Does Access To Small Scale Irrigation Promote Market Oriented Production In Ethiopia?

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Abstract

The study examined the extent and nature of market oriented production in irrigated compared to rainfed systems in Ethiopia. By doing so the paper identifies the role of irrigation in market-oriented production, while at the same time highlighting the main constraints to market oriented development. Our results indicate that irrigation contributes significantly to increases in market participation, volume of marketed produce and, hence, income, by inducing shifts in farmers' cropping mix. The impact of commercialization of production on household food security is not direct and immediate mainly because of failures in the food market.

While irrigation enhances market production, there are series of factors that pose serious constraints to market production. Land size, oxen holding, access to market and means of transport were found to be important determinants of market oriented production calling for policy interventions in land markets, access to productive assets and infrastructure development and policy measures to improve the performance of agricultural markets. The study also found education has market promoting effect in terms of increasing the probability of participation and volume of sale. Increased support to education can, thus, help in the long-term to transform traditional subsistence agriculture into more market-oriented agriculture. Finally there are unobserved site specific effects, related to location and other covariates, which influence market participation and volume decisions.

Key terms: irrigation, change in cropping mix, market participation, volume of sale, Probit and Truncated regression; Ethiopia, Africa.

1. Introduction

Irrigation development is 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 (marketable surplus production) and perhaps food security. Irrigation is also expected to lead to changes in crop mix (cash crop orientation) which is expected to have far reaching consequences on household welfare (Joshi et al., 2003). Crop-switching as Hussain and Hanjra (2004) noted involves substituting low yielding and low profitable crops with new high-yielding and more profitable crops. Implicitly this implies switching from subsistence production to market-oriented production (ibid.). 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).

In risky environments such as Ethiopia, smallholder 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 p.6). Irrigation removes some of the risks associated with rainfall variability and thereby increases the likelihood of using purchased quality inputs due to the reduced risk of crop failure. 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).

While irrigation development is expected to induce such changes, the realization of these effects cannot be taken for granted. This could be especially true in countries like Ethiopia, where many of the preconditions for market production seem to be missing. The households' orientation towards market production is often hampered by various factors at the household and village levels, by market access conditions and other institutional and policy factors. The World Bank (2006) indicated that current limited access to transportation and markets undermines incentives for surplus agricultural production and reinforces the highly vulnerable subsistence-oriented structure of the economy. It further indicated that smallholder farmers, generally with less than 1 hectare of land, account for about 95 percent of the agricultural output. In times of good weather, roughly 75-80 percent of the output is consumed at the household level (World Bank, 2006). Bhattarai and Pandy (1997) in their study in Nepal indicated that wheat production was economically more profitable in locations with better access to irrigation and rural infrastructure. They also found that farmers with access to irrigation and markets are found to be much more responsive to changes in wheat prices than farmers without access to such infrastructure, indicating the complementarity between infrastructure development and access to market and crop productivity. Lapar et al. (2003) pointed out that smallholders generally have inadequate capital resources—including, physical and financial resources, but also intellectual capital resources such as experience, education and extension— which limits their ability to diversify production portfolios. Lapar et al. (2003) further indicated that the inability of smallholder producers to take advantage of economies of scale in production and marketing is a significant impediment to market participation. Smallholders are often disadvantaged due to poor access to information and market-precipitating services such as extension visitation and credit assistance and these impediments often give rise to low rates of adoption of improved technologies that could potentially increase productivity, diversification and, hence, market participation. In addition, poor infrastructure often increases the transaction costs of smallholder market participation.

However, there is little empirical evidence on market participation in developing countries, particularly in Africa. The limited studies there are focus on smallholder producers' decision to participate in coarse grain markets (Goetz, 1992) or in livestock markets (Lapar et al. 2003; Bellemare and Barrett, 2006). To our knowledge there is no

study, which has systematically investigated the role of irrigation in inducing market-oriented production in Sub-Saharan Africa.
A sound understanding of the patterns of market oriented production and the constraints it faces could contribute to the development of more appropriate policies regarding institutional arrangements and the creation of adequate infrastructure, which could benefit a large mass of smallholder producers. This study is an attempt in this direction. Specifically it aimed to: (i) examine the extent and nature of market oriented production in irrigated sites in contrast to rainfed areas in Ethiopia; (ii) identify the determinants of market-oriented production, including the role of irrigation in the process, and (iii) draw implications of market oriented production on food security and poverty reduction.

We used a unique dataset covering various small and medium scale irrigation schemes, both traditional and modern. Corresponding data from rainfed systems were used as a control. We explored the differential impact of irrigation development on market production as contrasted to rainfed systems. In explaining a household's decision to participate in the market we introduced the distinction between participation per se and volume decisions (i.e. level of participation). Where participation investigated whether the household produces and sells products to the market regardless of the amount (value) of sale and the level of participation investigated the factors that influence the quantity of sale. It is difficult to assume *a priori* that the factors that influence the household's decision to participate in the market are different from the factors that influence volume decisions. Hence, we also tested whether the decision to participate and the volume of sale are made simultaneously using appropriate econometric techniques.

The paper is presented as follows. Part two presents a theoretical model for modeling participation and volume decisions followed by the presentation of testable hypotheses and econometric approaches in parts three and four. In section five the study site and data description and some descriptive statistical summary results are presented. Part six discusses the econometric results and part seven concludes and draws policy conclusions.

2. Modeling participation and supply decisions

We developed a simple conceptual framework that captures interactions, processes and outcomes that result from irrigation development. Unlike rainfed agriculture, irrigation development enhances cropping intensity as households are able to produce more than once in a year. Irrigation also opens new horizons for growing new crops which are not usually possible under rainfed conditions (Joshi et al., 2003; Hussain and Hanjra 2004; Hussain, 2005; Huang et al., 2006). Furthermore, irrigation development enhances increased use of purchased inputs by reducing the risk of crop failure and increasing returns to agriculture and, hence, increasing household's willingness to use purchased farm inputs such as fertilizer, herbicides and pesticides and also hired labor (Hussain and Hanjra, 2004). These changes in cropping intensity and shift in cropping choice (diversification) are expected to have far reaching consequences on food security and poverty, not least through the market behavior of smallholder farmers (Pandey and Sharma, 1996; Hussain and Hanjira, 2003; Hussain and Hanjra 2004; Huang et al., 2006).

Irrigation development is expected to trigger this host of processes. However, while irrigation is the necessary condition to induce these changes, it is not as such a sufficient condition as there are various factors that influence these processes. First we present the theoretical model that focuses on the household's decision to produce for the market before we present the possible factors that influence market participation and volume decisions.

We consider market participation and supply decisions in the context of traditional Probit and Tobit models applied to household production data (see Lapar et al. 2003). For each household, i, i = 1, 2,…N, assume that the observed data, namely y_i = 1 if participation is observed and y_i = 0 otherwise, is conditioned by a K-vector of household-specific covariates, x_i. The decision rule is to participate when the utility of doing so, say, $U_i(x_i)$ exceeds utility $V_i(x_i)$, which is the utility reaped from some alternative enterprise (e.g. to produce food crops). Taking Taylor-series expansions of these two utility functions around the point x_i = 0, yields the linear model, y_i = 1 if $x_i\gamma \geq x_i\mu$, y_i = 0 if $x_i\gamma < x_i\mu$, where γ and μ are K-vectors of first-order effects depicting the impacts on the two utilities of changes in the levels of the covariates. Subtracting the left-hand-side from both sides of the inequalities, equating the result to a latent variable, Z_i, and permitting the equality to hold with error, μ_i, we are left with

$Z_{pi} = x_i\beta_p + \mu_{ip}$, $Z_i \geq 0$ if $y_i = 1, Z_i \leq 0$, otherwise. (1)

Here $\beta_p \equiv \gamma - \mu$ measures the difference in allocating resources to either enterprise, i.e. food or cash crop production.

Supply decisions are modeled in a similar way. We assume that the quantity supplied on the market is a linear function of another set of household characteristics, which may be the same as the set represented by the covariates xi, above. Specifically, the supply relationship is:

$$Z_{si} = x_i\beta_s + \mu_{si}, \qquad (2)$$

where Z_{si} denotes household i's the volume supplied; x_i denotes covariates relevant to the supply decision; β_s denotes a vector of unknown parameters depicting the relationship between supply and the household covariates; and $\mu_{si} \sim N(0, \sigma_{si})$ denotes random error.

Unlike the latent specification in the Probit model, the dependent variable in (2) takes on positive and zero values. When a zero value is observed, we assume this to imply that the household in question, rather than possessing an excess of the marketable product, actually has a demand for the commodity (that is, a negative supply). Hence, sales quantities are left-censored at zero.

3. Hypotheses

In this section we present, in the form of testable hypothesis, various factors that influence the irrigation-market production nexus.

In most rural economies, farm households are dominant decision-makers when it comes to the management of land and water resources. Farm households appear to represent an extremely robust and dominant decision-making unit in relation to production, consumption and market exchange in the types of economies we studied. Farm households, therefore, become the natural core units in our models and analysis. Various development interventions, including irrigation development, may have changed their decision-making environment, however, in terms of their capacity to produce, access markets and the prices and price variability they face in these markets.

In a world with well developed markets, households will participate in all factor and commodity markets when these factors are used in production and commodities are produced and/or consumed by the households, as long as factors and commodities are imperfect substitutes and distribution of factors and commodities vary across households. There will always be gains from trade when trade is costless (zero transaction costs). Such a world favors specialization. Under such scenario, irrigation development is expected to promote market oriented production

regardless of the households' consumption demand.
In the real world there are transaction costs causing there to be price bands where purchase prices are higher than selling prices. Significant positive transaction costs and information asymmetries can lead to market imperfections (de Janvry et al., 1991). For an economy where there are both sellers and buyers of a factor or commodity, in the so called two-sided markets, positive transaction costs and information asymmetries lead to non-participation and a "self-sufficiency orientation" for factors that are owned and used in production and commodities that are produced and consumed by households. In general, we expect that the higher the transaction costs, the wider the price band and the larger share (%) of households that will be non-participating. An implication of this is that market non-participation can be an indicator of the size of the transaction costs in a specific two-sided market. However, the distribution among households and substitutability of factors in production and commodities in consumption within households may also influence the degree of non-participation. The higher the elasticity of substitution in production and consumption the higher we expect the probability of non-participation to be. Overall, significant market non-participation is a sign of significant market imperfections in an economy. On the basis of these broader perspectives, we developed some testable hypothesis.

H1. Smallholder producers with access to irrigation are more likely to participate in markets than farmers under rainfed systems.

H2. Smallholder farmers with better access to markets (i.e., close to larger markets) are expected to be much more likely to participate in the market than farmers without access to such infrastructure.

H3. Households with better endowments such as labor, capital (including livestock), land and other resources such as information and education are more likely to participate in markets than households with fewer endowments.

H4. Smallholder farmers are often disadvantaged due to poor access to information and market-supporting services such as extension services and credit assistance and these impediments often give rise to low rates of adoption of improved technologies that could potentially increase productivity, diversification and, hence, market participation.

Hypothesis three implies that poverty may limit households' participation in markets. Besides, food insecure households may allocate most of their resources to meet their food demands, even if growing for the market is economically more rewarding. Hypothesis four implies that availability of inputs and new technologies also facilitate market oriented production. In this case, the functioning of input markets and extension services play an important role in facilitating increased adoption of new technologies (improved seeds, agronomic practices, etc) by farmers. Adoption of new technologies plays a critical role in farmers' increased market oriented production as technological change without increased commercialization seems unlikely because of the increased use of purchased inputs and diversification/specialization are inherent elements of most technological innovations in agricultural production. Hence, policies to speed up commercialization and technological change move jointly in a reinforcing way (von Braun, 1995). Hence, we propose that households with good access to services (input and capital markets) are more likely to participate.
These hypotheses were tested systematically. The results are reported in the subsequent sections.

4. Econometric estimation

Let the amount of crops supplied by a household i be given by:

$$y_{si} = x_1\beta_1 + \mu_1 \quad \textbf{\textit{(3)}}$$

where y_{si} is the volume of sales supplied by the household that is expected to depend on the vector x_1 regressors outlined in equation (2). As y_{si} is censored this can be estimated using variants of censored regression models. The most often used model is the Tobit model (Wooldridge, 2002).

The participation equation, whether the household decides to participate or not, is given by:

$$y_{pi} = 1[x\delta_2 + v_2 > 0] \quad (4)$$

where (x, y_{pi}) are always observed whereas y_{si} is observed only when $y_{pi} = 1$. Eq. (4) can be estimated using variants of the binary choice model, in our case we used the Probit model. We assumed that (u_1, v_2) is independent of x with mean of zero implying that x is exogenous, and $v_2 \sim N(0,1)$.

One of the assumptions in, and important limitation of, the Tobit model is a single mechanism determines the choice between $y_{pi} = 0$ versus $y_{pi} > 0$ and the amount of y_{si} given $y_i > 0$. However, in reality participation decisions and volume decision could be separate, and are influenced by different factors. Estimating these decisions simultaneously while the decisions are separate may lead to inconsistent estimates and wrong conclusions. Alternatives to censored Tobit have been suggested to allow the initial decision of $y_{pi} = 0$ versus $y_{pi} > 0$ to be separate from the decision of how much y_{si} given $y_{pi} > 0$. These include Cragg's double hurdle model (Probit plus Truncated regression model) (Cragg, 1971) or Wooldridge's model using Probit plus lognormal regression models (Wooldridge, 2002). Hence, nested (log-likelihood ratio test) and non-nested Voung test (Voung, 1989) model test statistics were derived to determine whether to use the Tobit model formulation or either the Cragg or Wooldridge model. If these test results showed that these were separate decisions, then we used the double hurdle model (Cragg, 1971) or Probit plus lognormal regression models (also known as Wooldridge model) along with other explanatory variables to explain volume decisions of households.

The Cragg model has the advantage that it nests the Tobit model and a likelihood ratio test can be performed easily to determine if the household market supply decision is best modeled by a one-step or a two-step procedure. The difficulty in comparing the Wooldridge model against the Cragg model is that they are not nested to each other. The same is true for Tobit model and Wooldridge model. We used the Voung (1989) non-nested model selection test. Following, Greene (2000) and Fin and Schmidt (1984) the restriction imposed by the Tobit model is tested against the Cragg model by performing a likelihood ratio test of the following.

$$L = 2(\ln L_{probit} + \ln L_{truncatedregression} - \ln L_{Tobit})$$

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where L is distributed as chi-square with k degree of freedom (K is the number of independent variables including a constant). The Tobit model was rejected in favor of the Cragg model if L exceeded the chi-square critical value. The likelihood ratio test statistics of chi2 (37) = 4574.21, p=0.0000, indicated that the restrictions imposed by the Tobit model is rejected in favor of the Cragg model. Thus, the same household and farm characteristics did not have equal influence on both the participation decision and the decision for how much to sell. It also implies that the participation decision and volume decision are not made simultaneously. However, hypothesizing that a given variable is interrelated with the participation decision and not with volume decision or vice versa is difficult. Consequently, the three models are estimated with the same variables.

Once the Tobit model was rejected, the Cragg model could be compared with Wooldridge model using Voung's non-nested model specification test. Voung's non-nested model specification test is given by

$$V = n^{-1/2} LR_n(\hat{\theta}_n, \hat{\upsilon}_n) \big/ \hat{\omega}_n \rightarrow N(0,1) \quad (6)$$

where $LR_n(\hat{\theta}_n, \hat{\upsilon}_n)$ is the difference between the log-likelihood values for the two models, $\hat{\theta}_n$ and $\hat{\upsilon}_n$ is the maximum likelihood estimators from the two models, respectively and V is distributed as a standard normal variable. The Voung test statistic of (V= -27.858, p= 0.000), strongly indicated that the Cragg model dominates the Wooldridge model. The critical values (c) for the 1 and 5 percent significance level are 2.58 and 1.96, respectively. Consequently the results presented below are derived from the Cragg model.

Finally, we also corrected the standard errors for clustering effects by assuming that observations are not independent within the cluster although they are independent between clusters, in this case the household (Rogers, 1993). This is fair assumption as management could vary across households but not within plots run by the same household.

5. Study site description and data description

This study is part of a comprehensive nationwide study on the multiple impacts of irrigation on poverty and environment run between 2004 and 2007 in Ethiopia. It was a component of the Impact of Irrigation on Poverty and Environment (IIPE) research project run by the International Water Management Institute (IWMI) with support from the Austrian government. The socio-economic survey, which investigated the impact of irrigation on poverty and irrigation contribution to national economy, addressed a total sample size of 1024 households from eight irrigation sites from 4 regional states involving traditional, modern and rainfed systems (see Fig. 1 and Table 1A). 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 4,953 plots (a household operating five plots on average). Of the total 4,953 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 collected include demographics, asset holdings, access to services, plot level production and sale and input use data (distinguished between irrigated and rainfed), constraints to agricultural production and household perceptions about the impact of irrigation on poverty, environment and health and other household and site specific data. The data was collected for the 2005/2006 cropping season.

6. Results and discussion

Summary statistics

We present a summary of some of the most important variables here (for details see Table 1 below). Of the total households surveyed, about 54 percent of the households participated in the market by selling a product and earning an average of Birr 591 (SD 2169) [††††††]. The gross value of sales realized by households varies greatly

[††††††] 1 US Dollar (USD) = 8.39625 Ethiopian Birr (ETB) in May 2006.

as can be seen from the high variance. This variation is also stronger between farmers working in different irrigation types. Households in traditional irrigation and in modern schemes earn an average income of Birr 699 (SD 2679) and Birr 779 (SD 4090) respectively from crop sales in contrast to rainfed Birr 476.10 (1076.1). It seems that average gross value of sales from modern irrigation schemes is higher than those from traditional schemes. However, testing for equality of the mean, in sales between the three irrigation types, indicated that there is a statistically significant difference (p-value 0.0001). However, a separate test for traditional and modern scheme indicated that the mean difference is not statistically different (p-value 0.5354). This indicates that there was no difference in mean value of sales between traditional and modern schemes, although average sales from both sources are higher than those obtained from the rainfed system.

When asked about whether the households faced any output market and marketing problems about 59 percent responded that they did not face any problems while the remaining 41 percent said that they did. There is a difference in the perception of the presence of a market and marketing problems between farmers working in rainfed systems and under irrigation systems. More farmers under irrigation systems seem on average to face market and marketing related problems than those working under rainfed systems. The major problems include: market problem (low demand and low selling price) (30.7%), distance to market, road and transport problems (23%), same product & peak time supply (20 %), unstable prices (11%), lack of services (information, service cooperatives, high tax) (5.3%), high purchase prices of agriculture goods when they want to buy them (4.4%), low supply and poor quality (3.3%), exploitation by local traders (1%), and others (additional costs) (0.7%).

The functioning of input markets is expected to influence the functioning of output markets through its influence on production. Hence, we wanted to understand whether farmers faced any input access problem during the 2005/06 cropping season. Reporting on their experience of input access, about 53 percent of the households responded that they had no input access problem, compared with 47 percent who indicated that they did. The problems included: high input prices (45.8%), shortage of capital (high down payment, not member of service cooperatives and lack of access to credit) (18 %), lack/shortage of supply of inputs (mainly pesticides and herbicides but also fertilizer) (16 %), lack of timely supply (10 %), shortage of equipment and materials and skilled labor to apply these inputs (2.4), and distance to input markets and lack of supply locally (1.9%). The most important problems are, hence, high input prices, lack of credit access and lack of availability of inputs in space and time. There is a significant difference in the perception of the presence of input related problems between farmers working in rainfed systems and under irrigation systems. On average more farmers under rainfed systems seem to face input access problems than those working under irrigation.

Moisture stress and water shortages could pose serious constraints to agricultural production and, hence, to market supply of agricultural outputs. Asked if households faced any shortfall in rain during the production season about 61 percent of the respondents indicated they did not, while the remaining 39 percent indicated that they did. Similarly, irrigation farmers asked if they faced water shortage during the irrigation season, 73 percent responded that they did not, while 27 percent of the respondents did.

We present the composition of crops under different irrigation systems. The percentage values indicated the percentage of the plots covered by these crops (Figure 3). The dominant crops under traditional irrigation system, in order of importance are: maize, wheat, teff, followed by horticultural crops such as mango, potato, banana and tomato (Figure 3a). In the modern irrigation schemes, in the order of importance, the dominant crops are teff, maize, onion, wheat, tomato, barley and potato (Figure 3b).

In the rainfed agricultural system cereals are the dominant crops: teff, wheat, maize, sorghum, barley and pulses and oil crops. Horticultural crops such as onion, potato and perennial crops such as mango and *gesho* (local hops) each cover less than 1 percent of the total plots (Figure 3c).

Finally we looked into the nature of market production, i.e. whether households are really exercising shifts in their cropping choice? Or is it just the produced surplus which is supplied to the market? How are the quantity of sales and value of sales correlated? We estimated a simple correlation coefficient between quantity and value of sales. A calculated correlation coefficient of 0.18 indicates that there is low linear association between quantity and value of outputs. Therefore, it could be that farmers are shifting to more valuable products as the crop composition also attest.

Explaining market participation

The results from the Probit regression model on factors that determine households' market participation, are reported in Table 2 below. The fitted binary choice model is found to explain the observed variation with the observed probability of 0.60 and predicated probability 0.62. We also estimated the marginal effects for the Probit model and these are reported here.

Farmers working under different irrigation management schemes may have different probabilities to participate in the market. Households working in modern irrigation schemes were found, albeit at 10 percent level of significance, less likely to participate in the market compared to rainfed farmers. Similarly, farmers working under the traditional irrigation scheme are found to have not significant difference in participating in output markets. These results show that participation *per se* is not influenced by whether the household works under irrigation system or not. However, when we disaggregate by crop types, farmers growing irrigated annuals and irrigated perennials are more likely to participate in the market in contrast to farmers that grew rainfed annual crops, with marginal effects 0.21 and 0.29 respectively. It is believed that this is because the rainfed annual crops tend to be mainly food crops. The participation of the farmers growing rainfed perennials is found not to be significantly different from those growing rainfed annuals perhaps indicating the inherently low scale of cash crop production in the former. Hence, the result strongly indicates that irrigation significantly contributes to market participation by enabling farmers to grow crops that are marketable although rainfed growers also sell crops for various reasons.

Various household characteristics and resource level endowment variables were found to have a significant effect on any households' decision to participate in the market. From among the household characteristics education attainment of the head of the household and family size were found to be significant in explaining market participation. The number of years of education of the head was found to be positively and significantly associated with the households' decision to participate in the market implying that educated households are more likely to participate in the market. As education increases by a unit, the probability of participation increases by about 2 percents. On the other hand family size was found to have a negative effect on market participation indicating that households with more family members are more likely to focus on food production to meet family food requirements. This is typical of economies where food markets are not well developed and, hence, households choose to first be food-self sufficient, before they produce for the market. From among the household resource endowments, the size of the operated land area has a positive and highly significant effect on the decision to participate in markets. A unit increase in area of operated holding leads to a 23% increase in the likelihood of participation. This result indicates that land holding size could be an important constraint to market participation even if irrigation access is ensured. Other resources such as labor (both female and male), oxen holding were found to be insignificant in explaining market participation perhaps indicating that these resources may not pose as significant constrains to participation *per se* in rural Ethiopia.

Distance to the market where produce is sold and type of means of transport had also significant effect on market participation. Market participation *per se* increased with distance to market where the products are sold. Although this sounds counter intuitive, this may be related to the fact that households who manage to transport to distant but larger markets are likely to benefit from the high price differentials manifest in fragmented markets. As agricultural markets in Ethiopia, as in most rural economies of the developing world, are not well developed, price effects are not easily transferred across locations. This implies that farmers need to select markets where their products can fetch good prices and the incentive to take a product further afield requires market knowledge as a precondition. Below we test this theory by determining if the value of output increases with distance to the market where the output is sold. Conversely, this may also suggest that irrigation schemes are not positioned close to markets. Participation also seems to increase with the use of donkeys as a means of transport in reference to use of human power. Those who used donkeys are 6 % more likely to participate in the market compared to those who used human power.

Access to input markets were also found to have significant effect on market participation of households. The households who reported to have faced input access problems were found to be the most likely ones to participate. This may reflect a reverse causality in that those who participated in the market ones most likely to face input access problems. Households producing for the market were about 6 percent more likely to face input access problems such as untimely availability of seeds, seedlings, and chemicals. This result was reflected during the rapid appraisal study which indicated that farmers had a hard time getting vegetable seeds and pesticides. This may call for reorientation of the input supply system to meet the requirements of the irrigation system.

Community (site) level effects were also found to be significant in explaining variations in the probability of participation. These effects could be related to village level covariates (such as location of the site, agro-ecology and crop suitability factors, irrigation experience, weather conditions and other external effects) which may influence market conditions. So taking Debre Zeit (Wedecha Belbela systems) as a reference, we found that households in Endris (marginal effect -0.20), Golgol Raya, Haiba (marginal effect -0.17) and Hare (marginal effect -0.11) are less likely to participate in the market while households in Golgotha are more likely to participate (marginal effect 0.28). Both the Wedecha and Golgotha irrigation schemes are located close to the major markets, Addis Ababa and Nazareth, on a well established marketing route for vegetables (see Fig. 1). However, from the results we have here it is difficult to attribute to one factor, e.g. distance to market, as being the principal factor influencing market participation. It is likely that the dummy variables confound various factors. Hence, we can only say that there are site level covariates influencing market participation.

Finally, although less expected plot level characteristics such as slope of the land and soil quality were found to be significant in explaining market participation. Accordingly, households operating land with medium (marginal effect 0.07) and steep slope (marginal effect 0.08) were found to be more likely to participate than those operating flat lands. One possible explanation could be that the slope of land may influence crop choice, so irrigated annuals and/or perennials are grown on such lands. Households operating medium (marginal effect 0.06) and good quality lands (marginal effect 0.08), i.e. with more productive soils, were found to be more likely to participate. The effect of these plot characteristics on market participation could be through their influence on crop choice and productivity. Below we will explore further if the same set of factors also affect the level of participation, the volume of sale made by households.

Explaining volume decisions

The most important determinants of volume decisions (measured by the value of sale) are reported below. But for the truncated model we did not report the calculated marginal effects as the purpose of our analysis is not confined to the sub population. Hence we report the coefficients as indicated in Table 3.

Households operating both modern and irrigation schemes supply more to the market than farmers working in the rainfed system. In line with the results from the binary choice model, farmers growing irrigated annuals and irrigated perennials supply more to the market in comparison to farmers that grow rainfed annuals because, as indicated above, the rainfed annual crops tend to be mainly food crops. The results here, hence, strongly indicate that irrigation significantly contributes not only to market participation but also to increased supply of produce to the market. This could be the result of increased cropping intensity and diversification into more cash crops, mainly horticultural crops. Households that reported to have faced shortages in rainfall supplied significantly lower volumes of produce, and hence, earned less from the market. This indicates that shortfalls in rain, may pose a serious constraint to market development.

In line with the results in the probability model, education and family size were also found to be significant in explaining the amount of sale. The education level of the head of household was found to be positively and significantly associated with high value of sale, implying that educated households are more likely to be market oriented. This may be because they are well positioned to choose high return crops and introduce innovative technologies. In contrast to the negative influence of family size on explaining market participation, here family size was found to have a significant and positive effect on volume of sale. This suggests that once households have decided to grow for the market, the family size does not negatively influence volume of sale.

Furthermore, households' resource endowments, specifically the size of the operated land area and oxen holding, have positive and highly significant effects on the volume of sale. Farmers usually allocate part of their land to grow high value crops after they have allocated sufficient land to grow food crops. Oxen holding increases the chance of increasing operating land holding through informal land transaction such as sharecropping and fixed renting. Therefore, households endowed with more land and oxen holding are more likely to sell more to the market than households with smaller land holding and no oxen.

Distance to market where the output was sold has significant effect on the volume of sale strengthening our conjecture that households who are able to participate transport their produce further but to more attractive markets. In line with this, the volume of sale was found to be significantly influenced by the choice of transport. In this case, households who rent vehicles have higher volumes of sale compared to those using human power. Moreover, unlike the result in the Probit model, use of donkeys as a means of transport has a negative effect on the volume of sale indicating perhaps that higher volume of sale requires other means of transport than pack animals or human power (e.g. *ISUZUs,* the famous small trucks which can operate deep in rural areas.)

In contrast to the participation decision, reported market related problems were found to have no significant effect on the amount of goods sold. This implies that market and marketing related problems may deter households from participation but once they have made the decision to participate they supply what they can. However, those who reported input access problem were also found to be supplying more produce to the market. This may reflect, as argued earlier, a reverse causality in that those who participated in the market are more likely to face inputs access problems. It could also be related to the location of the irrigation schemes in relation to input supply centers and the orientation of the input supply system of the country. Access to off-farm income was found to have a negative effect on the value of sale perhaps indicating that those who have access to off-farm income do not consider it worth the effort of growing for markets.

The same community (site) level effects were also found to be significant in explaining variations in the volume of sale. So taking Debre Zeit (Wedecha Belbela systems) as a reference, we found that households in Haiba, Hare and Tikurit supply low volumes of output while households in Golgotha and Zengeny supply more output (i.e., more valuable), Disentangling which specific site level variables are important in explaining market participation is something that needs further inquiry.

Finally, the same plot level characteristics such as slope of the land and soil quality were also found to be significant variables in explaining volume decisions. Accordingly, households operating lands with steep slopes were found to supply more than those operating flat lands. One possible explanation is that the slope of land influences crop choice, so irrigated seasonal or perennials are grown on such lands. Households operating medium and good quality lands, i.e. with more productive soils, were found to be supplying higher volumes of output, underlining that production enhancing factors have also market participation enhancing effects.

7. Conclusions and recommendations

The objective of this study was to examine the extent and nature of market oriented production under irrigated systems in contrast to rainfed systems in Ethiopia. The study t identified determinants of market-oriented production, including the role of irrigation in the process, in order to understand the main constraints and opportunities for market oriented development. Based on the study findings we have drawn policy implications relating to institutional arrangements and the creation of adequate infrastructure, which could benefit a large mass of smallholder producers.

One of the most important findings of this study is that irrigation contributes to a significant increase in market participation, volume of marketed produce and, hence, income. Farmers working under irrigation, traditional or modern, supply more marketed produce and earn more income than farmers operating under the rainfed system. The bulk of the contribution comes from irrigated annual and perennial crops, which indicates that farmers are shifting their cropping mix as a result of access to irrigation.

While irrigation enhances marketed oriented production, there are a series of factors that pose serious constraints to the process. Households having on average relatively larger plots are found to be more market oriented. This implies that those who have smaller plots on average have access problems and tend to focus on food production. This is especially true with households that have bigger family sizes. This calls for policy intervention in the area of easing land transactions and assisting household's to access important productivity increasing assets such as oxen.

The study also shows while the impact of market oriented production on income poverty is direct and immediate; households are faced with a possible trade-off between growing for the market and growing for home consumption. Growing for the market may not ensure household food security in a situation where food markets function poorly. Under this situation of market failure households prefer first to be food self-sufficient and only then become involved in market production. Another entry point for policy could, therefore, be to create the necessary infrastructure and policy environment to improve the performance of food markets. Such measures could induce farmers to be more market oriented.

Market problems and input access problems seem to be pervasive in Ethiopia, and more so in areas where irrigation-induced market oriented production is high. The study indicated that farmers face diverse market problem such as low demand and low selling price, distance to market, road and transport problem, same product and peak time supply, unstable prices, lack of services (information, service cooperatives, etc) and high tax. Similarly farmers reported that they faced diverse input access problems the most important of which were high input prices, lack of credit access and lack of availability of inputs in all seasons and sites. Transport problems seem to pose a serious problem as well. Households who are able to rent vehicles supply more to the market. Those unable to transport their produce are unable to reap the benefits of better markets. The implication of this evidence is that irrigation development and market infrastructure development are poorly linked. Hence, there is a need to link irrigation development with road infrastructure development and improvements in other marketing services. There is also a need for reorientation of the input supply system to fit the requirements of the irrigation system.

The study also found that education has market promoting effects in terms of increasing the probability of participation and volume of sale. Adequate support to education can, thus, help in the long-term transform traditional subsistence agriculture into more market oriented and modern agriculture. Finally there are unobservable site specific effects that influence market participation and volume decisions. Identification of the most important village level effects requires further inquiry.

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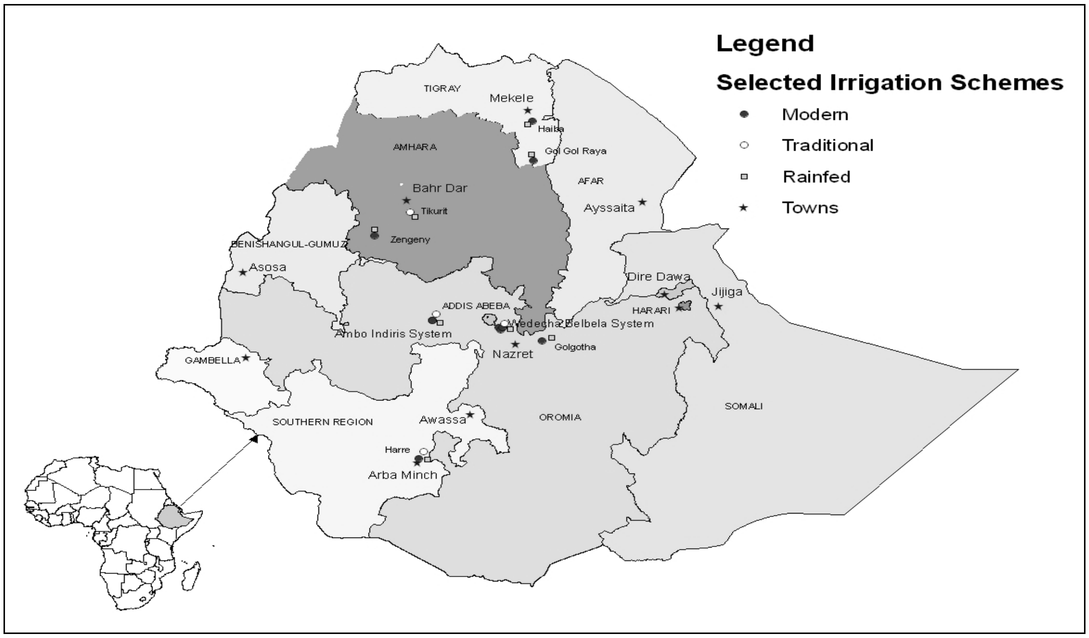


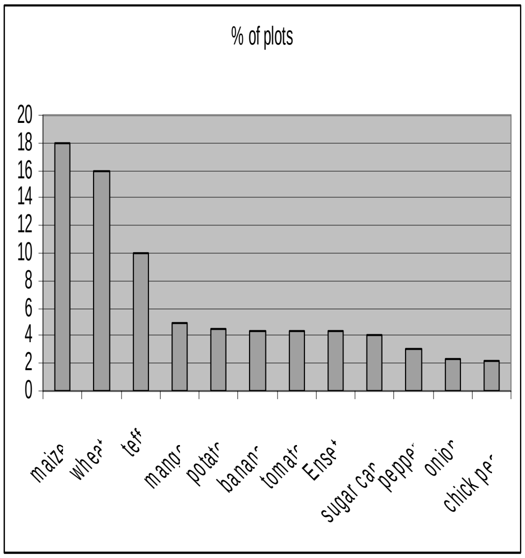
Fig. 1: Sample sites

Table 1A: Study sites

Region	Scheme name	Typology	Closer town	Irrigation type	Sample size
Oromiya	Endris System	Small	Ambo	Modern	55
				Traditional	55
				Dryland	55
Oromiya	Wedecha-Belbella System	Medium	Debre Zeit	Modern	55
				Traditional	53
				Dryland	57
Oromiya	Golgotha	Medium	Nazareth	Modern	55
				Dryland	55
Amhara	Zengeny	Medium	Gimjabet	Modern	55
				Dryland	53
Amhara	Tikurit	Small	Bahir Dar	Traditional	83
				Dryland	47
Tigray	Haiba	Medium	Samre/ Mekelle	Modern	54
				Dryland	54
Tigray	Golgol Raya	Micro-irrigation	Alamata	Modern	53
				Dryland	46
SNNPR	Hare	Medium	Arba Minch	Modern	55
				Traditional	54
				Dryland	55

Table 1: Summary statistics

Variable name	Mean (Standard deviation in parenthesis)		
	Overall	**Rainfed**	**Irrigated**
Age of household head, years (n= 4915)	46 (15)	45.0 (15.09)	46.29 (15.05)
Years of education of household head (n= 4900)	2.0 (3.1)	2.05 (3.06)	1.98 (3.07)
Family size, (n= 4948)	5.7 (2.4)	5.54 (2.35)	5.87 (2.48)
No. of Female adults (n= 4948)	1.4 (0.85)	1.34 (0.74)	1.39 (0.89)
No. of male adults (n= 4948)	1.5 (1.0)	1.45 (0.94)	1.58 (1.07)
Amount of income from non-farm, Birr (n= 4948)	537 (3067)	705.54 (4125.69)	459.60 (2422.15)
Remittances, Birr (n= 4948)	243 (1973)	27.38 (646.05)	342.89 (2339.14)
Number of oxen (n= 4923)	1.4 (1.2)	1.56 (1.07)	1.32 (1.21)
Number of donkeys (n= 4923)	0.5 (0.9)	0.65 (0.94)	0.50 (0.86)
Number of contacts of household with extension agent (n= 4948)	1.6 (3.2)	2.36 (3.97)	1.25 (2.73)
Number of contacts of extension agent with households (n= 4948)	2.5 (5.3)	3.79 (6.38)	1.89 (4.59)
Land area, ha (n= 4786)	1.4 (1.2)	1.34 (1.39)	1.42 (1.19)
Distance to market where output was sold, km (n= 4947)	7.6 (6.9)	8.36 (7.49)	7.18 (6.67)
Gross value of Sales, birr (n= 4948)	591 (2169)	476.10 (1076.1)	645.14 (518.65)
Market problem Dummy (yes =1) (n= 4953)	40.7	37.7	42.1
Input access problem Dummy (yes =1) (n= 4953)	46.6	53.3	43.4
Rain/water shortage Dummy (yes =1) (n= 4953)		39.1	26.8



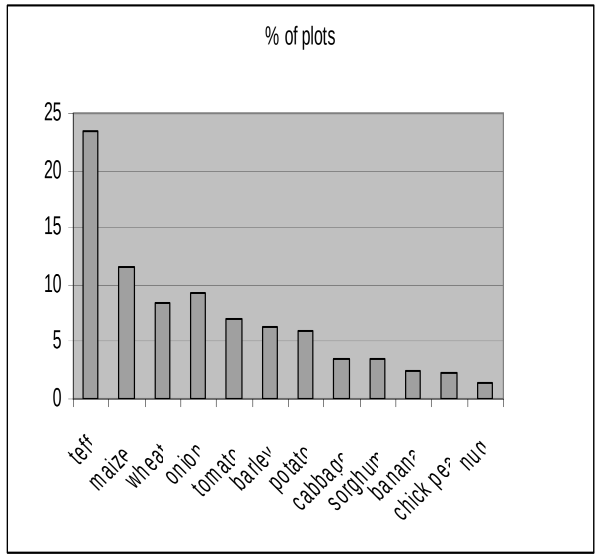


Fig. 3a: Dominant crops under traditional irrigation system (n= 1240) Fig. 3b: Dominant crops under modern irrigation system (n= 2092)

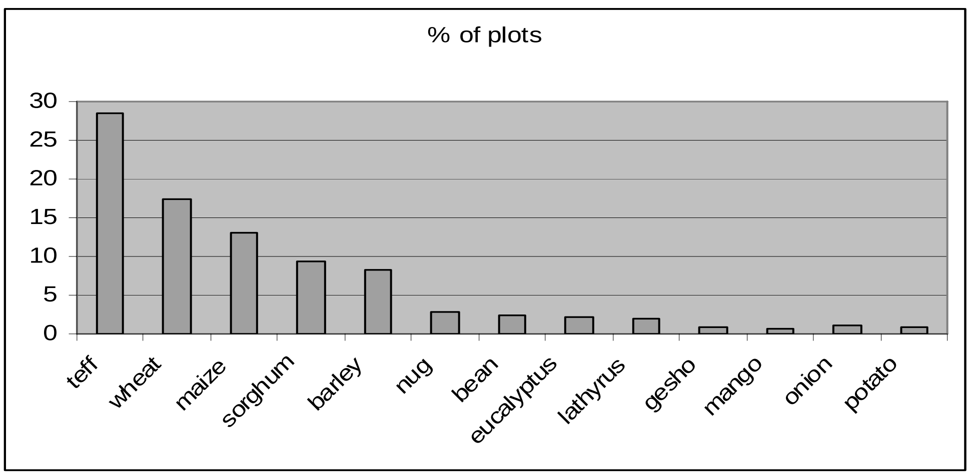


Fig. 3c: Dominant crops under modern rainfed system (n= 1533)

Table 2: Determinants of the probability of participation (standard errors adjusted for cluster effects)

Dependent variable : Whether the household sells a product to the market or not (0/1)

Variable description	**Coefficient**	**Standard errors**
Female headed household (dummy variable male =0)	0.022	0.078
Age of the household head	0.001	0.002
Education level of head	0.017	.010*
family size	-0.026	0.016*
Female adult	-0.050	0.037
Male adult	0.038	0.032
Off-farm income	1.02e-06	7.69e-06
Remittance income	0.0001	0.00003
Oxen holding	-0.013	0.025
Distance to the market where output is sold (in km)	0.016	0.005***
Means of transport (donkey) (reference= human)	0.151	0.090*
Means of transport (horse) (reference= human)	0.228	0.171
Means of transport (mule) (reference= human)	0.115	0.199
Means of transport (vehicle) (reference= human)	0.059	0.118
Household's contact with extension agent	0.003	0.011
Land area (in ha)	0.062	0.023***
Rain shortage (dummy 1= yes)	0.026	0.074
Irrigation water shortage (dummy 1= yes)	-0.021	0.085
traditional scheme (dummy reference =rainfed)	-0.050	0.084
Modern scheme (dummy reference =rainfed)	-0.278	0.075***
Input access problem (dummy 1= yes)	0.171	0.065***
Marketing problem (dummy 1= yes)	0.042	0.059
Dry land perennial (reference dry land seasonal)	0.109	0.120
Irrigated seasonal (reference dry land seasonal)	0.582	0.070***
Irrigated perennial (reference dry land seasonal)	0.996	0.158***
Endris irrigation scheme (reference= Debere Zeit)	-0.506	0.095***
Golgol Raya irrigation scheme (reference= Debere Zeit)	-0.448	0.136***
Golgota irrigation scheme (reference= Debere Zeit)	0.921	0.192***
Haiba irrigation scheme (reference= Debere Zeit)	-0.441	0.112***
Hare irrigation scheme (reference= Debere Zeit)	-0.281	0.152*
Tikurit irrigation scheme (reference= Debere Zeit)	-0.020	0.128 *
Zenegeny irrigation scheme (reference= Debere Zeit)	-0.038	0.184
Medium Slope (dummy reference= flat) |	0.190	0.0622***
Steep slope (dummy reference= flat)	0.215	0.102**
Medium fertility (dummy reference= poor)	0.165	0.077**
good fertility (dummy reference= poor) |	0.228	0.078***
_cons |	-0.194	0.176
	Number of obs = 3754	
	Wald chi2(36) = 300.17	
	Prob > chi2 = 0.0000	
	Log pseudo-likelihood = -2276.33	
	Pseudo R2 = 0.0969	

*, **, *** significant at 10, 5 and 1 percent level of significance.

Table 3: Level of participation (Value of sale)
Dependent variable: Value of sale (in Birr)

Variable description	Coefficient	Standard errors
Female headed household (dummy variable male =0)	-3679.5	(473.846)
Age of the household head	37.04	(79.00)
Education level of head	2001.188	(486.2001)***
family size	2831.62	(689.7989)***
Female adult	-4731.888	(1960.598)**
Male adult	-2636.161	(1702.532)
Off-farm income	-1.124729	(.3445668)***
Remittance income	-.5153223	(.7632368)
Oxen holding	-2780.298	(1304.623)**
Distance to market	160.1715	(107.3297)
Means of transport (donkey) (reference= human)	-23025.99	6164.656***
Means of transport (horse) (reference= human)	-2342.406	6569.129
Means of transport (mule) (reference= human)	7528.12	8567.152
Means of transport (vehicle) (reference= human)	19583.99	5675.037***
Household's contact with extension agent	-1264.534	(688.0457)*
Land area	6722.116	(728.9046)***
Rain shortage (dummy 1= yes)	-7626.328	(4227.934)*
Irrigation water shortage (dummy 1= yes)	-3272.534	(4214.353)
traditional scheme (dummy reference =rainfed)	20030.93	(5983.328)***
Modern scheme (dummy reference =rain fed)	17768.58	(5768.995)***
Input access problem (dummy 1= yes)	13467.66	(3457.655)***
Marketing problem	-4479.403	(3194.229)
Dry land perennial (reference dry land seasonal)	-11678.92	(10525.31)
irrigated seasonal (reference dry land seasonal)	17526.23	(4057.36)***
irrigated perennial (reference dry land seasonal)	24931.89	(7034.23)***
Endris irrigation scheme (reference= deberezeit)	-5600.18	(5543.335)
Golgol Raya irrigation scheme (reference= deberezeit)	-9191.548	(6577.918)
Golgota irrigation (reference= deberezeit)	11853.08	(6385.049) *
Haiba irrigation scheme (reference= deberezeit)	-197758	(24293.52)***
Hare irrigation scheme (reference= deberezeit)	-47682.18	(11743.92)***
Tikurit irrigation scheme (reference= deberezeit)	-28460.84	(7124.578)***
Zenegeny irrigation scheme (reference= deberezeit)	39782.97	(9889.322)***
Medium Slope (dummy reference= flat) |	2169.702)	(3414.557
Steep slope (dummy reference= flat)	26719.8	(6862.004)***
Medium fertility (dummy reference= poor)	11340.24	(6171.729)*
good fertility (dummy reference= poor) |	12887.67	(6265.083)**
_cons	-106551.5	(13938.39)***
sigma _cons |	8990.92	(327.1781)***

Number of obs = 4610
(2086 left-censored observations at gvout<=0 2524 uncensored observations)
LR chi2(31) = 294.28
Prob > chi2 = 0.0000
Log likelihood = -32017.082
Pseudo R2 = 0.0046

*, **, *** significant at 10, 5 and 1 percent level of significance.