An econometric analysis of the link between irrigation, markets and poverty in Ethiopia: The case of smallholder vegetable and Fruit Production in the North Omo Zone, SNNP Region

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Abstract

This paper examines the anti-poverty impacts of irrigation and markets on the welfare of rural households within the PRISM framework. Specifically, the papers addresses: the magnitude of anti-poverty effects of irrigation and conditions strengthening the poverty-reducing impact of it; and the market constraints of fruit and vegetable producers. The relationship between irrigation, market-orientation of smallholders and poverty is examined using descriptive statistics and multivariate analysis. In the descriptive analysis, low prices for vegetable and fruit, weak demand, lack of price information, and inadequate transportation have been identified as the main limiting factor for output market.

The beneficial effect of irrigation, literacy rate of household heads, and extra years of schooling is readily apparent from the regression. A simulation approach is also used to explore the impact of irrigation and other factors, individually and together, on poverty. The results show that although irrigation reduces poverty, the effect is greater when combined with improving the literacy level of households. This evidence calls for policy measures that focus on the concurrent interventions in irrigation, education, markets, and other supporting inputs, thereby reducing poverty in the cash growing rural areas.

Key words: Ethiopia, Fruits, irrigation, markets, poverty,vegetables.

1. Introduction

Ethiopia, like other sub-Saharan African (SSA) countries, is an agrarian economy, with a very small industrial sector. The agricultural sector, on average, accounts for about 45% GDP; 90 percent of merchandise export earnings; 80% of employment; more than 90% of the total foreign exchange earnings; 70% of the raw material supplies for agro-industries, and is also a major supplier of food stuff for consumers in the country. Smallholders who produce more than 90% of the total agricultural output and cultivate close to 95% of the total cropped land dominate the sector. Inter-regional difference in terms of agricultural production is quite noticeable. For instance, the three regions, namely Amhara, Oromiya and Southern Nations, Nationalities and Peoples (SNNP) contribute more than three-fourth of the total agricultural production in the country. Agricultural production is highly dependent on the vagaries of nature with significant variability in production and actual production patterns. The majority of smallholders have not practiced irrigation to mitigate the adverse effects of weather variability and water is the main limiting factor of agricultural production. As a result, the poverty situation of the country has not changed over time. For instance, the proportion of people living under the absolute poverty line in 1999/00 was close to the level five years earlier (1995/96), estimated at 45% (MOFED 2002). Poverty (on the aggregate) has, at best, not decreased in spite of improved economic performances in the 1990s. Moreover, poverty is concentrated in the rural areas where basic services are in critical shortage to meet the bare minimum demands (Mulat et al, 2005).

It has been documented that low farm production and productivity resulting from use of backward technology and other productivity-enhancing modern inputs are the major reasons for rampant poverty and food insecurity in rural Ethiopia (Workneh, 2005; Mulat et al, 2005). Given diminishing arable land per capita[3] and limited off-farm activities, increasing farm production through improved technology-based farm intensification can be an important strategic element for agricultural growth and rural development. Utilization of modern technologies is extremely low in Ethiopia (Mulat 1999; Belay 2003; Mulat et al, 2003). For example, close to 2% of peasants use improved seeds (Abebe and Mulat 2003). Similarly, less than 5**%** of the total irrigable land is utilized so far and use of other modern inputs is very low. This is extremely scary but reflects the existence of a huge gap between the actual performance and the potential that could be attained through improved technologies (Mulat et al, 2003). By all counts, the country has experienced very little in terms of productivity-driven agricultural growth and poverty reduction. Note that whatever growth has been registered in the agricultural sector, it is mainly driven by area expansion with little gain in productivity. For instance, based on the past trends of agricultural

[3] As for holding size, about 65 % of farm households in the country hold less than a hectare (Workneh, 2005).

performance (specifically, between 1995 and 2002), about 70% of the increase in crop production has been attributed to area expansion (Diao et al, 2005).

In Ethiopia, roads are extremely underdeveloped: the average road density is 27 kilometers per 1,000 km^2. Close to 70% of Ethiopian farmers is reportedly more than half a day's walk away from an all-weather road. Poor market access which entails high transportation costs significantly increases the gap between consumer and producer prices. This in turn lowers the farm gate prices received by farmers located in remote areas. It has been documented that the average grain price gap is estimated to be in the range of 30 to 70 percent across regions. Moreover, domestic marketing costs can account for more than half of fertilizer prices paid by farmers, which tends to reduce profitability of modern inputs (Jayne et al, 2003). A recent study also confirms that agricultural growth in Ethiopia requires concurrent investments in roads and other market conditions (Diao et al, 2005). Better access to markets has reduced the cost of inputs and expanded the market for produce.

Any solution to reduce rural poverty must focus on increasing the production and productivity of smallholder agriculture and speed up the process of structural transformation. In order to overcome the challenges faced by small farm households[4], comprehensive market-based poverty reduction interventions, which establish a framework to operationalize integrated market systems for the rural poor, are required. The intervention would ensure sustainable natural resource management, reduce poverty and enhance gender equity if based on access and control of water for crop irrigation. The framework, which focuses on reducing rural poverty via use of irrigation and smallholder markets, is known as Poverty Reduction through Irrigation and Smallholder Markets (PRISM). The PRISM model places a high priority on identifying strategies that enable smallholders to access, store and control water for crop irrigation via low cost, household level, micro-irrigation systems which maximize water-use efficiency, minimize labour-burdens and brings high economic returns to the poor small farm households.

The main objective of the paper is to provide empirical evidence regarding the impact of irrigation and markets on poverty in the cash growing rural area of Southern Nations, Nationalities, and Peoples (SNNP) region. To do so, both descriptive, econometric and simulation techniques have been used.

The rest of the paper is organized as follows. In the second section, we review the link between irrigation, markets and poverty. Section III presents a model of welfare determination and develops a simulation framework. Data description, simulation results and analysis also are given in this section. The final section, Section four, concludes.

[4] The term small farm households is synonymous with smallholders.

2. The link between irrigation, markets and poverty

It has been quite a while since poverty has posed a serious problem in most developing countries of the world. During the past two to three decades, a wide array of studies and researches have been undertaken to understand the root causes of poverty in developing countries. The results of these studies indicate that the poverty problem in developing countries is complex and multidimensional and is a result of a myriad of interactions between resources, technologies, institutions, strategies and actions and others (Hussain, 2003). It is now well understood that poverty in most developing countries is a result of lack of resources, information, appropriate institutions and inappropriate domestic policies. Given that agriculture is largely rain-fed, irrigated water has become a very crucial resource in agricultural production, productivity and poverty reduction.

According to the available evidence, regions such as East Asia and Pacific and Middle East that have succeeded in poverty reduction have the greatest proportion of irrigated land. The poverty-reducing impact of irrigation is substantial as evidenced in many Asian countries. For instance, about 35-40% of cropland in Asia is irrigated and poverty reduction in the 1970s was substantial (Hussain and Hanjra, 2003). It should be noted that the availability of irrigation not only boosts agricultural production but also makes possible the adoption of modern inputs such as improved seeds, fertilizers and pesticides (Ray, Rao and Subbarao, 1988). Note that the transmission mechanisms through which irrigation may lead to poverty reduction are via increased yields, increased cropping areas and higher value crops. It also leads to higher employment. The cumulative effect of all these is that irrigation increases food supplies and raises calorie intakes and better nutrition levels.

A number of empirical studies confirm the above facts: irrigation has been instrumental in the fight against poverty in many countries. In Bangladesh and Nepal, irrigation has been an effective tool for reducing poverty, increasing cropping intensity, grain production, household incomes, waged labour employment and livelihood diversification (Angood et al, 2003, 2002;Hussain et al, 2004; Hussain and Hanjra, 2003; Madhusudan et al, 2002). Apart from these, there are also stability effects in agricultural production because of reduced reliance on rainfall. In other words, irrigation lowers the variance of yields, output, and employment (Diao et al, 2005; Dhawan, 1988). Comparison of irrigated versus non-irrigated areas indicates that crop productivity and output tend to be much higher in irrigated systems than the non-irrigated and rain-feed areas (Jatileksono and Otsuka, 1993; Datt and Ravallion, 1998). Similarly, value of crop production, household income and consumption are almost double in irrigated settings than the non-irrigated areas and labour employment and wages are much higher in irrigated areas. In a comparative study, Hussain et al (2004) indicate that poverty incidence is about 20-30% higher in rain-fed settings than irrigated setting. A study by Haung et al (2005), using a plot-level data in rural China, indicates that irrigation boosts cropping income and reduces poverty and inequality.

In general, the results of these econometric studies indicate that crop output and productivity, farm income, consumption, employment and rural wages tend to be much higher in irrigated areas and irrigation is a positive and significant determinant of income and consumption and a negative determinant of poverty[5]. Note that irrigation alone may not lead to poverty reduction. Rather, the poverty-reducing impact of irrigation will be stronger if it is supported by use of other yield-enhancing inputs. It is often argued that even though irrigation and other modern inputs are used to enhance production, this may not entail the intended result if farm households don't have access to markets for their produce. A combination of irrigation, other modern inputs and access to markets is critical for poverty reduction and this will eventually lead to accelerated agricultural growth. For instance, reducing marketing costs primarily benefits smallholders via better prices for their produce and raises farmers' income. Moreover, there is also another effect of improving market conditions: it stimulates the trading sector, which itself can generate greater non-agricultural income.

[5] Hussain and Hanjra (2004) provide an extensive review of past work on irrigation-poverty linkages.

3. Modelling the effect of irrigation and markets on Poverty

In this section, an attempt will be made to quantify the link between irrigation, markets and household welfare, measured in terms of consumption per capita. In the process of modelling such linkage, simulations will also be carried out to examine the impact of some policy interventions and other socio-economic factors on the well-being of rural households.

3.1 Econometric models and methods of estimation

The objective of specifying the model is to assess to what extent irrigation and markets affect the well-being of rural households. To answer questions about the effect of these variables, conditional on the many other potential determinants of poverty, multivariate analysis is required (Gibson and Rozelle, 2002; Ravallion, 1998). In this regard, econometric models of the determinants of poverty where key modern agricultural inputs such as irrigation and market access variables would be entered explicitly as an argument in the model. The usual approach in the multivariate analysis of poverty is to classify households as poor and non-poor based on consumption per capita (Datt, 1998; Gibson and Rozelle, 2002; Mulat et al, 2003). Denoting the i^{th} household's per capita expenditure by C_i, then a household is classified as poor if the i^{th} household's C_i is less than the poverty line (Z). Accordingly, a binary variable is constructed to classify households as poor and non-poor. Then the probit estimation assumes the following functional forms:

$$pr(h_i = 1|X) = \Phi(X_i\beta) \qquad [1]$$

where Φ is the standard cumulative normal distribution function, X is a matrix of explanatory variables such as agricultural technology and market-related variables and other determinants of consumption, and β is a vector of parameters to be estimated. However, the probit estimation, as indicated in equation (1), focuses only on incidence of poverty and ignores the poverty gap and severity. A more generalized poverty measure for household i can be specified as (Foster, Greer and Thorbecke, 1984):

$$P_{\alpha,i} \quad = \quad \left\lfloor \max\left(\left(\frac{Z-C_i}{Z}\right), 0\right)\right\rfloor^{\alpha} \quad , \quad \alpha \geq 0 \qquad [2]$$

Where $\hat{P}_{\alpha,i}$ is the estimated poverty measure of household i, Z refers to the poverty line and α is a non-negative parameter taking integer values 0, 1 and 2. It should be noted that aggregate poverty of a given population is simply the weighted mean of the above poverty measure, where the weights are given by household size. When α assumes values of zero, one and two, the aggregate poverty measure corresponds to the incidence of poverty or head-count index, the poverty gap and squared poverty gap (which is sensitive to inequality amongst the poor), respectively.

Instead of using poverty probits, the approach of this paper is to model the determinants of consumption per capita, and then derive from the regression model estimates of the various poverty measures following simulated changes in certain variables. More specifically, the model is of (log) nominal consumption expenditure per adult equivalent, deflated by a poverty line, which gives a ratio often known as the "welfare ratio" (Gibson and Rozelle, 2002; Blackorby and Donaldson, 1984) [6] and is given by:

$$\ln\left({C_i}/{Z} \right) \quad = \quad \beta_0 + D_i\beta_1 + H_i\beta_2 + F_i\beta_3 + A_i\beta_4 + \upsilon_i \qquad [3]$$

Where C_i denotes per capita consumption of household i, D_i refers to demographic characteristics, human capital variables are given by H_i, F_i denotes farm characteristics, A_i is a matrix of technology-related variables such as irrigation , Z is the poverty line and v_i is a stochastic term with zero mean (0) and constant variance (σ^2). In a more compact form, equation (3) can be expressed as:

$$\ln\left({C_i}/{Z} \right) \quad = \quad X_i\beta + \upsilon_i \qquad (4)$$

Where X_i is a matrix of explanatory variables indicated above. Since the consumption model estimates are independent of the chosen poverty line, it is potentially attractive to model household consumption level, and then link it to household poverty level (Mulat et al, 2004). After normalizing consumption per capita by poverty line, it is possible to classify households into poor and non-poor, i.e. if the logarithm of the normalized welfare ratio (ln (C_i/Z)) is less than zero, then a household is deemed to be poor, otherwise non-poor. The probability of the i^{th} household being poor can be derived from the estimated parameter $(\hat{\beta})$ and standard error $(\hat{\sigma})$ of the regression. Formally, the probability of the i^{th} household's logarithm of welfare ratio being less than zero is given by:

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[6] Following the standard approach, a consumption-based measure of individual welfare has been employed in this study. This is due to (i) consumption is regarded as a measure of welfare achievements by households (Atkinson 1989); (ii) consumption fluctuates less than income (because households tend to smooth their consumption (Simler et al, 2004); and (iii) households are more willing to reveal their consumption behaviour than their income. In aid dependent economies such as Ethiopia, households tend to report their consumption on the high side.

$$prob\left[\ln\left(C_i/Z\right) < 0\right] = \Phi\left[\frac{\ln\left(\hat{C}_i/Z\right)}{\hat{\sigma}}\right] \quad (5)$$

Equation (5) gives the weighted average of the predicted incidence of poverty for the i^{th} household ($P_{0,i}$) where the weights are household sampling weights in terms of adult equivalent household size. Similarly, the methodology can easily be extended to derive the simulated poverty gap denoted by ($P_{1,i}$) and poverty severity ($P_{2,i}$) as:[7]

$$\hat{P}_{1,i} = \hat{P}_{o,i} - e^{\hat{\beta}' X_i + \frac{1}{2}\hat{\sigma}^2}\Phi\left(\frac{-\hat{\beta}' X_i}{\hat{\sigma}} - \hat{\sigma}\right) \quad (6)$$

$$\hat{P}_{2,i} = \Phi\left(\frac{-\hat{\beta}' X_i}{\hat{\sigma}}\right) - 2e^{\hat{\beta}' X_i + \frac{1}{2}\hat{\sigma}^2}\Phi\left(\frac{-\hat{\beta}' X_i}{\hat{\sigma}} - \hat{\sigma}\right) + e^{2\hat{\beta}' X_i + 2\hat{\sigma}^2}\Phi\left(\frac{-\hat{\beta}' X_i}{\hat{\sigma}} - 2\hat{\sigma}\right) \quad (7)$$

Equations (5), (6) and (7) are employed to generate predictions of poverty following various policy simulation exercises.

3.3 Description of explanatory variables of the model

The set of variables that is hypothesized to determine the level of consumption, and hence poverty, may be categorized into:(a) household characteristics; (b) human capital; (c) farm charactersitics; (d) access to market and modern technology. Among the set of potential determinants of poverty, an attempt is made to choose those variables that are arguably exogenous to current consumption.

(a) Household characteristics: This includes household size, age and sex of household head. In order to take into account non-linearities in the relationship between consumption and household size, a quadratic term has been introduced in the regression model.

(b) Human capital: Included in this category are literacy of household head and years of schooling for adults.

[7] For an indepth derivation and discussion of the methodology, see Mulat et al (2003), Simler et al (2004) and Datt and Jolliffe (1999).

(c) Farm characteristics: include holding size and quality indicator of land. The number of plots (as a proxy for the degree of crop diversification) has also been included in the model. It should be noted that the number of plots indicates the land covered by different crops, hence serves as a proxy for crop diversification.[8]

(d) Access to modern technology and markets: with regard to market access variables, distance to the largest buyer (output market), distance to the most important input supplier (input market), and the proportion of sales to the total output are included. Similarly, a number of variables have been identified that reflect use of modern agricultural technology: Irrigation practices and experience, the proportion of irrigated land, soil conservation and water harvesting practices.

3.4 Estimation of the model

3.4.1 Description of dataset

The dataset used in the estimation of the model is obtained from a household survey in two woredas of North Omo zone: Arbaminich and Mirab Abbaya woredas in the Southern Nations, Nationalities and Peoples (SNNP) region. These woredas are the major producers of fruits and vegetables.[9] The woredas have been purposively selected from the woreda Agricultural Office since the focus of the study is on cash crop producers using irrigation. A list of Peasant Associations (PAs) that mainly produce fruit and vegetable using irrigation was obtained from the woreda Agricultural Office and then households have been randomly selected from those PAs. Accordingly, a total of 216 households have been included in the survey. The survey provides data on a wide spectrum of socio-economic variables including household composition and structure, education, use of modern technology, household assets, employment and income, consumption expenditure (both food and non-food), health status and other welfare indicators. More importantly, the questionnaire included a module which is designed to capture plot-level information such as whether a plot is irrigated, the area of irrigated land, type of crop grown on a plot, crop yield, land quality and slope of land. In addition, a market participation module has been included in the questionnaire, which intends to capture key market variables.

[8] In many empirical literature, number of plots denotes the degree of land fragmentation, which carries a geographical connotation.

[9] For instance, the two woredas accounted for about three-fourth of the total zonal fruit and vegetable production in 2001.

3.4.2 Results and Discussions

Descriptive statistics

(a) Household demographics and Farming characteristics

Before going directly to the model results, it is important to give some basic background information regarding the sample households. Of the sample households, the majority (90%) are male-headed with only 10% are female-headed households.

Farming provides the primary source of livelihood for the sample households. The average holding size is about 1.1ha for the sample households.[10] This means that, with an average family size of six persons, per capita holding size would be about 0.18ha in the study area. 48.4% of farm households have less than a hectare of land while 18.4% have landholding size greater than 1.5ha (Table 3.1). As for the farm characteristics, about 77.1% reported that their farmland is of fertile quqlity while medium quality is indicated in 19.2% of the cases. Only 3.7% reported that the land is of poor quality.[11] It seems that, on average, the land is suitable for agricultural production in the study area. Note also that the majority of households have flat farmland, i.e. less steep and hence not susceptible to soil erosion. 97% of the sample households reported that soil erosion is not a problem in the village.

Table 3.1: Distribution of landholding size

Description	Number of households	% of households
Landholding size		
<0.50	38	18.4
0.50-1.0	62	30.0
1.0-1.5	69	33.3
1.5-2.0	20	9.7
>=2	18	8.7
Land quality		
Leum (Fertile)	165	77.1
Leum-teuf (Medium)	41	19.2
Teuf (Not fertile)	8	3.7

Source: Own calculation from survey data

As for the education level of household heads, about 49.3% don't read and write while 42.7% have some primary education. Only 7.5% of the sample household heads have completed secondary education (Table 3.2). Almost all female-headed households are either illiterates (90%) or have some primary education (10%).

[10] The national average holding size is less than a hectare.
[11] The average response for the land quality question is 1.1. Similarly, the average response for the gradient of the farmland is 1.01.

Table 3.2: Education level of household head by gender

Education category	Male	Female	Total
Illiterates	45.08	90.00	49.30
Primary education	46.11	10.00	42.72
Secondary education	8.29		7.51
Post-secondary education	0.52		0.47
Total	90.61	9.39	100.00

Source: Computed from survey data

With regard to the use of modern inputs, it is indicated that 3.6%, 81.3% and 17.6% of the sample households use chemical fertilizers, improved seeds and other chemicals such as pesticides, respectively (Table 3.3). It should be noted that about 90% of the cultivated land is irrigated. The average irrigation experience of the sample households is 13 years, indicating that irrigation has been practised quite a long period in the study area. More than half of the sample farm households have more than 15 years of experience in irrigation. River or stream diversion is the main source of water for irrigation, and pump irrigation is nearly non-existent.

Table 3.3: Irrigation experience and type of irrigation scheme

Description	N	%
Experience in years		
Less than 5 years	32	15.02
Between six and ten years	61	28.64
Between eleven and fifteen years	56	26.29
Greater than fifteen years	64	30.05
Type of irrigation scheme		
River/stream diversion	213	99.50
Pump system	1	0.50

Source: Own computation from survey data

(b) Market access and source of price information

It has been documented that inefficient, underdeveloped and fragmented output and input markets are the main cause for low and variable prices for vegetables and fruits (Mulat and Ferede, 2005). Unstable and low prices have an adverse impact on the use and profitability of new technologies for farmers. For instance, low and unstable prices discourage farmers from using improved farm technologies, and business people may refrain from investing in processing activities, and deterring wholesalers, retailers and transporters from investing in improved market and transport services.

The average distance from the main output market in terms of hours was estimated at 7 hours while it was about 50 minutes from the most important input supplier. Close to 69% sell their produce to private traders in Addis Ababa, while 22% sell in the regional market, Arba Minch. Only 8% sell to private traders in the local or village market (Table 3.4). It appears that the Addis

Ababa central market is the main out let for smallholders. A remark is in order as farmers don't sell their produce directly in the Addis Ababa central marrket nor traders at Addis Ababa buy from farmers directly. The marketing channel can be described as follows:

Farmers→Village brokers→ Addis Ababa Central market.

In other words, village brokers, who serve as an agent for the central traders, determine both the quality and price of vegetables and fruits at the farm. The central traders inform village brokers how much to buy and at what price to buy. However, borkers fix another price, which is usually lower than that determined by the central trader. Farmers can't bargain as they don't have price information. Hence, output prices are depressed at two levels: traders at the central fix a lower price than what is prevailed in the market and brokers also set another price which is lower than that determined by the central trader. In the absence of price information, farmers find themselves in a weak bargaining position and lose a substantial amount of revenue.

As for the price information, the majority of sample households get information regarding the prices of vegetables and fruits from private traders (or brokers). This is not reliable price information as traders or brokers usually understate the prevailing market prices of vegetables and fruits. According to the available evidence, vegetable and fruit producers in Mekie and Ziway areas in the SNNP region lose a significant amount of revenue as a result of inaccurate price information obtained from private traders or brokers (Mulat et al, 2004).

Table 3.4: Distribution of vegetable and fruit buyers

Buyer	N	%
Peasant association/cooperatives/unions	1	0.50
Private trader in local market/village	16	7.50
Private trader in regional market /Arba-Minch or Awassa	47	22.1
Private traders in Addis Ababa	147	69.0
Individual consumers	2	0.90
Total	213	100.00

Source: Computed from survey data

There are a number of problems with regard to undermining the output market of stallholders in the study area. The sample households were asked to rank the problems of the output market on a four-point scale: (1) no obstacle, (2) minor obstacle, (3) moderate obstacle and (4) very severe obstacle. It turns out that low prices for vegetable and fruit, weak demand, lack of price information, and inadequate transportation have been identified as the main limiting factors for the output market (Table 3.5).

Note also that access to credit is another problem for sample households. Access to credit is usually low, as about 62% of the respondents don't acquire any loans. Only 38% have acquired loans mainly from friends and relatives.

Table 3.5: Extent of vegetable and fruit output marketing problems (in %)

Type of problem	No obstacle	Minor	Moderate	Very severe obstacle	Total
Low vegetable and fruit prices	0.47	3.29	16.43	79.81	100.00
Unstable prices	-	4.72	33.96	61.32	100.00
Inadequate transportation	2.80	10.75	23.36	63.08	100.00
High tax rates	25.23	22.90	19.16	32.71	100.00
Lack of price information	0.94	2.35	14.08	82.63	100.00
Lack of standards or grading	5.66	27.36	33.96	33.02	100.00
Too many local brokers or dealers	11.32	19.34	25.94	43.40	100.00
Limited access to credit	15.02	27.70	22.07	35.21	100.00
Crime, theft, disorder and lack of trust	7.94	18.69	10.75	62.62	100.00
Anti-competitive practices (e.g. monopoly)	7.01	6.54	17.29	69.16	100.00
Weak demand for vegetables and fruits	3.27	6.54	9.35	80.84	100.00
Inadequate access to market information	5.39	7.84	14.22	72.55	100.00
Other			8.33	33.33	100.00

Source: Computed from survey data

(c) Changes in welfare: Household perceptions about welfare trends

Many of the poor, who depend largely on rain-fed agriculture for their livelihood, are located in rural Ethiopia. At the national level, much of the increase in agricultural production has come from expansion of cultivated area with limited yield increase (Mulat et al, 2005). However, farm households depend on irrigated agriculture for their survival in the study area. Moreover, they produce mainly vegetables and fruits: the major vegetable being banana. Note that the poverty situation in the country is closely linked to the performance of the agricultural sector since off-farm employment is limited.

To examine the evolution of household welfare, households were asked about welfare status and changes in their living conditions over time. The majority (about 65%) of sample households declared that they classify themselves in the middle (i.e. average) compared to other households in the same village, while only 2.8% classified themselves as the richest. About 16.7% classified themselves as poor relative to other households in the same village (Table 3.6).

Table 3.6: Relative self-declared status of households in the village

Welfare status	N	%
Richest	6	2.79
Richer than most households	33	15.35
About average	140	65.12
A little poorer than most households	29	13.49
Poorest	7	3.26
Total	215	100.00

Source: Computed from survey data

A look at the evolution of household welfare reveals that the proportion of self-reported very rich households declined from 1.4% some ten years ago to 0.5% three years ago. While 51% of households classified themselves as poor ten years ago, the proportion declined three years ago: only 13.5% reported as poor. On the other hand, households that declared themselves as medium or average increased from 40% ten years ago to 71% three years ago. Close to 51%, 18% and 13.5% classified themselves as poor ten, five and three years ago, respectively. This indicates that the welfare situation of most households tend to improve and concentrate at the margin (Table 3.7).[12]

Table 3.7: Dynamics of self-declared welfare status

Description	Ten years ago		Five years ago		Three years ago	
	N	%	N	%	N	%
Very rich	3	1.44	3	1.40	1	0.47
Rich	15	7.21	11	5.12	30	13.95
Average	84	40.38	159	73.95	153	71.16
Poor	106	50.96	39	18.14	29	13.49

Source: Computed from survey data

It appears that irrigation, improved agricultural technology and access to markets is very crucial for sustainable agricultural production, therefore for the allevaition of poverty in the country. Although there is huge potential for irrigation in the area, it has not been fully utilized as smallholders face both production and marketing constraints. This reflects the existence of a a huge gap between the actual performance of the agricultural sector and the potential that could be attained via improved technologies, including irrigation. As mentioned above, despite availability and use of irrigated agriculture for crop production, many households have felt that their living standard improved in recent years. According to the self-declared welfare status, the

[12] This is consistent with the poverty statistics reported by the Ministry of Finance and Economic Development (MOFED). In the report, it is indicated that the incidence of poverty in the SNNP region declined from 55.8% in 1995/6 to 50.9% in 1999/00, representing a 8.78% decline (MOFED, 2002). Note also that the incidence of poverty in the North and South Omo Derashe and Konso zone is 66.1% in 1999/00, which is higher than the regional index. However, if the regional poverty line (birr 1038.73) is used, then the zonal incidence of poverty would be 48% during the same period.

size of poor households has declined over time. This raises the question: what are the causal factors conditioning household welfare in the study area? To assess the relative and combined effects of irrigation and marketing on the welfare of smallholders, an econometric model is required where welfare depends on a set of demographic, farm, and environmental characteristics.

3.4.3 Determinants of consumption and poverty

The regression results which include the parameter estimates, t-rations and 95% confidence interval for the determinants of welfare are presented in Table 3.8. The measure of the goodness of fit of the model, R^2, is on the high side (0.52) for models based on a cross-section data. Although the statistical significance of the different variables of interest varies markedly, the signs of key variables are as expected.[13]

As can be gleaned from the estimated model, while household size tends to reduce welfare, the estimated coefficient of square household size is found to be positive and statistically significant, suggesting a U-shaped relationship between welfare and household size. Age and gender of household head don't seem to be associated with welfare as both are statistically insignificant.

As expected, irrigated land, extra years of schooling and literacy of household head affect welfare positively. Similarly, welfare increases with holding size, investment in soils, and water harvesting. Contrary to the expectation, the sign on the coefficient measuring the degree of market-orientation of farm households is found be negative. But the effect of the variable when interacting with education is found be welfare improving and also statistically significant. This suggests that education increases the bargaining position of households in the process of buying and selling acts.[14]

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[13] Noted that the dependent variable of the model is the natural logarithm of welfare ratio. The estimated regression coefficients measure the percentage change in real consumption per capita for a unit change in the independent variables.

[14] It should be noted that interaction terms have been included to account for the differential effects of demographic, farm and environmental factors on household welfare (Datt and Jolliffe, 1999). Accordingly, an interaction term mainly between schooling and degree of market-orientation has been included in the model.

Table 3.8: Determinants of rural poverty in Ethiopia

Logarithm of welfare ratio (Dep. Variable)	Coef.	Robust Std. err	t	P>|t|	[95% Conf. Interval]	
Demographics						
Age of household head	0,002	0,014	0,180	0.856	-0,025	0,030
Age of household head squared	0,000	0,000	-0,340	0.735	0,000	0,000
Sex of head of household	-0,187	0,152	-1,230	0.219	-0,486	0,112
Household size	-0,304	0,080	-3,790	0.000	-0,462	-0,146
Household size squared	0,014	0,007	2,120	0.035	0,001	0,027
Education						
Average years of schooling of adults	0,051	0,022	2,290	0.023	0,007	0,096
Education of household head	0,871	0,295	2,950	0.004	0,288	1,454
Holding size and Farm characteristics						
Landholding size	0,170	0,060	2,840	0.005	0,052	0,288
Land quality	0,316	0,078	4,060	0.000	0,163	0,470
Number of plot	0,030	0,023	1,270	0.206	-0,016	0,076
Access to markets and modern technology						
Percentage of land that is irrigated	0,403	0,164	2,450	0.015	0,079	0,727
Dummy for soil conservation	0,416	0,096	4,340	0.000	0,227	0,605
Dummy for water harvesting	0,721	0,114	6,350	0.000	0,497	0,945
Participate in the extension programme	-0,260	0,132	-1,970	0.050	-0,520	0,000
Commercialization	-0,436	0,285	-1,530	0.128	-0,998	0,126
Commercialization*education of household head	0,957	0,327	2,920	0.004	0,311	0,160
Constant term	-2,430	0,540	-4,500	0.000	-3,496	-1,365
Regression with robust standard errors			Number of obs =205 F (16, 188)=13,19 R-squared=0,5236 Root MSE=0,43252			

After estimating the welfare model and using the simulation framework developed earlier, an attempt has been made to generate the impact of irrigation and other factors on poverty. Table 3.9 provides the results of the various poverty simulations performed with the model. In the first simulation, we examine the effect of converting all non-irrigated into irrigated land and that it appears that the three poverty would fall by 1.2, 3.5 and 5.0%, respectively. The effects of increasing the educational levels of household heads and adults on poverty are presented in simulations 2 and 3, respectively. It appears that the poverty reducing impact of education is found to be dramatic, compared to irrigation. For instance, the headcount index would fall by a significant magnitude (25.5 %) if all household heads could be made literate, regardless the characteristic and gender of the head (sim2). Similarly, the incidence of poverty falls by about 1.6% if the average schooling years per adult increases by one year (sim3). It should be noted that what is common in both simulation experiments is that the depth and severity of poverty indices would fall by a greater percentage than the incidence of poverty as those in greatest poverty currently have the least access to education. It implies that providing education services to the poorest of the poor would reduce poverty since the depth and severity indices fall faster than the headcount index.

Simulation 4 is concerned with an increase in the holding size per household by 50% for all holders. Note that the average holding size is 1.1 ha for the sample population., and a 50% increase in holding means that, on average, each household would have a holding size of about 1.65ha.This kind of intervention leads to a fall in the incidence, depth and severity of poverty by 3.3, 8.4, and 11.6%, respectively.

It should be noted that simulations 1-4 are carried out independently, one after the other. Simulation 5 presents the results for the combined simulated effects of converting all non-irrigated land into irrigated and making all household heads literate. It appears that the poverty-reducing effects of such simultaneous intervention is highly significant compared to individual effects. The incidence of poverty, for instance, falls by a large magnitude (27.3%), which is higher than in any of the individual interventions indicated above. This supports that argument that a holistic approach, instead of a one sided intervention, is required to reduce poverty within a reasonable period.

Table 3.9: Simulation results of certain changes of explanatory variables on rural poverty

	Headcount index	Poverty gap	Poverty Severity
	Percentage change from the baseline predicted value		
Sim1: If all non-irrigated land is converted into irrigated	-1,20	-3,50	-5,02
Sim2: Increase the literacy rate of household heads to 100%	-25,47	-31,17	-33,25
Sim3: Increase household average school years per adult by one year	-1,65	-4,36	-6,13
Sim4: Increase landholding size of each household by 50%	-3,32	-8,41	-11,60
Sim5: Sim1 and Sim2 simultaneously	-27,28	-34,17	-37,06

Source: Model simulation

4. Conclusion

The main objective of this study was to examine the quantitative relationship between irrigation, market access and poverty in the Southern part of the country. Specifically, the study assessed the effects of irrigation, farm characteristics and community factors on the welfare of the sample farm households.

There is a negative relationship between household size and household welfare. In other words, households with larger family size are more likely to fall into poverty than those households with smaller family size. A quantitative analysis undertaken in this study uncovers the fact that irrigation has a positive impact on welfare. Welfare increases with holding size, investment in soils, and water harvesting. Similarly, extra years of schooling and improving literacy of household head enhance welfare. The effect of the degree of market-orientation (commercialization) when interacting with education is found be welfare improving.

The analysis also points to the importance of education in terms of realizing the benefits of irrigation. In other words, the poverty reducing impact of irrigation is stronger when households are literate. It should be noted that better access to markets tends to reduce the cost of inputs and to expand the market for produce. Given the severity of poverty and from the point of view of reducing such rampant poverty, either of these interventions is inadequate, i.e. one intervention could not be seen as an alternative strategy to the other. This reinforces the argument that simultaneous intervention in irrigation, education and other market conditions is important for reducing rural poverty.

This study suggests that poverty and food insecurity can be reduced through a coordinated application of a set of complementary interventions such as irrigation, education, markets, and other supporting inputs. Hence, promoting small scale, low cost and labour-intensive irrigation projects and building the capacity of farmers are very important for reducing poverty in the cash growing rural areas of Ethiopia.

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