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Original Research Article

ACCESS TO SMALL-SCALE IRRIGATION AND FARM HOUSEHOLDS' CROP CHOICE DECISION IN KILTE-AWLAELO WOREDA OF EASTERN TIGRAY

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Abstract: - Policy discourses around agricultural transformation tend to separate producers into different types of farm (small farms, large farms) growing different types of crops (staple crops, cash crops) with simple distinction made between "subsistence" and "commercial" or "export" agriculture. Transforming the subsistence-oriented production system into a market-oriented production system as a way to increasing the smallholder farmer's income and thus its welfare outcomes, and reducing rural poverty, has been in the policy spotlight of many developing countries, including Ethiopia. In this paper I attempted to demonstrate how access to irrigation determines household's decision to allot their agricultural land to the production of either staple crop or cash crops in irrigated compared to rainfed systems. By doing so the paper identifies the role of irrigation in share of land allotted to cash crop production. The results from the sample t-test indicate that irrigation contributes significantly to increase in cash crop production by inducing shifts in farmers cropping mix. Analyzing household data from Kilte-Awlaelo woreda in Eastern Tigray, I found that having access to irrigation, income, credit and number of oxen along with other factors determine the crop choice model in favour of the production of high value crops. While age of the head and non-farm income are other determinant factors that have negative impact on the production of cash crops. Looking beyond purely the agricultural activities of a household, having access to irrigation highlights the importance attached to the profit motive within the farm households. Hence, this paper concludes with implication for policy to integrate farm households' for those who don't allot their plot to cash crop with markets if additional funds for agricultural research activities dealing with investments in irrigation projects are made.

Key words: access to irrigation, crop choice, GLM model, Kilte-Awlaelo woreda

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Introduction: Background of the study: Nations across the world differ in their resource endowments and level of technology used in the production of goods and services. Given these conditions, Sub-Saharan African countries are mainly exporting agricultural commodities in which they have comparative advantages due to cheap labour and tropical climate. For instance, in Ethiopiaagriculture is the most important rural enterprise, which contributes an average of 46% of total gross domestic product and 85% of Agribusiness (exports) (Makombe et al., 2007). Agriculture and the rural economy accounts for about 80% of employment opportunities, furthermore, agricultural growth can have significant multiplier effects on employment within the local non-farm economy through increased demand for goods and services of the small-scale enterprise sector. Since about 85% of the region's poor live in rural areas, agricultural growth is the key to poverty alleviation (Makombe et al., 2007).

Ethiopia agricultural potential is believed to be quite substantial; it has a total land area of 1.13 M km^2 with an estimated 55 M ha arable which is approximately half of the total land mass. However, only about 20% of the total arable land is currently being utilized for crop production. The potential arable land encompasses both rain-fed and irrigable lands that are agro-ecologically suited to the production of a variety of crops, including cereals, pulses, oil crops, tree crops and vegetables (Hordofa et al., 2007). In addition, Ethiopia is said to have also an estimated irrigation potential of 3.5 million hectares (Awulachew et al. 2007). However, the total estimated area of irrigated agriculture in the country in 2005/2006 was 625,819 ha, which in total constitutes about 18 percent of the potential (MOWR, 2007). Particularly, in Tigray, based on secondary data from BoFED[1], the total cultivated area during the 2006 agricultural season was about 1.9 million hectares, of which only about 0.02 million hectares was irrigated (Gebre-egziabher, 2008).

Irrigation has played a significant role in agricultural development. Presently, a considerable amount of food and industrial crops are produced by using irrigation water and believed to continue in a more intensively to support increasing population.Since, empirical evidences suggest that irrigation projects have positive impacts on agricultural production and reduction of poverty for farmers (von Braun, Puetz, and Webb 1989; Hussain and Hanjra 2004; Smith 2004; Lipton 2007; and Hussain 2007b), providing farmers with a reliable water source to meet food self-sufficiency, generate export earnings, and provide raw materials for industry on a sustainable basis (MoWR, 2001) is essential. This strategy is also expected to increase market participation of producers (Rosegrant et al., 1995; MoFED, 2006). Higher yields, higher cropping intensity and all year round farm production leads to increased market-oriented production, implying a shift in supply (markeatable surplus production) and perhaps food security.[2] Irrigation is also expected to lead to changes in crop mix (cash crop orientation) which is expected to have far reaching positive impact on household welfare (Joshi et al., 2003).

In line with that, government strategy in agricultural extension, water harvesting, export promotion, co-operatives, credit and finance should be linked to commercialization of agriculture (Alemu, 2006). For instance, for areas with good agricultural potential but imperfections in factor and/or product market, development strategies that stimulate households to shift their resource use from semi-subsistence farming towards production of high value and marketable commodities are crucial (Ruben and Pender, 2004). High value and labour intensive cash crop production contributes towards better

[1]BoFED = Bureau of Finance and Economic Development

[2]There are reports, however, that indicate that increased market orientation may not necessarily ensure food security especially if the macroeconomic environment is not conducive or there are distorted trade policies or there is poor infrastructure development (Van Braun, 1995) or social protection for food security is not provided through markets and government interventions (de Janvry et al.1991).

employment opportunities for landless farm households and as a result contribute towards reducing rural poverty (Ruben and Pender, 2004).

In risky environments such as Tigray, small holder farmers, who constitute the bulk of the population, are often caught in production of low- risk/low –return food grains. With insufficient cash funds, and unpredictable outcomes, they cannot afford to take the risk of diversifying from subsistence food production into potentially higher-return ventures (such as growing cash crops for market), or of spending their limited cash on purchased agricultural inputs, because if they fail – either because of crop failure, price collapse, or lack of demand – they will not have either the basic food they would otherwise have produced, nor the cash to purchase it, and their families will go hungry (MOFED, 2006).

In line to the constraints discussed above, farm households also face other constraints related to; risks (Fafchamps, 1992), high transaction costs (Omamo, 1998; Key et al., 2000), limited food markets (de Janvry et al., 1991), limited insurance options (Binswanger and Rosenzweig, 1986) and limited access to credit (Eswaran and Kotwal, 1986) which can limit the participation of farm households in different markets.

Therefore, the development of small-scale irrigation schemes with the aim of producing high-value crops has a number of advantages. It helps to reduce the impact of erratic rainfall on household income fluctuations, promote intensive land use and thereby increases the likelihood of using purchased inputs due to the reduced risk of crop failure (Rahmato, 1999). Therefore, irrigation is, hence, expected to remove or ease risk so that farmers can venture into an inherently high risk-high return production pathway, which may have a significant effect on poverty reduction (MoFED, 2006).

Cognizant of this reality and to redress the problem and make agriculture play its proper role in the economy, the government of Ethiopia in general and the regional Government of Tigray in particular has put agriculture on top of the sustainable development and poverty eradication agenda of the country (PASDEP); and irrigation is widely believed to play a central role in achieving this goal. The goal is sustainable rise in agricultural productivity through promotion of green-revolution type technologies coupled with natural resources rehabilitation and conservation. Special emphasis is given to harness and develop the water potential of the country by promoting construction of micro dams, river diversions, ponds and wells (FDRE, 2002a: FDRE, 2002b).

Statement of the problem: Smallholder farmers in regions like Tigray account for most of the Tigrian population and the food grain production. Notwithstanding this fact, agricultural productivity remains too low due to several interlinked factors such as unpredictable climate, unreliable rainfall, small and fragmented land holding, land degradation, limited technological inputs, and poor infrastructural development and market linkages. Soil fertility depletion, soil erosion, soil acidity, salinity, overgrazing, deforestation, and the use of manure and crop residues for fuel are major problems facing the region (Hordofa et al., 2007).

Apparently, with the common belief on the important role of irrigation in agricultural growth, the regional government of Tigray has embarked on an ambitious irrigation development programto achieve such broad objectives as economic growth, rural and agricultural development, food security, and protection against adverse drought conditions—all expected to contribute to improved social outcomes (gebre-egziabher, 2008). In addition, irrigation can benefit the poor through raising yields and production, lowering the risk of crop failure, and generating higher and year-round farm and nonfarm employment. It can enable smallholders to adopt more diversified cropping patterns, and to switch from low-value subsistence production to high-value market-oriented production.

However, the transition towards high-value agriculture is not without constraints, especially for smallholders. If the high-value commodities are products that the farmers have not grown before, the farmers may lack necessary information on production methods, marketing opportunities, and the probable distribution of net returns. This problem is particularly acute when the target consumers have very specific quality requirements and/or strict food safety requirements. Of course, the farmers can attempt to gather information, but this often involves a fixed cost (one not related to the level of output), thus giving an advantage to larger-scale farmers (Minot and Roy, 2006).

Furthermore, a smallholder farmer who allocates land to a commercial crop often has to depend on market purchases to meet food requirements, resulting in an additional source of risk. Some high-value agricultural commodities also require significant investments, including the use of specific inputs. Finally, the production and marketing of highly perishable high-value commodities benefit from the producing farm being located near markets and good marketing infrastructure (Torero and Gulati, 2004d cited in Brithal et al., 2007).

In addition to these, farmers in developing countries such as Ethiopia, particularly poor farmers in Tigray, have inadequate capita resources – including, physical and financial resources, but also human capital resources such as experience, education and extension – which limit their ability to diversify production portfolios (Lapar et al., 2003). In addition, Brithal et al. (2007) further indicated that, small holder producers often do not have savings or credit access needed to make these investments and purchase the necessary inputs. However, high-value commodities like fruits and vegetables may become viable prospects when these constraints are relieved through intervention. In addition, poor infrastructure often increases the transaction costs of small holder's market participation (Hagos F. et al., 2007).

Considering these challenges and prospects, therefore, this paper attempts to explore empirically the impact of irrigation intervention on farm household's decision to crop choice and to understand the factors affecting the extent and determinant factors to crop choice decision of farm households' in Tigray.

Objectives of the Study: The general objective of the study is to assess the overall impact of small scale irrigation intervention on agricultural crop choice decision using a quantitative approach.

Specific objectives of the study are:

1. To examine the impact of small scale irrigation on farm household's crop choice in irrigated systems in contrast to rain fed system in Tigray;
2. To identify factors influencing crop choice decision of farm households in Tigray including the role of irrigation in the process; and
3. To assess policy implications of farm households' decision to cash crops at household level.

Study Area and Data:

This study uses a secondary data from a representative Survey of 101 households conducted by Gebre-egziabher (2008) from a household and plot level survey. Tigray is located in the northern part of Ethiopia (see Figure 1). The Tigray national Regional State (TNRS) is divided into 7 administrative zones, 48 woredas (districts), 550 tabias more than 3500 kushets, and 74 towns. The zones are Eastern, Central, Southern, Western, North Western, South Eastern and Mekelle city. TNRS has an estimated total population of 4,448,997 consisting of 2,192,996 men and 2,256,001 women. Out of which 3,519,000 or 81.2% of the population are estimated to be rural inhabitants, while 816,000 or 18.8% of the population are estimated to be urban inhabitants (CSA, 2006).

The climate of the region is highly unpredictable characterized by sparse and highly uneven distribution of seasonal rainfall, and by frequent drought. The amount of rainfall increases with altitude and from east to west, and decreases from south to north. Annual rainfall ranges from 450 to 980ml with significant spatial and temporal variability. Most of the precipitation falls within the three months of June, July and August, and with high intensity (Berhanu et al., 2003). Generally, the rainfall distribution is mono-modal in character, with few exceptions in the southern and eastern zones, where is bimodal.

In the study area, Kilte-Awlaelo woreda, agriculture contributes much to meet major objectives of farmers such as food supplies and cash needs. The sector is characterized by its small scale and subsistence nature. Mixed farming is the major economic sector in the woreda, where crops are grown for food and cash, and livestock are kept for complementary purpose, as a means of security during food shortage, and to meet farmers' cash needs. Both crops and livestock production are equally important.

The total area of the woreda is estimated to be 1010.28km^2 of which 21% is cultivated land, 4.5% is grazing land, 21% is covered with forest and shrubs, and 53% is not used for production purpose due to different reasons. The total cultivable land under irrigation is 1227.15ha.

River Birki, where the specific research place, is one of the small scale irrigation technologies among the upgrade diversion schemes located in Kilte-Awlaelo woreda, tabia Mesanu and kushet Laelay Agulae. It is situated geographically at latitude 13^{0}41^{0}36''N and longitude 39^{0}37^{0}24''E, the altitude is 2020 masl. The agroclimatic zone of the area in which the river is found is weina dega. With the highest average monthly temperature varies between 25.8^{0}c in month November to 29.9^{0}c in the month of June. The average monthly minimum temperature varies between 7.3^{0}c in the month of December to 14^{0}c in the month of May. The rainfall of the area is bimodal where big rain occurs in the month of July to September locally known as 'kremti' and small rain starts in February and extends to the end of April known as 'belg'. The Kilte-Awlaelo rainfall situation is assumed to represent the area where my thesis is made with a mean annual rainfall of 551ml. and there is a dry weather road branches out to the left at about 3.4km from Agulae town on the way to Adigrat. This road almost passes through the proposed thesis site.

Theoretical and Empirical model

Theoretical Framework on Irrigation and Crop choice: Most people in developing countries earn at least part of their livelihood throughproduction in their own enterprises that is generated from their farming activities.Agriculture is generally the primary source of income for the rural poor, both through crop production activities and via employment in agriculture and agriculture-related industries.Agricultural activities involve mainly crop production and animal husbandry. Crop production, which is the mainstay of rural households, involves various items of products, of which the production technologies may differ. We restrict our attention to two major activities, namely, production of staple crops and production of cash crops.

In this thesis, a theoretical model of household choice that captures the core issues surrounding the impact of irrigation on crop choice is stated. I attempt to analyze how access to irrigation affects the decision of a household to allot its plot of land either for staple crop or cash crop.

In this section, the researcher develops a model to understand farmers land allocation decision across different crops (staple crops and cash crops) and activities (farm production, off-farm work and leisure) to maximize their utility subject to a full income constraint. The farmer produces two crops using labor (L), a purchased input (I) and a given amount of land (Ln). The farmer divides his land between the staple crop (S) and the cash crop (C). He also decides how to allocate resources like labor and other inputs across different crops and activities to maximize utility. The farmers' decisions are:

- what proportion of land to cultivate for each crop;
- how much labor to allocate to the production of each crop and off-farm work;
- how much purchased input to use;

- how much of each crops to sell; and how much to consume.

Production of each crop is a function of flows of privately held quasi-fixed assets, including land, labor (both quantity and quality, as reflected in education and experience), livestock and other productive capital (e.g., irrigation, tractor), reflected in the vector A. Public goods and services, such as extension services and farmer associations that provide information or inputs, represented by the vector G, may likewise affect output. L_i is the total labor used in production of crop i, where i = C, S and C denotes the cash crop and S denotes the staple crop. θ is the proportion of land cultivated with the cash crop and Z is a vector of household characteristics. The farmer's problem is given by:

$$\text{Max } U(S, C, \theta, l) \qquad \text{………………eqn. 1}$$

s.t.

$$P^cC+P^sS+P^i(I^c + I^s) + wL^h \leq P^cQ^c(\theta Ln, L^c, I^c, G, A, Z) + P^sQ^s([1-\theta]Ln, L^s, I^s, G, A, Z) + WL^m \qquad \text{………………eqn. 2}$$

$L = L^h + L^m$; where L^h denotes hired labor and L^m denotes the quantity of labor sold out

$Ln^c = \theta Ln$, $Ln^s = [1-\theta]\, Ln$; where $0 \leq \theta \leq 1$

Where U (.) is utility function of a household, C and S are consumption of cash crop and staple crop respectively, l is the amount leisure consumed, P denoted the market price of consumption, L is the total quantity of labor employed on own farm, F(.) is the production function of farming. Ln^c and Ln^s are land alloted to cash crop and staple crop respectively and θ is share of land allotted to cash crop.

The household maximizes its utility from consumption of staple and cash crop, share of land to cash crop and leisure subject to, Equation 2, the budget constraint, which requires total expenditure on each crop (i.e., consumption of staple and cash crop), wage for hired labor plus purchased input needs to be less than or equal to the value of marketed surplus, i.e., from production, and possibly sale, of any or all of the crops plus off-farm income.

The theoretical framework suggests that a household's decision to allot his plot of land to cash crop production is by and large a function of, among others, access to irrigation. There are, however, other factors which are deemed to be important in affecting crop choice. These include per capita land, age of the head (hhage), gender of the head (hheadsex), family size, extension service (extnser), credit market participation (creditp), income (income) and off-farm (nnofffarm) income of the households.

For a given P^c and P^s, and costs, the model is given by:

θ = f (irri, edu, hhage, hheadsex, prolab, depratio, land, income, credit, offfarm, oxen, expinput, extnser)

where, dummy access to irrigation and other variables like education, land, income, credit, oxen, expenditure on farm inputs and gender (male) would affect θ (share of land to cash crop) positively, age of the head is undetermined and the other variables affect it negatively.

Model Specification for crop choice:

Based on the theoretical model I analyzed above, a household's decision to allot a plot of land to cash crop production is by and large a function of, among others, access to irrigation. There are, however, other factors which are deemed to be important in affecting crop choice. These include level of education, age of the household head, family size, number of oxen, credit market participation, off-farm income and income of the household.

Crop choice is calculated as or a percentage of cash crops as compared to all crops cultivated by a household (Von Braun et al, 1994).

$$\text{Share of land allotted to cash crop (ccintensity)} = \frac{\text{share of land allotted to cash crops}^{3}}{\text{Total cultivated land}}$$

[3]**Cash crops or high value crops: are** crop produced for sale rather than for subsistence.

Staple crops: are produce of food which have commercial value and are staple food.

As Papke and Wooldridge (1996) argue that, to illustrate the methodological issues that arise with fractional dependent variables, suppose that the dependent variable Y, $0 \leq Y \leq 1$, is to be explained by a vector of the various explanatory variables x. Then, for all i:

$$E\,(Y/X) = X_iB \qquad \text{……………eqn. 4}$$

Where B is a vector, rarely provides the best description of E (Y). The primary reason is that "Y" is bounded between 0 and 1, and so the effect of any particular X_j can not be constant through out the range of X (unless the range of X_j is very limited). To some extent this problem can be overcome by augmenting a linear model with non linear model functions of X, but the predicted values from an OLS regression can never be guaranteed to lie in the unit interval. However, one of the drawbacks of running OLS on a fractional dependent variable would entail similar problems as it does in the linear probability model for strict binary cases (Wooldridge, 2002), that is the predicted values of OLS estimates would not necessarily lie in the [0,1] interval.

The most common alternative to eqn.4 has been to model the log-odds ratio as a linear function. If Y (ccintencity) is strictly between 0 and 1 then a linear model for the log-odds ratio is:

$$E\,(\log[Y/(1-Y)]/X) = X_iB \quad \text{………..eqn.5}$$

Eqn.5 is attractive because log[Y/(1-Y)] can take on any real value as Y varies between 0 and 1, so it is natural to model its population regression as a linear function. Nevertheless, such procedure does not account for data that includes the limits 0 and 1. Moreover, it is not possible to recover the predictions for the dependent variable without some simplifying assumptions. In my thesis, though a value of 1 is rare, there are a number of households who do not allot their plots for cash crop at all. One way out could be to proceed with such transformation by giving an extremely small number for values equal to zero and a near unity number for values of 1. This is, however, arbitrary which may lead to undesirable results (Wooldridge, 2002).

At last, Papke and Wooldridge (1996) suggested as an alternative the Generalized Linear Model (GLM) that makes use of quasi-maximum likelihood estimation procedures. The notion of the GLM is that a regression model can be decomposed into a random component with expected value and variance of the dependent variable, a systematic component that is predicted by covariates, and a link function that relates the systematic component to the random component. For classical regression models, the random component is assumed to be distributed normal and the link function is an identity in the sense that the random and systematic components are identical (McCullagh and Nelder, 1989).

What makes GLM more relevant is that the normality assumption on the distribution of the random component could come from any function of the exponential family, and the link function could be any monotonic differentiable function (McCullagh and Nelder, 1989).

Given the dependent variable ccintencity (share of land allotted to cash crop) and the vector of the various explanatory variables x, where $0 \leq$ ccintencity ≤ 1. For each household, i, i = 1, 2, …, N, assume that the observed data, namely e $(y_i) = X_iB$, $0 \leq y_i \leq 1$, where y_i is household's decision to allot its plot of land to cash crop, X_i is K-vector of household-specific covariates and β_{cc} are vector of parameters to be estimated by the model.Then, for all i:

$$e\,(\text{ccintencity}) = X_iB \qquad \text{…….eqn.6}$$

In this case, the random component, E (ccintencity), is expected to have a value of μ so that $0 \leq \mu \leq 1$, and, unlike the linear regression model, the random component could have a distribution different from normal. It might rather have a binomial distribution which is from the exponential family.

More importantly, the link function cannot be assumed to be identity because the systematic component (X_iB) does not ensure the condition that the random component, E (ccintencity), lies between 0 and 1. Hence, the link function that relates E (ccintencity) and (X_iB) could be given by:

$$E\ (ccintencity\ /X_i) = G\ (X_iB) \quad ....eqn.7$$

Where G (.) is a link function satisfying the condition that $0 \leq G\ (.) \leq 1$.

Gourieroux, Monfort, and Trongen (1984) showed that quasi-maximum likelihood estimators (QLME) are consistent as long as the likelihood function is in the linear exponential family and given that the link function under (eqn.4) holds. Papke and Wooldridge (1996) suggested the random component to be Bernoulli for it being easy to maximize. For the link function, we use the logistic distribution as suggested by McCullagh and Nelder (1999).

Thus, for ccintencity -Bernoulli with a logistic link function, we have:

$$G\ (X_iB) = \lambda\ (X_iB) = e^{XiB} / [1+e^{XiB}] \quad ....eqn.8$$

The Bernoulli likelihood function is given by:

$$F\ (ccintencity_i/X_i;\ B) = [\lambda\ (X_iB)]^{ccintencity\ i}\ [1-\lambda\ (X_iB)]^{1-\ ccintencity\ I} \quad ………………………eqn.9$$

This can be transformed to give:

$$L\ (B) = ccintencity_i \log [\lambda\ (X_iB)] + (1-\ ccintencity_i) \log[1-\lambda\ (X_iB)], \quad ……………...eqn.10$$

Here B = measures household's decision in allocating resources to either enterprise, i.e. staple or cash crop production.

Therefore, in estimating the impact of irrigation on farm household's crop choice decision, this paper adopts GLM model for analyzing the determinants factors of household's commercialization decision.

Results and Discussions

In this chapter, the results of the findings from the quantitative as well as qualitative data are discussed thoroughly followed by the discussion of the respective issues of interest.

Description of the variables

The total impact of irrigation can be best assessed by comparing same agro-environments, which are similar in all aspects, including endowment of resources, except in access to irrigation infrastructure. Summary statistics (table 5.1) presented below shows distinct differences in the household's resource endowment and household characteristics. This indicates household characteristics and resource endowment that may affect their decision on crop choice.

The survey data indicate that about 77% of sampled households were irrigation users while 23% were purely rainfed cultivators. That is, irrigation enables producers to cultivate their land intensively and select high value crops for their production using continuous flow of water. The availability of such facilities affects cropping pattern and related cropping decision.

Household characteristics include those related to human capital, labor supply and the life-cycle stage of the household. The average age of the household head is computed to be approximately 41.67 years and the minimum and maximum age of the household head is computed to be 18 and 80 years respectively. Age of household head is expected to have a quadratic relationship with both inter and intra specific diversity, as younger households may be more willing to adopt new technologies including different crops and varieties, while older households may be reluctant to new technologies and less likely to try new crops and varieties (Abera, 2009).

Gender of the household head is one of the determinant factors for agricultural commercialization. From the sample survey, majority of the household heads are male-headed households (61%) which are quite higher than that of female-headed households (40%). Categorically, 64% of the male-headed households have access to irrigation while 36% of the female headed households have access to irrigation. Gender composition of the household (male-headed) is expected to have a positive effect, while household size is difficult to predict priori on commercialization through its effects on preferences and overall labor capacity. Family size is included as productive labour and dependency ratio, to capture the impact of consumption and productivity on crop choice.For the educational attainment of the head of the household, years of schooling by level (read a letter, write a letter, literacy program, attend to school, high grade completed and training/qualification in which the head attained) were considered.

Rural Ethiopia in general Tigray in particular is characterized by the practice of mixed farming except for certain areas known for their nomadic pastoralist life style. This is also the case in the context Kilte-Awlaelo woreda of Tigray. Oxen ownership is expected to contribute positively to diversity among cash crops through ensuring draught power for plowing and as a source of cash when it is needed. The effect of income that is exogenous to crop choice, such as remittances, gifts, aid, and pensions, is ambiguous. As table 5.1 demonstrates, household heads have income, on average, 1211 birr with minimum 0 birr and maximum 6000 birr.Credit take is also included to capture the impact of risk aversion on crop choice. Generally 65.35% (66) of the sample households heads in the survey have taken out loan in the production year, with a mean 1414 birr. Extension service is also included to capture its impact on getting integrated provision of market information.

In rural Africa many household obtain half or more of their income from non-farm sources (Reardon, 1997). Non farm activities refers both to self employment in non farm sectors and/or off farm employment. Participation in non farm activities is expected to have negative relationship with agricultural commercialization.Non farm income of the household are included to capture the impact of wealth on crop choice. Per capita land and expenditure on farm input are included, which are critical factors of production, to capture their impact on household's decision to produce surplus for market.

Finally access to radio is included to capture the impact of information asymmetry on crop choice. Access to radio has importance in accessing market information and in facilitating market transactions. It helps to transform from subsistence oriented farming into market oriented farming system. However, from the survey most of the household heads don't have radio, that is, 82 (81.19%), the remaining 19 (18.81) have radio.

Variable	Description of the variables	Obs	Mean
Percapitaland	total cultivable land/family size	101	1.159 (0.82)
Plottype	1= irrigated, 0=otherwise	101	0.772 (0.421)
hhage	age of the head	101	41.67 (16.60)
hheadsex	1=male, 0=female	101	60.40 (0.491)
Education of the household			
edu1	read a letter	101	0.376 (0.486)
edu2	write a letter	101	0.306 (0.463)
edu3	litracy program	101	0.138 (0.347)
edu4	attend to school	101	0.118 (0.325)
edu5	highgrade completed	101	0.029 (0.17)
edu6	training/qualification	101	0.029 (0.17)
Family size			
depratio	members < 15 and > 64/family size	101	0.485 (0.249)
produlab	adult labor	101	2 (1.086)
income	income of the household head	101	1211.324 (965)
credittake(1=credit)	1=loan take, 0=otherwise	101	0.653 (0.478)
amountcredit	amount of credit taken	101	1414.03 (1304.056)
extenser(1=extension)	extension service	101	o.67(0.473)
expfarminput	expenditure on farm input	101	554.085 (551.949)
oxen	total number of oxen	101	0.95 (1.033)
nonfarm income	non farm income	101	163.811 (273.641)
Means of transport			
mode1	no transaction	101	0.079 (0.271)
mode2	on foot	101	0.841 (0.3669)
mode3	mule	101	0.019 (0.14)
mode4	donkey	101	0.009 (0.099)
mode5	by car	101	0.049 (0.218)
wdonfoot	walking distance on foot	101	1.316 (0.615)

Results from the descriptive and statistical analysis: In this section, the results of the impact of irrigation on crop choice decision have been done on descriptive statistics. Apparently, the econometrics analysis conducted also reinforces the descriptive results.

Impact of irrigation on crop choice: Irrigation is a rare phenomenon of agricultural production in most parts of Africa (World Bank, 2007). What is now covered by irrigation is but a very small portion of what is potentially irrigable area in most countries (World Bank, 2007). However, use of irrigation is one of important way to enhance agricultural production, switches farm use away from staples to higher-value and market-oriented products. In this sub-section, I present descriptive results concerning the impact of irrigation on crop choice decision by smallholder farmers in Eastern Tigray on the percentage of share of land alloted to cash crop decision by plot type.

The statistical summary in table 2 depicts that a typical household head that uses irrigation allot their land to cash crop have, on average, 7% of their cultivable land while 0.7% of the sampled households under rainfed system allot their land to cash crop; the two sample t-test result shows that the difference is statistically significant at 5% level. This confronts with my expectation. i.e., irrigation development contributes to agricultural production and productivity improvement. Besides, irrigation made possible to diversify agricultural production by creating favourable condition to cash crop production.

Table 1: two-sample t test with equal variances

Variable	**Mean (Std. Err.)**
Rainfed	0.007 (0.007)
Irrigated	0.079 (0.017)
Combined	0.06 (0.0138)
Difference	-0.07 (0.03)
t = -2.2206 **	Obs = 101
degrees of freedom = 99	

Finally, from the two-sample t test evidence we can suggest that; even though access to irrigation have positive impacts on farm households crop choice decision there is a gap between the share of land allotted to cash crop production and households market participation decision. This might be due to the fact that "distress sales", that is, agricultural sales by poor households straight after harvest because they are desperate for cash. Where it is food that is being sold, the household may then be forced to buy back the same (or indeed a greater) quantity of food later in the year when the price is much higher. In this case, the crop sale raises the HCI, but is in no way indicative of increasing household welfare. i.e., the rise in the HCI is not driven by a profit motive, but rather a short term survival need. Since, risk minimization rather than profit maximization is an important driver of subsistence production.

In summary, the descriptive statistics indicate that irrigators are better off in terms of crop choice and market participation indicators. But this does not imply that the difference is solely due to access to irrigation. Other factors (both observable and unobservable) might have contributed to the crop choice and market participation difference between irrigators and non-irrigators.

Results for crop choice model: The results for the land allocation to cash crop model are shown in table 2. The results show that access to irrigation, age of the head, income, credit take, number of oxen and non farm income are significant for predicting household crop choice. The irrigation dummy is significant and positive. Irrigation may have two impacts. First, most cash crops which have high demand in markets require sustainable supply of water. Secondly, availability of irrigation scheme gives households the opportunity to produce more than once within a year. This in turn secures them to shift into the production of staple crops with low gestation period during a risk of falling prices of cash crops such as vegetables.

Rural households under study area who are younger tend to allot more land for the production of cash crops. This result is not unexpected, as risk taking behavior tends gradually to decline as people get older. Moreover, as farmers get older they may be unable to spend the time and energy needed for the production and marketing of cash crops.

The positive sign for income shows that household's who have higher income under the survey allot much land to cash crop. This might be due to the fact that income is associated with both in terms of capital and as a buffer to mitigate any production and market related shocks, which are relevant in a smallholder crop choice decision. The dummy for credit take shows that household's who take loan allot much land to cash crops compared to those who don't. This might be due to credit take may have implication on increased productivity, adopting new technologies and minimizing risk.

In the case of number of oxen, results show that it has positive and significant value to allot more land for cash crop. One explanation for positive association between cash crop production and number of oxen might be oxen are useful in cultivating land and useful in liquidity effect.

Lastly, non farm income is found to be significant at 1% level and negative. Household's who get more non farm income doesn't have much influence on the household's decision to allot more land to cash crops. This might be due to household's who get more non farm income have a tendency to shift their occupation to off farm employment and/or non farm income activities.

Unlike OLS regression, however, GLM regression does not assume linearity of relationship between the independent variables and the dependent does not require normally distributed variables and in general has less stringent requirements. It does, however, require that observations be independent and that the independent variables be linearly related to the fractional logit of the dependent. Therefore, Goodness-of-fit tests (likelihood ratio test) are made as indicators of model appropriateness, as is the Wald statistic to test the significance of individual independent variables. In addition, the robust action and endogeniety tests were performed to remedy hetroscdaciticity problems and endogeniety problems respectively.

Table 2: GLM Estimation of land allocation decisions[4]

Dependent variable: Share of land allotted to cash crop

Variables	coefficients (SE)	mfx	OLS estimates
Per capita land	0.29 (0.88)	0.01 (0.82)	0.01 (0.47)
Irrigation (1= irrigated)	3.38 (3.53) ***	0.04 (4.36)	0.07 (2.62)
Age of the head	-0.032 (-1.82) *	-0.001(-1.93)	-0.001 (-0.99)
Gender (1=male)	0.13 (0.22)	0.002 (0.48)	0.01 (0.78)
Education-Head			
Write a letter (read a letter)	0.50 (0.87)	0.01 (0.84)	0.01 (0.40)
Literacy program (read a letter)	0.38 (0.52)	0.01 (0.50)	0.005 (0.14)
Attend to school (read a letter)	0.86 (0.87)	0.03 (0.75)	0.005 (0.14)
High grade complete (read a letter)	1.38 (1.21)	0.06 (0.89)	0.11 (0.81)
Training qualification (read a letter)	0.19 (0.17)	0.01 (0.23)	-0.018 (-0.27)
Dependency ratio	-1.77 (-1.58)	-0.04 (-1.54)	-0.08 (-1.33)
Productive labor	-0.69 (-1.39)	-0.01 (-1.52)	-0.02 (-1.07)
Extension service	0.08 (0.15)	0.003 (0.24)	0.005 (0.15)
Income	0.001 (1.85) *	0.00 (2.10)	0.00 (0.87)
Credit take (1= take)	2.25 (2.60) ***	0.04 (3.17)	0.05 (0.87)
Amount of credit	0.0003 (1.21)	7.35 (1.24)	1.28 (0.06)
Expenditure on farm input	0.001 (1.17)	0.00 (1.28)	0.00 (0.63)
Number of oxen	0.58 (1.90) *	0.01 (1.71)	0.02 (1.15)
Non farm income	-0.005 (-2.69) ***	-0.00 (-3.42)	-0.00 (-1.54)
Intercept	-6.16 (-3.93) ***		-0.01 (-0.16)

Generalized linear models — No. of obs = 101

Optimization : ML

[Bernoulli]

[Logit]

AIC = 0.68

Log pseudo likelihood = -15.5793574 — BIC = -193.02

*. ** and *** represent significance at 10%, 5% and 1% respectively.

[4]However, including the square of age as an explanatory variable introduced severe. The direction of effect of the multicollinearity, and it was dropped from the final regressions.

Note: that the coefficients of the covariates are not slopes. To estimate the slopes I use mfx command after the GLM estimation. Normally, the slopes of the GLM are comparable with the OLS estimates.

Conclusions and Recommendations

Conclusions: In this chapter, the whole work of this research is summarized and presented briefly. This paper addresses the potential for interlinked small scale irrigation and farm households' decision to cash crop production to promote food crop productivity.Moreover, in this paper success factors and challenges posed the successes of households are also assessed. In the last section critical discussions of findings and practical and educational suggestions are presented.

A brief historical account shows that irrigation has played a key role in enabling sustainablefood production where it is well managed by lowering the risk of crop failure. Irrigation also helps to prolong the effective crop growing period in areas with dry seasons by permitting multiple cropping per year where only a single crop could be grown otherwise. Furthermore, irrigation reduces the risk of expensive agricultural inputs like fertilizers from being wasted as a result of crop failure caused by shortage of water. On top of that, irrigation development contributes to agriculture production and productivity improvement. This increase in agricultural production is due to agricultural expansion and intensification. Moreover, availability of food is improved by product diversification. Irrigation development enables to bring uncultivated land under cultivation and enable multiple cropping within a year time (agricultural intensification).

Last but not the least, irrigation made possible to diversify agricultural production by creating favourable condition to cash crop production. By irrigation, irrigators could produce more cash crops than non-irrigators.

In this paper, I investigate the interaction between access to irrigation and farm households' crop choice decision in Eastern Tigray. The findings from this study show that the majority of the households covered in the study are mainly dependent on agriculture for their livelihood. Most of them produce food crops for own consumption, that is, the share of land allotted to cash crop is 6% which indicates the majority of the households are subsistence oriented. The statistical findings showed that households having access to irrigation have positive impact on household's crop choice to cash crop than rainfed users which is more optimism and hope to generate benefits for poor rural communities.

The GLM regression analysis was performed to identify those factors that determine share of land allotted to cash crop production. It is shown that access to irrigation, age of the head, income, credit take and number of oxen have positive and significant association with share of land allotted to cash crop production while age of the head and non farm income have negative and significant impact on the share of land allotted to cash crop production.

In this work, therefore, the objective of investigating the role of irrigation in household crop choice and their decision to participate in markets are dealt, and were found that irrigation development can have positive cause and effect relationship with household crop choice decision in the region. Factors those may retard the effectiveness and sustainability of such projects were also identified.

Recommendations: High-valued cash crops represent one potential avenue of crop intensification in some areas. This paper addresses the role of irrigation in cash crop production and in promoting food crop productivity growth. The paper argues that, in addition to the direct stimulus that cash cropping can have on household incomes, there may be important indirect effects of cash cropping on the productivity of other household activities such as food cropping.

The study shows the impact of irrigation on cash crop production is direct and immediate, therefore, there is still potential of integrating farm households' for those who don't allot their plot to cash crop with markets if better support services in the form of technical advice, marketing opportunity and capacity building training to use technology and intensify production is provided; i.e., if additional funds for agricultural research activities dealing with investments in irrigation projects (such as river diversion, dams, …) are made.

The study also found that having many oxen has positive impact on cash crop production, therefore, policies that encourage asset accumulation processes through promoting investments in animal traction will create virtuous circle between cash cropping and assets. Hence, there is a need to link irrigation development with road infrastructure development and improvements in other marketing services, thus, can help in the long-term transform traditional subsistence agriculture into more market oriented and modern agriculture.

Further research into the factors that lead some factors to stay in agriculture while not engaging with allotting their land to cash crop would be useful. For example, given the finding that age of the household head, when gets older, affects share of land to cash crop negatively, is this a lifecycle effect (meaning that the current generation of young farmers may also leave from allotting their plot of land to cash crop when they get older), or a generational shift? Would these farmers want to move out of agriculture if better options were available? Investigating such questions could assist policy makers in designing strategies to improve currently precarious farming livelihoods, while facilitating a smooth exit from farming for those who wish to take it.

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