and power production. These impacts are transmitted through input, price and income effects onto the broader economy, and are exacerbated by an almost complete lack of hydraulic infrastructure to mitigate variability and market infrastructure that could mitigate economic impacts by facilitating trade between deficit and surplus regions of the country.

Evidences from elsewhere indicate that initial investments in water resources management and multipurpose hydraulic infrastructure had massive regional impacts with very large multiplier effects on the economy. Therefore, it is possible that irrigation investments in Ethiopia may have contributed to poverty reductions among other people than the irrigators, who are direct beneficiaries of the investment. However, in this paper we limit ourselves to the poverty impact of small-scale irrigation development on the direct beneficiaries or farmers.

Definition of concepts

Before addressing the rural poverty and irrigation nexus, it is important to clarify the meaning of poverty. There is great variation in the manner in which poverty is being defined and measured in developing countries (May,2001). Poverty is a persistent feature of socioeconomic stratification through out the world. Over the last twenty five years the understanding of poverty has advanced and become more holistic. From having been understood almost exclusively as inadequacy of income, consumption and wealth, multiple dimensions of poverty and their complex interactions are now widely recognized. These include isolation, deprivation of political and social rights, a lack of empowerment to make or influence choices, inadequate assets, poor health and mobility, poor access to services and infrastructure, and vulnerability to livelihood failure.

Often distinction is made between absolute and relative poverty. Relative poverty measures the extent to which a household's income falls below an average income threshold for the economy. Absolute poverty measures the number of people below a certain income threshold or 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. Consideration is also necessary of the dynamics of both chronic[1] 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). 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 any

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[1] Chronic poverty is an individual experience of deprivation that lasts for a long period of time. In this sense the chronic poor are those with per capita income or consumption levels persistently below the poverty line during a long period of time. Transient poverty is associated with a fluctuation of income around the poverty line.

assessment of how irrigation can affect 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. In order to understand the dynamics of poverty, one can draw on the notions of 'capabilities' and 'entitlements' that have received a good deal of attention (Sen 2000). Sen's work belies the idea that income shortfalls are the main attribute of poverty. He emphasises the importance of the bundle of assets or endowments held by the poor, as well as the nature of the claims attached to them, as critical for analyzing poverty and vulnerability.

Nevertheless, while recognizing that poverty is a multidimensional phenomenon consisting of material, mental, political, communal and other aspects, the material dimensions of poverty expressed in monetary values is too important an aspect of poverty to be neglected (Lipton 1997). Given the fact that there is 'a lack of consensus regarding the measurement of other forms of deprivation', the approach followed in this paper is ultimately grounded on the notion of some minimum threshold below which the poor are categorized (Lipton 1997). There is growing recognition that poverty may adequately be defined as private consumption that falls below some absolute poverty line. This is best measured by calculating the proportion of the population who fall below a poverty line (the headcount) and the extent of shortfall between actual income level and poverty line (the depth or severity of poverty). The poverty line is usually based on an estimated minimum dietary energy intake, or an amount required for purchasing a minimum consumption bundle.

This paper analyses the state of poverty and inequality among sample farm households with and without access to irrigation. It also analyses the correlates of poverty. Section two presents the data collection and analytical methods. Section three shows the results of poverty profiling, while section four assesses the determinants of poverty and their quantitative significance in predicting poverty. Section fives gives some policy conclusions and implications.

2. Methodological Issues

Data sources

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. The socio-economic survey data on which this paper is based is gathered from a total of 1024 households from eight irrigation sites in 4 Regional states involving traditional, modern and rain fed systems. The total sample constitutes 397 households practicing purely rainfed agriculture and 627 households (382 modern and 245 traditional) practice irrigated agriculture. These households operate a total of 4953 plots (a household operating five plots on average). Of the total 4953 plots covered by the survey, 25 percent (1,250 plots) are under traditional irrigation, 43 percent (2,137 plots) are under modern while the remaining 32 percent (1,566 plots) are under rainfed agriculture. The data was collected for the 2005/2006 cropping season.

Poverty indices

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 measurement than income for many reasons (Coudouel et al. 2002). One should not be dogmatic, however, about using consumption data for poverty measurement. The use of income as a poverty measurement may have its own advantages. In this paper we estimate poverty using income adjusted for differences in household characteristics.

As for the poverty measures, we will be concerned with those in the Foster-Greer-Thorbecke (FGT) class. The FGT class of

poverty measures have some desirable properties (such as additive decomposibility), and they include some widely used poverty measures (such as the head-count and the poverty gap measures). Following Duclos et al. (2006), the FGT poverty measures are defined as

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

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 α =0 equation 1 measures poverty incidence or poverty head count ratio. This is the share of the population whose income or consumption is below the poverty line, that is, the share of the population that cannot afford to buy a basic basket of goods.

At α =1 equation 1 measures depth of poverty (poverty gap). This provides information regarding how far off households are from the poverty line. This measure captures the mean aggregate income or consumption shortfall relative to the poverty line across the whole 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 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). Note also that, the poverty gap can be used as a measure of the minimum amount of resources necessary to eradicate poverty, that is, the amount that one would have to transfer to the poor under perfect targeting (that is, 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.

We calculated these indices using DAD4.4 (Duclos, J-Y et al., 2006)

Inequality indices

To assess the income inequality among the different farm household groups, we calculate the Gini coefficient of inequality and Decile ratios. **Gini coefficient of inequality** is the most commonly used measure of inequality. The coefficient varies between 0, which reflects complete equality, and 1, which indicates complete inequality (one person has all the income all others have none). The decile dispersion ratio presents the ratio of the 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 have 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 1075 Birr (1USD=9.07Birr), a level of welfare corresponding to some minimum acceptable standard of living in Ethiopia (reference). The poverty line acts as a threshold, with households falling below the poverty line considered poor and those above the poverty line considered non-poor. Third, after the poor has been identified, poverty measures such as poverty gap and squared poverty gap were estimated. Fourth, we constructed poverty profiles showing how poverty varies over population subgroups (example irrigators Vs non-irrigators) or by characteristics of the household (for example, level of education, age, etc.). 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. Lastly, we analyzed income inequality among sample households.

3. 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 rainfed farmers is below the poverty line. Interestingly also the mean per capita income values up to the eighth income decile is lower than the assumed poverty line. However, the mean per capita income for irrigators and the overall sample is higher than the poverty line and 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 doubles 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 decile 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	Rainfed	Irrigators	Overall	1st quartile [a]	2nd quartile	3rd quartile	4th quartile
First	38.5	114.5	72.6	90.8	80.4	116.5	233.4
Second	166.8	331.0	236.4	274.6	242.6	362.9	520.0
Third	285.6	503.0	391.0	385.5	466.7	538.9	708.2
Fourth	401.6	648.2	526.8	509.3	584.3	658.8	960.2
Fifth	514.2	850.9	651.5	673.4	813.8	864.0	1268.3
Sixth	617.0	1127.9	842.0	827.0	1035.8	1270.1	1641.1
Seventh	774.2	1507.0	1099.5	1112.8	1245.2	1766.1	2295.2
Eighth	984.5	2067.9	1542.5	1481.8	1729.0	2506.7	3294.9
Ninth	1379.2	3231.7	2425.7	2033.6	2374.8	3889.2	4796.6
Tenth	4152.5	8736.3	7096.5	6395.6	7447.2	9352.3	10212.0
Mean	930.7	1908.3	1487.3	1369.6	1613.7	2230.9	2492.7
Poverty line	1075	1075	1075	1075	1075	1075	1075
poor	486.2	498.5	492.8	503.4	527.0	525.2	602.9
non-poor	2688.4	3497.1	3290.5	2980.4	3123.2	3998.4	3718.5
% poor	77.1	58.5	65.7	66.3	58.9	53.9	41.8
Gini coefficient	0.499	0.546	0.547	0.507	0.515	0.537	0.503
Deciles ratio	11.6	26.9	20.7	14.8	20.1	22.6	16.4

Given the assumed poverty line, the proportion of poor households among those households with no access to irrigation is higher than those who have access to irrigation. The poverty reduction impact of access to irrigation is very much influenced by the size or irrigated area. The relationship between poverty and irrigation

and other relevant factors will be analyzed in more detail in the succeeding sections.

4. 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 rainfed farmers is higher when compared to irrigating poor farmers. Similar interpretations hold for tables 3 through 6 as well.

However, note that the incidence of poverty among the sample households is still higher irrespective access to irrigation. When comparing irrigation scheme types, the poverty situation is worse among irrigators belonging to traditional scheme. Poverty indices are also responsive to the size of irrigated area. Poverty incidence for households belonging to the first quartile of irrigated area is about 65.8%, which decreases to 40.3% for those in the fourth quartile.

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
1st quartile (0.66)	0.658	0.0374	0.351	0.0259	0.230	0.0220
2nd quartile (1.87)	0.586	0.0436	0.299	0.0298	0.203	0.0254
3rd quartile (3.56)	0.524	0.0390	0.268	0.0246	0.171	0.0209
4th quartile (7.92)	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 incidence values[1] and the results are shown in Figure 1 and 2.

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 in appropriate poverty line, we have plotted a graph depicting the relationship between all the realized income per capita and the corresponding poverty

Figure 1 shows that baring the results for the extreme low values of income per capita, at all of the realized per capita income (plausible poverty lines), the poverty incidence is higher among farmers with no access to irrigation. The vertical line indicates the assumed poverty line (1075 Birr).
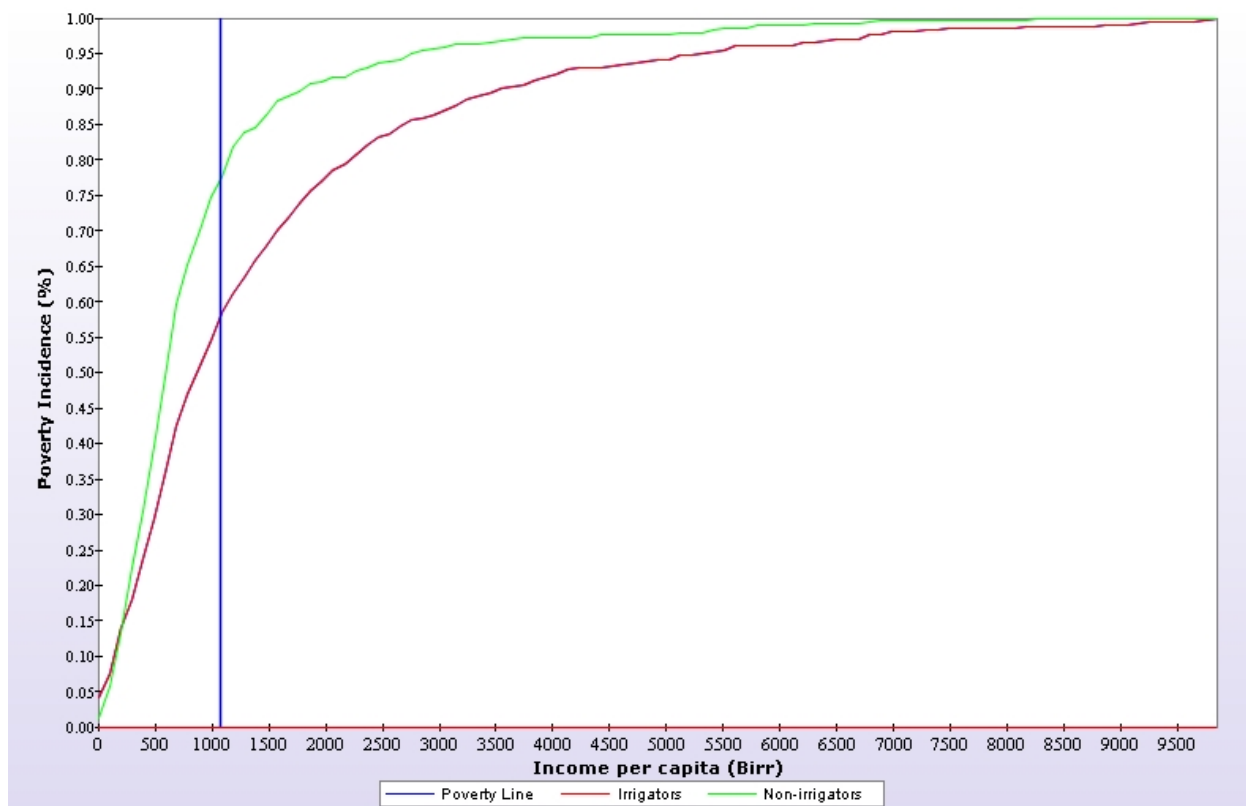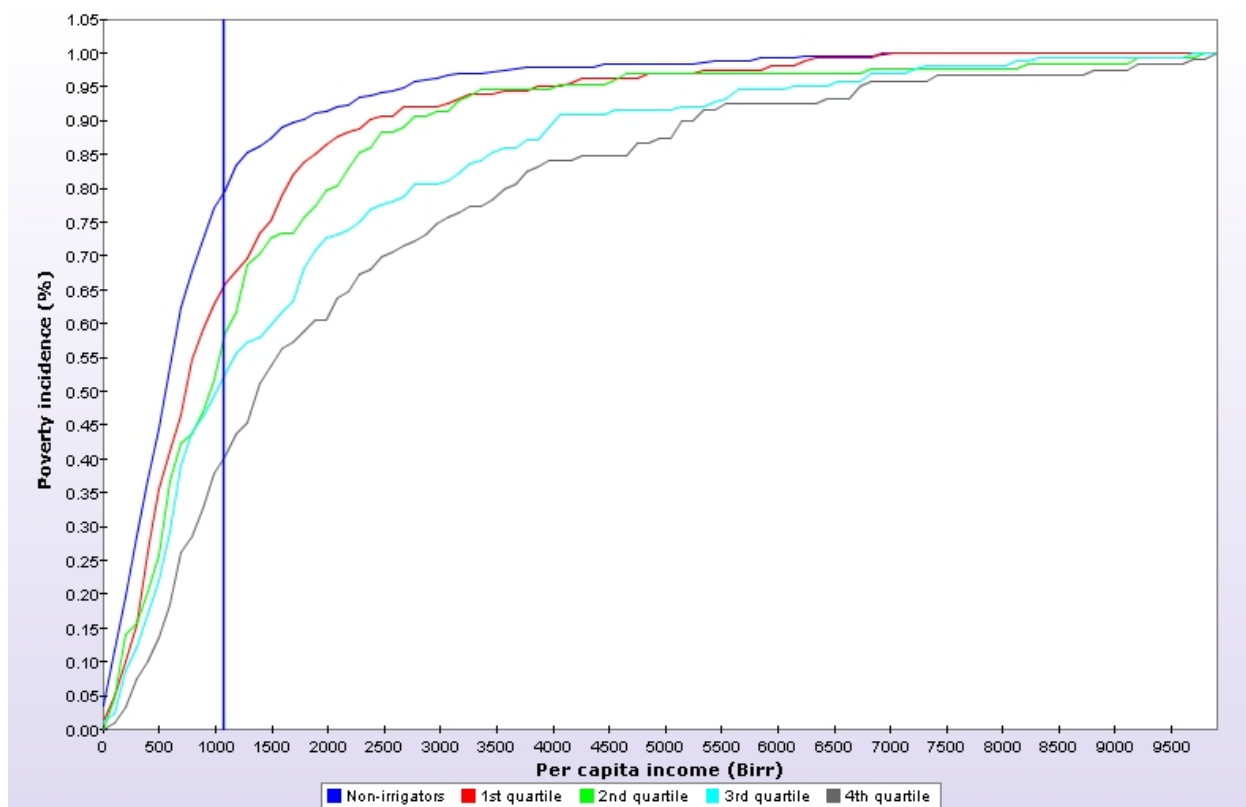
Figure 1. Poverty incidence curves for irrigators and non-irrigators under different poverty line assumptions.

1. We have used DAD 4.4 to generate these curves.

Figure 2 Shows poverty incidence for different irrigated area categories. The figure indicates that poverty incidence is very responsive to the size of irrigated area.

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. The relationship between livestock holding and poverty is generally as expected: 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						
1st quartile	0.789	0.0249	0.524	0.0216	0.400	0.0211
2nd quartile	0.700	0.0288	0.360	0.0204	0.235	0.0181
3rd quartile	0.600	0.0313	0.291	0.0201	0.183	0.0164
4th quartile	0.531	0.0312	0.260	0.0194	0.163	0.0157
Livestock holding						
1st quartile	0.657	0.0230	0.407	0.0231	0.299	0.0217
2nd quartile	0.669	0.0295	0.383	0.0212	0.260	0.0182
3rd quartile	0.654	0.0299	0.353	0.0205	0.231	0.0172
4th quartile	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 particularly important because most of the sample farmers grow low value staple cereal crops. On the other hand, the incidence, severity and depth of poverty is 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						
0.0 - 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
0.0 - 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
0.0 - 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
0.0-0.25	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 geographic characteristics

Table 5 shows poverty indices by geographic location of the sample households. The poverty incidence is generally higher in all of the Ethiopian regional states. It is relatively lower in Oromia and Tigray regional states and higher in Southern Nations Nationalities and Peoples states[2]. When comparing the zones included in the study, the lowest poverty incidence was observed in East Shewa and the highest in North Omo. The observed low poverty incidence rate in East Shewa is not surprising given the fact that the zone is relatively well developed in terms of services and infrastructure, thus providing relatively better marketing conditions and employment opportunities. We have also assessed poverty according to which basin the sample irrigation schemes or farm households

[2] However note the regional differences in poverty line and the non-representative ness of the sample

belong. It was found that poverty is significantly lower in Awash and Denakil basins.

Table 5. Headcount, depth and severity of poverty among sample households

Variable	Incidence ($\alpha = 0$)		Depth ($\alpha = 1$)		Severity ($\alpha = 2$)	
	value	SD	Value	SD	Value	SD
Sample total	0.657	0.0148	0.362	0.0107	0.248	0.0010
Zones						
North Omo	0.871	0.0285	0.626	0.0286	0.506	0.0302
Arsi	0.648	0.0460	0.268	0.0261	0.145	0.0222
Awi	0.717	0.0438	0.390	0.0325	0.264	0.0279
Raya Azebo	0.565	0.0351	0.299	0.0227	0.193	0.0178
East Shewa	0.455	0.0387	0.177	0.0192	0.092	0.0132
West Shewa	0.727	0.0347	0.417	0.0260	0.286	0.0227
West Gojam	0.664	0.0418	0.330	0.0277	0.207	0.0231
Basins						
Abay	0.707	0.0227	0.388	0.0166	0.262	0.0145
Awash	0.535	0.0301	0.219	0.0162	0.120	0.0127
Denakil	0.444	0.0500	0.272	0.0362	0.204	0.0310
Rift Valley	0.871	0.0284	0.626	0.0286	0.506	0.0302
Tekeze	0.704	0.0440	0.369	0.0302	0.235	0.0256
Region						
Amara	0.693	0.0299	0.368	0.0215	0.236	0.0188
SNNP	0.871	0.0285	0.626	0.0286	0.506	0.0302
Oromia	0.607	0.0233	0.293	0.0148	0.182	0.0123
Tigray	0.580	0.0343	0.323	0.0237	0.220	0.0200

The incidence of and severity of poverty is higher in rural than urban areas (52 per cent and 36 per cent, respectively). Poverty is uniformly distributed throughout the country's rural areas. An exception is the region of Oromiya, where the level and intensity of poverty is significantly lower.

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 there are no poor people with post secondary education. Poverty is also highly associated with family 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 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

5. Determinants of rural poverty: the role of access to irrigation

Poverty and poverty changes are affected by both microeconomic and macroeconomic variables. Within a microeconomic context, the simplest method of analyzing the correlates of poverty is to use regression analysis to see the effect on poverty of a specific household or individual characteristic while holding constant all other characteristics, which is the focus of this section. 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., household's income is more than the poverty line). In this paper we follow the later 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 regressions will return results only for the degree of association or correlation, not for causal relationships.

Empirical Model

The discussion in section 3 has relied largely on descriptive results, exploring relationships between variables without holding the effect of other factors constant. However, correlations among key variables potentially could obscure the relationship between poverty and a single factor of interest. 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, using logistic regression. 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 1075 Birr and 1 for poor if a household had a per capita income

less than 1075 Birr (which is considered her as a poverty line).

The 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, livestock holding), the nature of farming system (share of grains in the total cultivated area, size of irrigated area), and location (zones to which the household belong). See table 7 for details of the variables included in the model.

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 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 $[100(e^{\beta} - 1)]$.

(1)

Before presenting the model results we wish to 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.

(2)

(3)

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Table 7. Description of variables included in the model

Variables	Irrigators	Non-irrigators	t-statistic	χ^2
Proportion of poor (Y=1=poor, 0 other wise) (%)	56.8	76.6	NA	41.578***
Proportion of female (%) (X1)	14.8	19.6	NA	4.051*
Zones (Number) (X2)				
North Omo	55	55	NA	NA
Arsi	109	30	NA	NA
Awi	55	53	NA	NA
Raya Azebo	107	100	NA	NA
East Shewa	108	57	NA	NA
West Shewa	110	55	NA	NA
West Gojam	83	47	NA	NA
Irrigated area (Timmad) (X3)	3.02	NA	NA	NA
Farm Size (Timmad) (X4)	6.87	5.90	8.321***	NA
Area share of grains (%) (X5)	64.33	91.21	234.085***	NA
Livestock holding in TLU (X6)	3.78	4.20	2.708	NA
Family Size (number) (X7)	5.63	5.34	3.569*	NA
Age of household head (years) (X8)	45.99	44.84	1.386	NA
Years of schooling (X9)	2.34	1.65	11.389***	NA

The logistic regression analysis is fitted to strengthen and clarify the descriptive results of the preceding descriptive sections.

Empirical results

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 is related to the model variables. With regard to the predictive efficiency of the model, of the 1024 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 section. 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; Lanjouw and Ravallion 1994; Cortes 1997; Szekely 1998, Gang et al. 2004). Livestock holding size, which is usually regarded as a measure of wealth (Shiferaw et al.2007), 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 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 assess 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 4, 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	β	
Constant	-1.018	0.913	0.361	66.9
Size of irrigated area	-0.354**	0.117	0.702	-29.8
Area share of grains cultivation	1.942***	0.433	6.970	59.7
Irrigated area-by-area share of grain	0.291	0.156	1.338	53.8
Farm size	-0.202	0.026	0.817	-18.5
Livestock holding in TLU	-0.039	0.025	0.961	-23.2
Family size	0.724***	0.146	2.064	106.4
Square of family size	-0.022	0.012	0.977	-2.1
Age of household head	-0.050	0.035	0.951	-4.9
Square of age of household head	0.001	0.000	1.000	0.1
Level of education of HH head	-0.116*	0.032	0.890	-13
Sex of the household head(=Male)	0.438	0.246	1.549	34.9
Zones:				
North Omo	2.248	0.440	9.470	84
Arsi	0.663	0.378	1.940	94
Awi	-0.161	0.353	0.852	-14.8
Raya Azebo	-0.569	0.296	0.566	-43.4
East Shewa	-1.353***	0.309	0.258	-74.2
West Shewa	1.169	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 8, 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 increase the probability of being poor by 0.41% or a 1% increase in the proportion of area devoted to grain crops increase 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 immad increase in irrigated area would reduce the probability of being poor by 0.75% . 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. An unit increase in year of schooling decreases the probability of being poor by 0.0245.

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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 3). In the past due mainly to the demand for irrigated land exceeding the supply and due to also partly to the egalitarian policies followed for rural development, the irrigated land is rationed in Ethiopia. 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.

Rural poverty is also very responsive to cropping pattern changes (see panel c and d of Figure 3). Reductions in area share of food grains and increases in the area share of high value crops such as vegetables significantly reduces 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. Figure 4 (panel a and b)show that poverty is highly related to family size and level of education of the household head.
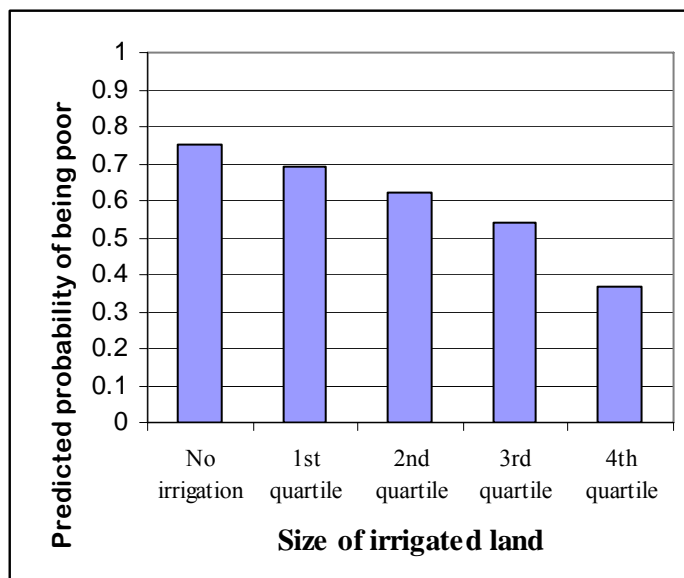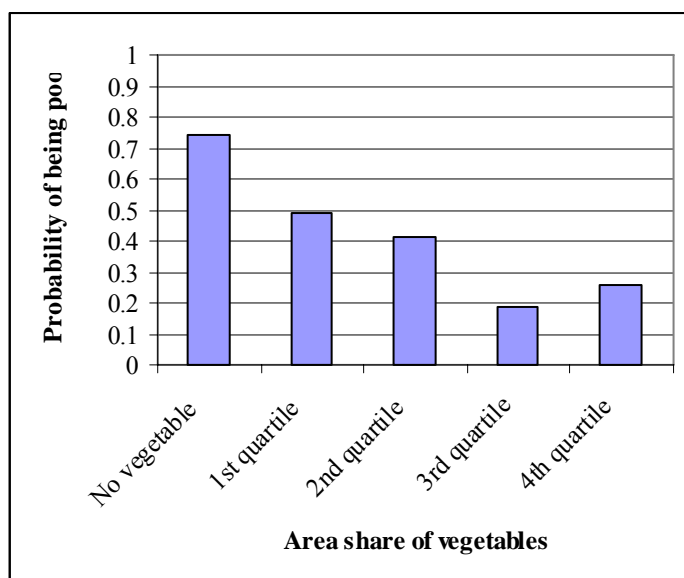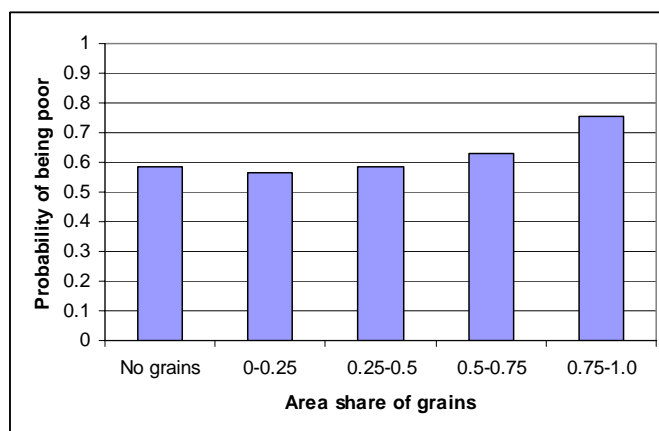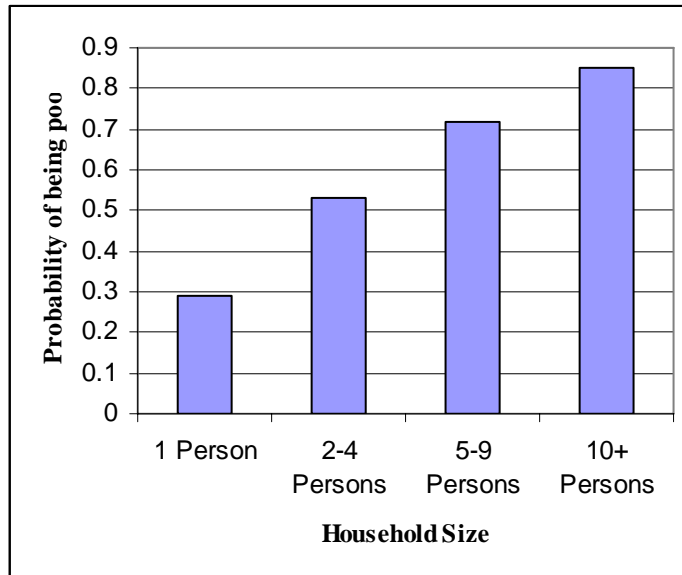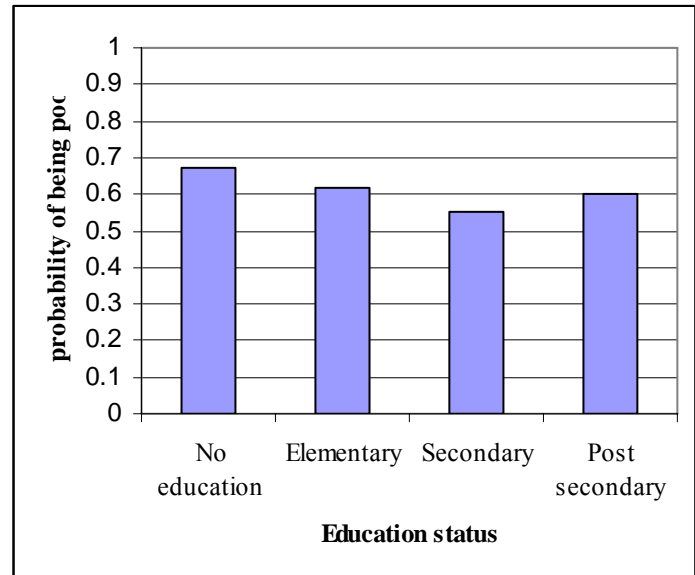
Panel a
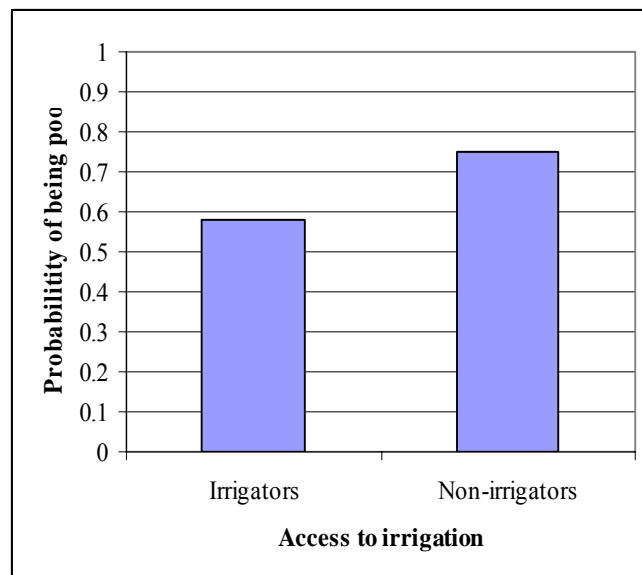
Panel b

Panel c

Panel d

Figure 3. Irrigation, cropping pattern and poverty

Panel a

Panel b

Figure 4. A graphical illustration of the influence of education and household size on poverty.

6. Conclusions and policy implications

In Ethiopia agriculture and even the performance of macro-economy is taken hostage by the amount and distribution of rainfall (Reference).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[3]. Several evaluation studies of these programs have underlined that the seed and fertilizer technologies were mostly successful in areas endowed with relatively ample moisture (reference). 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 form 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.

The study was based on the extensive data set generated form a total of 11 small-scale irrigation schemes (i.e., 7 modern schemes and 4 traditional schemes), sampled from four major regional states of Ethiopia. For comparison purposes a sample of adjacent villages with no access to irrigation was also sampled. All in all 1024 farming households were randomly sampled from the selected irrigation schemes and rain-fed villages. It consisted of 627 irrigating households (of which 382 are modern scheme irrigators and 245 are traditional schemes irrigators) and 397 purely rain-fed farmers. It is to be noted that even those households with access to irrigation do manage rain-fed plots. Only few farmers were found to be purely irrigators.

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

- 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 deeply entrenched in rural Ethiopia.
- Poverty indices are responsive to irrigation typology and irrigation intensity. Among the irrigation 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. This calls for an investigation to determine a minimum irrigated area that needed to be allotted to a household for sustained poverty reduction and food insecurity eradication.
- 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 with out access. The implication is that even though accesses to irrigation moves up the mean income, farmers have different capacity in making better use of the available irrigation water and therefore irrigation widens the income

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[3] See for instance the evaluation reports of the recent Extension Package Projects

gap[4]. 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 rainfed poor farmers is higher than those with access to irrigation!!!

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[4] See which studies agree with our findings and which ones do not?

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