IMPACT OF PERENNIAL CASH CROPPING ON FOOD CROP PRODUCTION AND PRODUCTIVITY[1]

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Abstract

The argument for promoting cash crops in developing countries has generally been based on their contribution to small farmer incomes and their impact on other household activities such as household crop production through interlinked markets. While these arguments are supported by some empirical results, there is little information on the impacts cash cropping can have on these household activities in the absence of interlinked markets. In addition, the impacts of cash cropping may depend on the types of cash crops studied, time and place. Perennial cash crops (PCC) can relax household liquidity constraints for purchasing productive inputs, maintain soil fertility and moisture and save inputs such as seeds and draft power, which can be used for food crop production even in the absence of arrangements for interlinked markets. In this study we build on previous studies by developing key hypotheses by which PCC (Chat, coffee and sugarcane) affect food crop production and the implication for household food security. In addition, we look at the link between perennial food crop, enset (Ensette venttricosum), and other annual food crops. We empirically measure these effects using survey data on 150 rural households collected in 1999 in Ethiopia. Our results indicate that-after controlling for conventional inputs, household wealth variables, education and other variables, higher chat (Catta edulis) production is associated with reduced value of food crop yields and total value of food crop production. On the other hand, higher sugarcane production is correlated with higher value of total food crop production and productivity. Moreover, more intensive coffee production is associated with more intensive enset production. However, production of coffee and enset do not have significant effects on food crop production and productivity. These results suggest that while farmers can gain from sugarcane production through cash income and its impact on food crops, coffee and enset can be produced to bring additional income to the household at no significant cost to food crops. The real impact of chat on the welfare of households should be viewed in terms of its opportunity costs and its contribution to household income.

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1. Introduction

The role of cash cropping in reducing rural poverty and improving food security is one of the most debated among development scholars with often different and opposing views. Generally, those who favour cash crops argue that cash crops can potentially contribute to alleviating poverty and food insecurity and to growth. On the other hand, others who deny these benefits and say that cash crops exacerbate food security problems oppose cash cropping.

The contribution of cash crops at the household level is one of the elements constituting the debate about cash cropping. These analyses at the household level used different definitions of the term "cash crops" and cut across arguments, crops, countries and time periods. The case for the contribution of cash crops to improve household food security at the household level is often based on the income cash crops bring to the households through specializing in producing cash crops as dictated by comparative advantage and through synergies that may exist between cash cropping and subsistence food cropping activities with arrangements for interlinked markets (e.g., Govereh and Jayne, 2003; Goetz, 1993). The concept of comparative advantage is based on the argument that households with resources to produce cash crops most efficiently can specialize in the production of cash crops and buy food crops, which raises their overall income. On the other hand, the concept of interlinked markets is based on the argument that cash crops can attract potential buyers who provide inputs to cash crop producers on credit basis to be used to increase production and productivities of both cash crops and food crops (e.g., Govereh and Jayne, 2003; Govereh, et al., 1999).

While the importance of comparative advantage is well understood in places where food markets work well, the problem of imperfect markets does not allow farmers in many developing countries to benefit from specializing in cash crop production. Moreover, arguments based on interlinked markets give little attention to the benefits that cash crops may deliver to households in the absence of market interlinkage. Research results that focus on interlinked markets neglect the areas, which have little or no arrangements for market interlinkage and cannot be generalized to these areas. For example, Govereh et al. (1999) and Maxwell and Fernando (1989) suggest that little chance may exist for synergies between food and cash crops in the absence of interlinked market arrangements.

However, evidences suggest that even in the absence of interlinked markets, households could benefit from producing both food crops and cash crops on the same farm. For example, a study by Goetz (1992) found that economies of scope exist on farms producing both cash and food crops. Similarly Coelli and Fleming (2004) show that there are gains in technical efficiency and diversification economies from producing both cash crops (coffee and food crops produced for sale) and subsistence crops. However, although there are indications that farmers could raise their incomes by producing both cash and food crops, empirical evidences on synergies or trade-offs between the two crops are scant to address the concerns that cash cropping can exacerbate food insecurity.

In addition, research results regarding the contribution of cash crops at the household level vary greatly with respect to the type of cash crops studied, agro-ecological and socio-economic conditions, time periods and other factors specific to a given country or region, making it difficult to generalize these findings to all countries and regions (e.g., Maxwell and Fernando (1989) This calls for country level studies on different types of cash crops.

This paper deals with the impact of cash cropping (defined as crops grown mainly for sale) on subsistence food cropping activities in southern Ethiopia characterized by an integrated set of cash cropping and subsistence food cropping activities. The study differs from previous studies in three main aspects. First, all cash crops studied are perennials. Second, it deals with synergies between cash cropping and subsistence food cropping in a region where there are no arrangement for interlinked markets and any program targeting the area. Third, the study area is one of the most densely populated in the world, as opposed to other studies conducted in land abundant tropical agriculture (e.g., Govereh, 1993).

As indicated by Maxwell and Fernando (1989), the impacts of cash cropping on household income and food security may differ from crop to crop. Perennial cash crops differ from annual cash crops in input requirement, impact on environment and in the extent of their ability to allow for intercropping with other crops. Given the scarcity of agricultural land owing to high population density, these perennial cash crops enable farmers to get higher returns from given resources both through their higher and relatively stable prices and through intercropping. The income from these cash crops can relax households' liquidity constraints to buy productive inputs in turn to increase production and productivity of food grains. On the other hand, cash crops and food crops may compete for some resources to some extent and there may also be negative technical relationships between intercrops. If these competitions and negative relationships outweigh the perceived synergies, cash cropping may reduce the outputs of subsistence food crops. If this happens to be the case, it should alert policy makers to take appropriate measures to ensure food security.

In addition to cash crops, the southern part of Ethiopia is characterized by production of a perennial food crop known as enset (ensette ventricosum), which is not common in other parts of the country. This crop is believed to be a response by farmers to the ever-shrinking agricultural land in this region because of its higher yield from a given area of land (e.g., Brandt, et al., 1997; Rahmato, 1996). Like PCC, enset saves input such as seeds and draft power, protects soil erosion, and conserves moisture thereby contributing positively to environmental sustainability. Enset can also be intercropped with other perennial crops (including PCC) and annual food crops thus increasing returns from resources. However, although it gives higher yield per unit of land, the food that is produced from enset is believed to have low protein content and additional type of food is often required to supplement the low protein content of enset food eaten by humans (e.g., Brandt et al., 1997). This raises the question about the carrying capacity of enset-based farming system since the concept of food security includes the nutritional adequacy of the available food. The important question that follows is whether the higher yield of enset can compensate for its low protein content if enset displaces annual food crops that have higher protein content The importance of this crop compared to other annual food crops in the area has its own implications regarding agricultural research, agricultural practices and technologies and extension services to be carried out in the area and the carrying capacity of the system in terms of both the amount and nutritional adequacy of food to ensure food security.

The objectives of this paper are two-fold. First, we study the impact of PCC and enset on annual food crop production and productivity. Second, we study the impacts of PCC and annual food crops on enset intensification. We use household level cross sectional data collected in 1998/1999. The study is intended to contribute to the cash crop-food crop dilemma, to assist in developing policy to help smallholder farmers achieve food security and better income in a region characterized by high population density, land degradation and market imperfections.

In section two, we present the conceptual framework of the study; section three presents data and description of the study area; in section four methods of data analysis are presented; results and discussions are provided in section five; and section six concludes the paper.

2. Conceptual framework

2.1 Synergies between cash crops, enset and food crops

Existing studies on synergies between cash crops and food crops are based on the concept of interlinked markets. Consequently, these studies are confined to areas where there are arrangements for interlinked markets. The perceptions of interlinked markets are that cash crops attract input supply agents, which provide agricultural inputs on credit basis to enhance the productivity of both food and cash crops in return for the purchase of the cash crops (e.g., Timmer, 1997).

The concept of interlinked market, while supported by empirical evidences (e.g., Govereh and Jayne, 2003), cannot be applied to areas where there are no interlinked markets. Although PCC compete with food crops for some resources, they make cash income available, which can be used to buy inputs to increase food crop productivity in situations where farmers are credit constrained (Strasberg, et al., 1999; Kelly et al., 1996). Unlike food crops, cash crops face a relatively higher price because some of them are exported and some are needed elsewhere domestically. In addition to their impact on cash income, cash crops may increase the credit worthiness of farmers from moneylenders through interlocked markets since lenders think default is less probable. Reducing soil erosion is another contribution of PCC. For example, Haileselassie et al. (2005) and Brandt (1997) show that in Ethiopia soil nutrient stocks did not decrease in areas under PCC. This can enhance sustainable productivity of crops intercropped with perennials. The ability to conserve soil moisture is another important contribution of PCC, especially in water stress areas of Ethiopia. There are also empirical findings relating cash cropping to income diversification strategy (e.g. Abdulahi and CroleRees, 2001)

Moreover, PCC save inputs such as draft power and seeds. These inputs can be used to intensify food crop production. They can also allow intercropping with other crops easing the problems of population pressure. Studies also indicate that households can reduce total costs by producing cash crops and food crops on the same farm. For example, Goetz (1992) found that producing both cash and food crops on the same farm results in 22.3% cost saving relative to producing the same quantities in two separate (specialized) farms.

Enset is one of the staple food crops in the southern parts of the country. Enset ensures food security in this part of the country (e.g., Brandt, et al., 1997). Like PCC, enset can save inputs, draft power and conserve soil and moisture thereby protecting the environment. Enset can also be intercropped with other crops, in which case younger enset plants are intercropped with annual food crops and older enset plants are intercropped with perennials such as coffee and citrus. Brandt et al (1997) note that although there are no research results on the impact of intercropping on the yield and growth of enset and other crops, farmers .know that it reduces the growth of enset. Therefore, to the extent that annual food crops could be intercropped with enset, these crops could benefit from the positive impacts enset has on the soil. On the other hand, if intercropping reduces growth of enset, the impact of intercropping depends on the gains from annual crops and the losses of enset yields from intercropping.

Brief descriptions of the three PCC and enset follow.

Coffee:
Coffee is one of the main PCC in Ethiopia and also in the study area. It is produced mainly for export although some of the production is consumed at home. It takes about three years for a coffee tree to bear its fruit. Coffee can be intercropped with other crops.

Chat:
Chat is a large perennial shrub, which can grow to tree size (e.g., Klingele, 1998). It is mainly grown in Ethiopia and Kenya and the main markets are in Ethiopia, Kenya, Somalia, Yemen, etc. Harvesting of chat takes place at least two years after planting. Chat is an important cash crop in the area. The leaves of chat are chewed for their stimulating effect and to dispel feelings of hunger and fatigue (e.g., Parker, 1995). This crop has been the most important cash crop in most parts of Ethiopia because of its high prices and the fact that it is harvested year-round. In addition to being a source of cash income, it is consumed by family members to abate hunger. Chat can be intercropped with coffee. However, farmers prefer to grow chat as a monocrop.

Sugarcane:
Sugarcane typically is a 12 to 18 month crop although it can be left in the ground for a further growing period if favourable conditions exist. In this case it becomes a 'ratoon' crop (when new shoots grow from the sugarcane root after cropping) (Mushtag and Dawson, 2002). Sugarcane has been an increasingly important cash crop in the area. Traders come from as far as the capital city to buy sugarcane. The cane from these smallholders is chewed for its juice, unlike cane from the big plantations, which is converted to white sugar. Sugarcane can be intercropped with food crops such as potato. Imam et al (1990) indicated that intercropping potato with sugarcane exploits the temporal complementarity between crops.

Enset:
Enset is related to and resembles the banana plant and is produced primarily for the large quantity of carbohydrate-rich food found in a false stem (pseudostem) and an underground bulb. It takes 6-7 years to be ready for harvesting although earlier harvesting may take place. More than 20 percent of Ethiopia's population concentrated in the highlands of southern Ethiopia depend up on enset for food, fibre, animal forage, construction materials and medicine (Brandt et al, 1997). Enset resists

water stress, is less prone to other risks and yields more per unit area than other food crops in the area. Enset can also be intercropped with other food and cash crops.

2.2 Theoretical model

Farmers in developing countries operate under many forms of market failures, including markets for food crops, credit and land (Sadoulet and de Janvry, 1995; Singh et al, 1986; Heltberg, 1998; Taylor and Adelman, 2003; de Janvry et al, 1991). Market failures introduce binding constraints in production where households cannot make separate decisions on consumption and production, rendering the household model nonseparable. We start with a household model, which draws on the model developed in Singh et al (1986).

Assume a given household produces food crops (Q_o), enset (Q_e) and PCC (Q_c) using labor (L_o, L_e, L_c) and other inputs (Y_j, j=o, e, c) and consumes food crop commodity (x_o), enset (x_e) a purchased commodity (x_m), a PCC commodity (x_c) and leisure time (x_l); and let z^h represent a vector of household characteristics which parameterizes the utility function of the household. Then the problem of the household is to maximize the household's utility function

$$\underset{(x_0, x_e, x_c, x_m, x_l, L_0, L_e, L_c, y_j)}{\text{Max}} u\left(x_o, x_e, x_c, x_m, x_l, z^h\right) \quad \textbf{(1)}$$

Subject to:

Budget constraint: $p_0 x_0 + p_e x_e + p_c x_c + p_l x_l + p_m x_m \leq p_0 Q_0 +$

$$p_c Q_c + E + p_l T - p_l L - \sum_{j=0}^{e} w\, Y_j - rB \quad \textbf{(2)}$$

Where p_o, p_e, p_c, p_m and r are prices of produced food crops, enset, PCC and purchased commodities and interest rate on loan B, respectively; p_l is wage rate and w is a vector of prices of other variable inputs; L is total labor demand by the household, both family and hired; y is a vector of variable agricultural inputs other than labor; E is exogenous income We assume households can sell parts or all of food crop, PCC and enset

In addition, farmers face credit constraint to purchase agricultural inputs at the time of planting. There is no formal credit facility in the area except for fertilizer credit given in kind. Therefore, farmers have to cover the costs of other purchased inputs and fertilizer beyond those provided by the government agencies. Framers have to use their own savings, income from sale of cash crops and income from hired out labor. Farmers may also get informal credit from village money lenders based on their credit worthiness, which again depends on their stock of cash crops. This informal borrowing is given by B(Q_c) $(\frac{\partial B}{\partial Q_c} > 0)$. The cash from the sale of PCC is predetermined (produced during the previous years) at the time of planting food crops.

Credit constraint: $\sum_{i=1}^{N} w_i y_i + p_l(L^{hi} - L^{ho}) \leq p_c Q_c + B(Q_c) + K + A + S$ **(3)**

Where L^{hi} and L^{ho} are labor days hired in and out, respectively; L^{hi} =L-F where F is family labor and L=$L_0 + L_c + L_e$; K is the amount of fertilizer credit. We assume that labor market exists at the same wage rate for hiring in and out[3].

Food crop production function constraint: $Q_o = f_o(A_o, L_o, Y_o, Z^q)$ **(4)**

Enset production constraint: $Q_e = f_e(A_e, L_e, Y_e, Z^q)$ **(5)**

Cash crop production constraint: $Q_c = f_c(A_c, L_c, Y_c, Z^q)$ **(6)**

where $A_c + A_o + A_e = \overline{A}$; $\overline{A}$ is total operated land holding; A_c, A_e and A_o are sizes (shares) of total operated holding planted to PCC, enset and food crops, respectively. z^q is a vector of farm characteristics; and $f(.)$ is a strictly concave production function. We assume that land is fixed due to imperfections in land rental markets.

Furthermore, the household utility function, u (equation (1)), is assumed to be strictly quasiconcave and twice continuously differentiable[4].

The Lagrangian function for the above maximization problem can be written as

[3] This seems a realistic assumption for the study area since land holdings are generally small and some of the households have reported they have hired in or out labour.

[4] This assumption is made for convenience (for the second condition to be satisfied) and is consistent with the classical consumer theory that the marginal utility of a given commodity increases at decreasing rate.

$$L = U\ (x_o, x_e, x_c, x_m, x_l, z^h) + \lambda\,(p_o Q_o + p_e Q_e + p_c Q_c + p_l T + E - \sum_{j=o}^{e} w\,Y_j - p_l L$$

$$- p_o x_o - p_e x_e - p_c x_c - p_m x_m - p_l x_l - rB(Q_c)) + \mu\,(p_c Q_c + B(Q_c) + A + K + S - \sum_{j=o}^{e} w\,Y_j - p_l(L^{ho} - L^{hi}) \quad \textbf{(7)}$$

Denoting the consumer goods by c_i (i=o, e, c, l, m) the interior first order conditions of interest are[5]:

$$\frac{\partial L}{\partial c_i} = \frac{\partial U}{\partial c_i} - \lambda p_i = 0 \quad \textbf{(8)}$$

$$\frac{\partial L}{\partial L_0} = \lambda p_o \frac{\partial Q_o}{\partial L_o} - p_l \mu - \lambda p_l = 0 \quad \textbf{(9)}$$

$$\frac{\partial L}{\partial L_e} = \lambda p_c \frac{\partial Q_c}{\partial L_c} - p_l \mu - \lambda p_l = 0 \quad \textbf{(10)}$$

$$\frac{\partial L}{\partial L_c} = \lambda p_c \frac{\partial Q_c}{\partial L_c} + -\lambda r \frac{\partial B}{\partial L_c} + p_c \mu \frac{\partial Q_c}{\partial L_c} - p_l \mu + \mu \frac{\partial B}{\partial L_c}. - \lambda p_l = 0 \quad \textbf{(11)}$$

$$\frac{\partial L}{\partial Y_o} = \lambda p_o \frac{\partial Q_o}{\partial Y_o} - \lambda w - \mu w = 0 \quad \textbf{(12)}$$

$$\frac{\partial L}{\partial Y_e} = \lambda p_e \frac{\partial Q_e}{\partial Y_e} - \lambda w - \mu w = 0 \quad \textbf{(13)}$$

$$\frac{\partial L}{\partial Y_c} = \lambda p_c \frac{\partial Q_c}{\partial Y_c} - \lambda w - \mu w = 0 \quad \textbf{(14)}$$

Equations (9) and (12) indicate that $P_o \frac{\partial Q_o}{\partial L_o} = P_l(\frac{\mu}{\lambda} + 1)$ and $P_o \frac{\partial Q_o}{\partial Y_o} = w(\frac{\mu}{\lambda} + 1)$ suggesting that if the credit constraint is binding (i.e., μ >0), farmers cannot use the optimal level of inputs that they would use in the absence of credit constraint. Furthermore, the higher the value of μ, the smaller is the amount of labor and other inputs used for food crop and enset production, leading to lower productivity and production. The size of μ is determined by the stock of PCC the household owns

[5] For households, which do not grow, some or all of the cash crops or enset the formulation of Kuhn-Tucker conditions for optimisation are omitted to save space.

since PCC relax credit constraints which means that farmers with larger stock of PCC are more productive since they can use optimal or closer-to-optimal level of inputs.

Manipulating the first order conditions gives us the reduced form model for food crops and enset production, which are functions of PCC and other variables:

$$Q_{oi}^{*} = Q_{oi}^{*}\left(z^{q}, A_{oi}^{*}, A_{ei}, A_{ci}^{*}, L_{i}^{*}, y_{i}^{*}, z^{h}\right), \text{ and} \qquad \textbf{(15)}$$

$$Q_{ei}^{*} = Q_{ei}^{*}(z^{q}, A_{oi}^{*}, A_{ei}^{*}, A_{ci}^{*}, y_{i}^{*}, z_{i}^{*}) \qquad \textbf{(16)}$$

where Q_{oi}^{*} is total aggregate value of food crops or value of food crops per unit of land (productivity) for household i; Q_{ei}^{*} is production of enset; and L_{i}^{*} and y_{i}^{*} are optimal labor and other inputs, respectively; and A_{oi}^{*}, A_{ei}^{*} and A_{ci}^{*} are sizes (shares) of operated land holding planted to food, enset and cash crops, respectively. A similar procedure can be used to derive the theoretical model of cash crop production indices.

3. Data and the study area

The data used for this study was collected in the 1998/1999-production year from Wondo Genet area located in the Southern Nations and Nationalities Regional State, 270 KM south of the capital, Addis Ababa. It lies within the southern rift valley of Ethiopia. Awassa serves as the administrative capital of the region, with Shashemene town being the nearest local market.

Households were randomly selected from two peasant associations, Wesha and Chuko. The area is characterized by a mixed crop-livestock production system. It is well known for its cash crops such as coffee, sugarcane and chat (khat), making it appropriate for cash crop research. Other main crops are enset, maize, bean, kale, banana, avocado and papaya. Maize is the main staple food crop, while enset is a well-known perennial food crop in the area. Chat trading is common in Chuko, while sugarcane trade is common in Wesha. The area has been a centre of rural business because of its cash crops and proximity to Awassa and Shashemene markets (Adya, 2000). Farmers in the area produce sugarcane, coffee, and chat, mainly for markets. Although there is no statistics on how much of the total of cash crops is sold, the number of farmers who sold the crops is presented in Table 1.

Although there are other crops grown by farmers in the area, they have little significance in terms of their area and contribution to household income. Production is mainly based on rainfall, which is bimodally distributed throughout the year. The area is among the highest annual rainfall areas in the country, making it suitable for coffee, sugarcane, and especially chat production, the yield of which is highly dependent on the amount of soil moisture throughout the year.

Interlinkages of input supply and output markets are not common in the area. Thus, most of the products are sold in the market and inputs are purchased both from the markets and from government agencies on credit basis. The inputs purchased from government agricultural development offices are mainly fertilizer and improved seeds. Farmers are expected by government offices to pay a certain portion of the input prices at the time of purchase with the remaining balance due at the end of the harvest period. Farmers cannot get these inputs on credit basis for the next season unless the previous year's credit is completely repaid. Seventy-five households were randomly selected from each of the two peasant associations. Households were interviewed about demographics, farm and non-farm activities, agricultural practices, asset holdings and attitudes and perceptions about different farm and non-farm activities. The data were collected using trained enumerators from the area with strict follow up by researchers for good quality data. Out of 150 households selected we use 127 households for econometric analysis because of incomplete information and outlier observations on some variables. However, data in Table 1 is for 147 households for which most of the data were recorded.

4. Methods of analysis and econometric procedures

In our conceptual framework, we hypothesized that cash cropping could influence food crop production and productivity in different ways. This section develops an empirical model, which enables us to measure the impact of the intensity of these crops on food crop production and productivity.

4.1 Impact of PCC and enset on food crop production and productivity

Since it is difficult to measure the production of PCC and enset (Q_c and Q_e) in one-year time, as they are perennials harvested over cropping cycle, we define a measure of the level of involvement (intensities) of households in the production of these crops. Based on the hypothesis that the intensity of PCC production can affect food crop production and productivity, we develop indices of intensity of PCC and enset cultivation. We define household i's PCC and enset cultivation indices as C_{ij} where j indexes the type of crop (j=coffee, chat, sugarcane, enset). For coffee this index (C_{icof}) is defined as the number of coffee trees divided by total operated land holding; for chat the index (C_{ichat}) is defined as the size of land planted to chat over total operated holding multiplied by 100. The sugarcane production index (C_{isugar}) is defined as the area planted to sugarcane divided by total operated holding and multiplied by 100; and the index for enset production (C_{ienset}) is defined as the number of enset trees divided by total operated holding. We use the number of trees for coffee and enset because they are intercropped with other crops more often than sugar and chat.

These indices simply measure the households' level of involvement in these crops' production relative to its available land for operation and do not show a production function relationship. The indices assume values of zero for some households. To study the impact of these indices on food crop production and productivity, we specify models for y_i , the aggregate gross value of food crops output for household i, and $\frac{y_i}{fland_i}$, the aggregate gross value of food crops output over the total land planted to food crops. Thus, the empirical specification of equation (15) can be written as:

$$y_i = f(C_{ij}, x_i, fland_i, z_i^h, z_i^q,) \quad \textbf{(17)}$$

$$\frac{y_i}{fland_i} = f(\ C_{ij}, z_i^h, z_i^q, fland_i, \frac{x_i}{fland_i}) \quad \textbf{(18)}$$

Where x_i is a vector of variable inputs; z_i^h and z_i^q are vectors of household characteristics and farm characteristics, respectively, which include non-conventional production variables that affect production and productivity). Equation (17) specifies the empirical model of the aggregate value of total food crop production (y_i) while equation (18) specifies the aggregate value of total food crop production divided by total land planted to food crop ($\frac{y_i}{fland_i}$). Descriptions and overview of variables used in the analysis are presented in Table 2.

We use Cobb-Douglas (C-D) type as the basic functional form of production functions given by (17) and (18) since this is a commonly used form of production in agricultural economics research (Hayami, 1970). The C-D form is also easy to interpret and holds the promise of more statistically significant parameter estimates (Liu and Zuang, 2000). Debertin (1986), Chambers (1988) and Brown (1970) present properties of the C-D production function

The aggregate value of food crops produced by a household, y_i; include maize, teff, wheat, barley, sweet potato, potato, yam, taro, soybean, horse bean, and chickpea. To get the total value of gross output, the outputs of individual crops are weighted by average market prices, which do not vary across households. The aggregate value is used because it solves the problem associated with mixed cropping (Rao and Chotigeat, 1981; Byiringiro and Reardon, 1996). There is no high-value crops in the aggregate value of food crops, and it is assumed that differences in aggregate productivity between small and large farms are attributed to size or returns to scale (Byiringiro and Reardon, 1996.

The dependent variables and all continuous explanatory variables, including the crop indices are transformed into logarithmic form. For censored right-hand side variables (with zero observations), we add one to all observations before transforming them into logarithmic form. Transforming the data into logarithmic form helps reduce heteroskedasticity in error variance (Maddala, 1998; Mukherjee et al, 1998). These transformations reduce problems associated with non-linearity and outliers, improving the robustness of the regression results (Mukherjee et al, 1998; Godfrey et al, 1988).

Consistent estimation of (17) and (18) depends on two conditions. First, y_i and $\frac{y_i}{land_i}$ are not all positive observations. A significant number of farmers reported zero values for these variables. Since there could be systematic differences between farmers with positive and zero values of these variables, taking only observations with positive values and estimating (17) and (18) can introduce selectivity bias (Heckman, 1979; Greene, 2000; Wooldridge, 2002). To correct for this selectivity bias, we use the Heckman's selection model ((Heckman, 1979) which involves running a separate probit model using all observations, generating the inverse Mill's ratio (IMR) and including this in the regressions for, y_i , $\dfrac{y_i}{fland_i}$ >0 observations.

However, since the standard errors of the second stage estimates become incorrect because the IMR is estimated, we have to bootstrap the standard errors from the second stage to get the correct standard errors (Deaton, 1997). Second, the PCC and enset production indices are basically the result of choices made by the households. If these indices are endogenous in equations (17) and (18), we get inconsistent parameter estimates (Shively, 1997). However, as we will show below, although they are endogenous to the household, they are predetermined variables and exogenous at the time of making food crop planting decisions as the latter are annual and the former (PCC and enset) having been planted before the annual food crops.

To make sure that they are predetermined only perennial crops older than one year are included in the indices, as they are not harvested before this age. As a precaution we use both the predicted and unpredicted values of the indices for comparison purposes and test the unpredicted indices for endogeneity. We use Tobit models to predict the indices, as many observations of the dependent variables assume zero values. We also use the log-log specification for these equations adding one before transforming the dependent variables and the right-hand side variables with zero observations. Thus, the impact of the PCC and enset production on food crop production and productivity are determined by the coefficients of the indices in (17) and (18).

In addition to PCC and enset indices and the conventional inputs, we include other explanatory variables including sex, education, and age of the household head, wealth variables such as total livestock unit, size of operated land holding, dependency ratio (consumer-worker ratio), size of male and female work forces, number of consumer units, the ratio of rented in land to total operated holding, the number of oxen owned by households, distance from markets and a dummy variable for location of the households (see Table 2). We use market distance and location of the households (dummy variable for the two peasant associations) as instruments in the first stage probit equation to identify equations (17) and (18).

While the conventional inputs are physical controls for production and productivity, inclusion of sex, education and age of household head assume that household head is the primary decision maker and thus provide additional controls for management input. Total land planted to food crops, on the other hand, measures the controversial relationship between the size of land and productivity on (18) and we expect positive and negative signs in (17) and (18), respectively. In areas where markets are imperfect, labour, wealth (livestock and operated land holding) and the number of oxen can put a given household at the advantage of early operation and credit worthiness and hence we expect positive signs both in (17) and (18). On the other hand, dependency ratio and the ratio of rented in land to total operated holding may reduce productivity and production.

4.2 Impact of cash and annual food crops on enset intensification

We use the indices defined in the previous section in a model for enset intensification with a slight modification as:

$$c_{aenset} = f(c_{iacof}, c_{ichat}, c_{isugar}, y_i, z_i^h, z_i^q, tophold) \quad \textbf{(19)}$$

where $c_{iaenset}$ now indexes total number of enset trees at all ages divided by total operated holding (tophold); c_{iacof} is the number of all-age coffee trees divided by total operated holding; c_{ichat} and c_{isugar} are the same as defined in the previous section since no chat and sugar cane of less than two years were recorded, unlike coffee and enset, which include trees of less than two years of age; y_i is aggregate value of food crop production; z_i^h, z_i^q are vectors of household and farm characteristics as defined previously; and tophold is total operated holding.

The dependent variable in (19) involves zero values for households who do not plant enset. However, the number of households with zero enset production is only 5% of the total households used for econometric analysis. Therefore, we use only observations with positive values of enset production. On the other hand, if all the three PCC and food crop production are endogenous in (19), the model will form a system of simultaneous equations system and the OLS estimates will be biased and inconsistent. Nevertheless, tests of simultaneity show that the PCC and food crops production are not endogenous in (19). We have also tested for heteroskedasticity and could not reject the null hypothesis of constant variance.

5. Results and discussion

5.1 Characteristics of cash cropping and enset farmers

Before we start discussing the results of the econometric analysis, we provide some descriptive insights on three categories of sample farmers based on their involvements in the production of cash crops and enset. Accordingly, we divide them into non-growers, average or below average growers and above average growers. We discuss only the main variables, which are used in (17), (18) and (19), the dependent variables and some important characteristics in relation to the categories (see Table 3). As the table shows, the average aggregate value of food crops is highest for non-chat producing farmers while it is lowest for farmers with more than average involvement in chat production. On the other hand, average total production is higher for farmers with more than average involvement in sugarcane production than it is for farmers with average and less than average involvement. Generally, aggregate value of food crop production per household is higher for non-producers of the PCC (except sugarcane) and enset suggesting that these crops tend to be produced at the expenses of food crops although the decrease may not be significant.

Total operated holding and livestock holdings are generally lower for non-cash and non-enset farmers. This is in line with the argument by Timmer (1997) that farmers with larger land holdings engage in cash crop production more than their counterparts as a means of diversification or to increase their income. Both total operated holding and food crop areas increase for above average enset producers indicating that larger farms have more advantage of both diversifying into enset and ensuring the family with food crops. This is in contrast with the belief that farmers with smaller holdings plant enset to intensify enset production, which is believed to give higher yields.

Growers of chat, sugarcane and enset also have higher number of male work force. However, the number decreases with the intensity of production. The value of fertilizer applied per unit of land of food crop is higher for non-producers of chat, sugarcane and enset but it increases with chat production intensity while it reduces with the intensities of sugarcane and enset production. On the other hand, it is higher for producers of coffee than non-producers but it decreases with the intensity of coffee production. Per unit of land uses of labour, oxen and seed are higher for sugarcane and coffee producers than non-producers while it is lower for chat producers. However, there is no indication that cash crops enable farmers to apply more fertilizer per unit of food cropland from these statistics. One reason for this might be that fertilizer is obtained on credit basis from government and non-cash crop (and poorer) farmers substitute fertilizer for other inputs, which require immediate cash outlays. Nevertheless, sugarcane and coffee producers produce more food crops per unit of land than non-producers of these crops in line with our hypothesis while chat producers are less productive.

These descriptive statistics may not provide clear insights into the impacts of cash crops and enset on household crop production and productivity since we cannot control for other variables at the same time. These will be addressed in the next sections.

5.2 Econometric results

5.2.1 Determinants of the probability of food crop production

First we look at factors influencing the probability of growing food crops. Results of probit models of determinants of the probability of growing food crops are presented in Table 4 (Model I). Column two of Table 4 provides the two-stage limited dependent variable (2SLDV) estimation results while column three (b) presents the probit estimation without predicting the four crop indices.

The results of the tests of the null hypothesis that the cash crops and enset indices are exogenous are reported at the lower part of Table 4. As we can see from the tests for the endogeneity of the crop indices, we cannot reject the hypothesis that the indices are exogenous in the model. As a result, model 1 (b) can consistently estimate the parameters of the probit model and our discussions are based on results reported in column three (b)

The results show that the intensity of coffee production is associated with lower probability that the household produces food crops. This could be because of the fact that coffee is intercropped with food crops and other crops less often, which means that once land is occupied with coffee, the probability of growing food crops is low. Other PCC and enset are not related with the probability of growing food crops significantly.

Both male and female workforces are positively correlated with the probability of growing food crops. This is an indication that food crops are demanding in terms of labour. The ratio of consumers to workers or dependency ratio (cwr) is also associated with the probability of growing food crops positively. On the other hand, total consumer unit (cu) is correlated with food crop planting probability negatively suggesting that households may use enset as a means of intensification given higher consumer unit. This result seems strange at first sight but given that enset productivity is higher, households may resort to producing enset instead of other food crops to meet their consumption needs.

5.2.2 Impacts of PCC and enset on annual food crop production

In the second stage, we estimate equations (17) and (18) including the IMR generated from the probit model in the first stage. Model 2 of Table 4 provides estimation results of the determinants of food crops production. The coefficient of IMR is not statistically significant (Column four, (c)), which also uses the predicted values of the four crop production indices, suggesting that there is no selectivity bias resulting from using the sub sample for which food crop production is greater than zero. Subsequently we estimated model (d) (column five) excluding IMR and using unpredicted crop indices. This enables us to test whether these indices are endogenous in the model. The test for endogeneity shows that we cannot reject the exogeneity of these variables with F= 1.96. The test for heteroskedasticity also shows that we cannot reject the homoskedasticity of the variance (column five, (d)). This means that we can use OLS estimates with ordinary standard errors to get the consistent parameter estimates of the household total food crop production determinants. These estimates are given in column (column six (e)). The estimates show that the intensity of chat production is associated with reduced total household annual food crop production. This may be because the results of competition for resources including land may outweigh the potential synergies between chat and food crops. In addition, the frequent harvest of chat may not be suitable for food crop production. Farmers may also neglect food crops altogether and commit resources to chat affecting food crops adversely. This is evident in some areas where farmers replace food crops and other perennial crops such as coffee with chat, which has raised concerns about its impact on food security.

On the other hand, sugarcane production is correlated with increased annual food crop production. Thus, an increase in the area of sugarcane by one percent is associated with 0.08 percent increase in value of total annual food crop production.[6] While sugarcane production apparently competes for land (although they can be intercropped) with food crops, the synergies between the two crops possibly resulting from reduced soil erosion, and moisture conservation and use of optimal inputs may outweigh the loss of production due to competition for land. Coffee and enset production do not have significant effect on food crops. This could be because of the counteracting effects of competition for resources and synergies between the perennials and food crop productivity and shows that these two crops can be grown at little expenses to food crops.

The availability of male workforce is positively and significantly associated with food crop production as expected. This is believed to be because of the fact that annual food crop production requires male labour for ploughing, threshing, and other activities. On the other hand, female workforce is negatively and significantly related

[6] This is a measure of elasticity because both variables are expressed in logarithm form.

with food crop production. Women in Ethiopia are not involved in some of field crop operations including ploughing and threshing. They are more involved in operations of PCC and enset, which are planted closer to the household. The educational level of household head is also positively and significantly associated with food crops after controlling for other variables. Household annual food crop production is positively and significantly associated with the size of land planted to food crops as expected. A one percent increase in land is associated with about 0.5 percent increase in the value of food crop production, other factors held constant. This result is similar with previous studies (e.g. Govereh and Jayne, 2003).

Households' annual food crop production is also positively and significantly associated with the amount of seed used probably suggesting farmers do not use optimal seed rate

5.2.3 Effects of PCC and enset on annual food crop productivity

Given that the IMR is not significantly different from zero (F statistic) and that we cannot reject the exogeneity of the cash crops and enset production indices in model (g) of Table 4, we use the OLS estimates of the food crop productivity model with robust standard errors since homoskedasticity is rejected (see (h), Table 4).

Similar to our estimation results for total food crop production (model (e)), there is negative and significant relationship between chat production and food crop productivity (yield). This could be associated with the decreased use of inputs such as labour and seed per hectare with the intensity of chat production (Table 3) and other effects not measured in our data. On the other hand, food crop productivity is positively and significantly associated with the intensity of sugarcane production. Possible explanations could include the fact that more intensive sugarcane production is associated with higher use of labour and seed per hectare of food crops in addition to other possible synergies in terms of preventing soil and moisture losses. However, the intensities of coffee and enset production do not have any significant effect on food crops productivity. While coffee production is associated with the increased use of labour, seed, and fertilizer inputs per unit of food crop area, the intensity of enset production is associated with decreased use of seed, labour and fertilizer for food crops indicating the shift of attention from other food crops to enset. Nevertheless, the decreases and increases may not be big enough to affect food crop productivity significantly.

Educational level of household head is associated with higher food crop productivity , suggesting that farmers with higher education are more productive than those with lower or no education farmers. Total area of food crop production has a negative and significant effect on food crop productivity, other factors held constant. Farmers with smaller area of food crops have higher yields. Results of model (h) suggest that a one percent increase in food crop area reduces yield by about 1.05 percent, which is an inverse relationship between farm size and productivity. This is in line with the results found by, among others, Assuçãno and Ghatak (2003) and Heltberg (1998).

Labour and seed inputs measured by man-days and Eth. Birr, respectively, and normalized by total area of food crops are positively related with food crop productivity, with labour input having the biggest elasticity of the conventional inputs. Total male labour force available to households has a positive effect on food crop productivity suggesting the importance of male labour in food crop production. Surprisingly, the ratio of rented in land to total operated holding has a positive and significant effect on food crop productivity. Since this is the total rented in land rather than the rented in land dedicated to food crops, it may suggest that farmers use more of this land for food crop production and thus use more inputs for food crops, which outweighs the negative impact of tenure insecurity. In addition, the type of land contract is mostly of fixed rent and this minimizes the presence of inefficiency resulting from share tenancy. Research results from Ethiopia and else show that informal land rental contracts do not affect input use adversely (e.g., Place and Hazel, 1993; Gavian and Ehui, 1999)

5.2.4 Effects of cash crops and other food crops on enset intensification

Results of the estimation of number of enset plants per total operated holding are presented in Table 5.Having rejected the hypothesis that the model is a system of simultaneous equations and heteroskedasticity, we estimated the model using OLS. These results are reported in the third column of Table 5 (Model 5). In addition, we estimated the equation using the two-stage limited dependent variable (2SLDV) procedure since the cash crop indices are estimated using Tobit models for comparison purpose. These results are presented in the second column of Table 5 (Model 4). The signs of the two model estimates are similar. However, the OLS estimates are more efficient owing to the fact that the 2SLDV procedure gives inefficient estimates in the absence of simultaneity (Gujarati, 1995). Therefore, the following discussions are based on results of Model 5.

We excluded female workforce (fwf) from Model 4 because it was found to be collinear with consumer unit and yet insignificant. Total livestock unit (tlu) was also omitted from both models due to its collinearity with oxen. Results of Model 5 show that, surprisingly, the distance of the household from markets is negatively and significantly correlated with enset intensification. This raises a question whether households can depend solely on enset for food consumption. If households need other stables other than enset for consumption, this result makes sense since households have to insure themselves for these staples. This line of argument with discussions by Brandt et al (1997) that the low content of protein in enset diet makes it necessary to mix enset with other crops in human diet. The intensity of coffee production is positively and significantly correlated with enset intensification. Possible explanations include the fact that coffee and enset are intercropped since enset may provide shade to coffee,, hence the complementarity between the two crops. The number of female labour unit is negatively correlated with the intensity of enset production. This is contrary to our expectation, as enset production is believed to be female labour intensive.

On the other hand, the larger the number of consumer unit, the higher is the intensity of enset production. This is in line with the fact that enset can insure food security from a relatively smaller landholding.

Although there are apparent competitions between enset, on the one hand and cash and annual food crops on the other hand for some resources, these competitions do not seem to reduce the intensity of enset production. Unlike among cash crops and other food crops, most of the synergies among cash crops and enset may be the result of intercropping possibilities and other positive interactions, which make it possible to get more benefits from engaging in the production of many crops rather than specializing in certain crops.

6. Summary and conclusion

This study addresses the impact of emerging PCC production activities on enset intensification and on annual staple food crop production and productivity and the potential for the cash crops and enset production. We hypothesized that in view of the decreasing landholding owing to population pressure, PCC can have negative and positive impacts on food crop production and productivity, respectively, through competition for resources (especially land) and enabling farmers to get more cash income for purchasing and using productive inputs and through their impact on maintaining soil fertility and moisture. We also hypothesized that the intensity of enset production can have negative impact on annual food crops since farmers may substitute this crop for food crops, as it is a food crop itself and is more productive. Moreover, food crop production can reduce enset intensification due to competition for resources. Results show that after controlling for other relevant variables, chat production reduces both total production and productivity of annual food crops supporting the claims that chat is replacing food crops while sugarcane production increases both production and productivity of annual food crops. On the other hand, coffee and enset do not have any significant impact on food crop production and productivity. However, intensity of coffee production is positively and significantly related to enset production.

This point to the fact that the impacts of cash cropping on annual food crops depend on the types of the cash crops in addition to other factors such as market interlinkage.. Whilst there are frequently heard assertions that cash crop production comes at the expenses of food crops, some authors found out that there are synergies between cash crops (cotton) commercialisation and food crop productivity through interlinked markets and regional spillovers (e.g., Dorward et al, 1998; Govereh and Jayne, 2003). However, our results show that there is no guarantee that cash crop production per se can improve the production and productivity of food crops in areas where there are no spillover effects and interlinked markets. Moreover, interlinked markets are not necessary for cash crops to have positive impact on food crops. Thus caution must be taken when advocating rural development policies based on the trade-offs or synergies between cash crops and food crops under all conditions with out careful studies of the types of cash crops and other local conditions.

While further empirical studies are needed to answer some questions, for example, why female labour force is negatively related to both enset and food crop production, there is evidence that at least some of the PCC can be grown without reducing production of staple food crops. Although there are tradeoffs between chat production and food crops, the impact of this cash crop on household welfare depends on the level of income from chat production and the foregone food crop production. The net impact depends on the relative prices of the two crops and the amount of output of food crops lost due to chat production and the yield of chat.

On the other hand, coffee and enset can be grown to bring additional income to the household without significant costs to food crop production, while sugarcane is beneficial both for additional cash income and its positive impact on food crop production and productivity. The results also suggest that complementarity exists between coffee and enset production.

Improving market infrastructure to reduce marketing costs and provision of credit to bridge the income gap between planting and harvesting of perennial crops can improve household welfare by encouraging farmers to produce PCC, enset and other food crops, which can alleviate problems arising from population pressure because PCC and enset productions are ways of farm intensification in the area ensuring food security. On the other hand improving improved market infrastructure to reduce marketing costs can allow farmers to grow cash crops that give higher returns to resources but which reduce production of food crops.

References

Abdulahi, A. and CroleRees, A. 2001. Determinants of income diversification amongst rural households in Southern Mali. Food Policy 26, 437-452.

Adya, S. 2000. Determinants and measurement of crop Diversification: A study in Wondo Genet, Southern Ethiopia. MSc. Thesis (unpublished), department of Economics and Social Sciences, Agricultural University of Norway, Aas.

Assução, J. j. and Ghatak, M. 2003. Can unobserved heterogeneity in farmer ability explain the inverse relationship between farm size and productivity. *Economic letters* 80, 189-194.

Brandt, S. A., Sunita, S., Clifton, H., McCabe, J. T., Tabogie, E., Diro, M., Woldemichael, G., Ytingo, G., Shigeta, M., and Tesfaye, S. 1997. *The tree against hunger: enset-based agriculture systems in Ethiopia*. American Association for the Advancement of Science, Washington, DC, Awassa Agricultural Research Center, Kyoto University Center for African Area Studies and University of Florida. (WWW.aaas.org/international/africa/enset/)

Brown B. W. 1970. Tests for Cobb-Douglass and CES production functions. *International Economic Review* 11(1), 77-83.

Byiringiro, F. and Reardon, T. 1996. Farm productivity in Rwanda: effects of farm size, erosion, and soil conservation investments. Agricultural Economics 15, 127-136.

Chambers, R. G. 1988. *Applied production Analysis: A dual approach*. Cambridge University Press, Cambridge

Coelli, T. and Fleming, E. 2004. Diversification economies and specialization efficiencies in a mixed food and coffee smallholder farming system in Papua New Guinea. Agricultural Economics 31, 229-239.

de Janvry, A., Fafchamps, M. And Sadoulet, E. 1991. Peasant household behaviour with missing markets: Some paradoxes explained. *The Economic Journal,* 101, 1400-1417

Deaton, A. 1997. The analysis of household surveys: A microeconomic approach to development policy. The World Bank, Washington, D.C.

Debertin, D. L. 1986. *Agricultural production Economics*. Macmillan Publishing Company, New York.

Dorward, A., Kydd, J. and Poulton, C. eds. 1998. *Smallholder cash crop production under market liberalization*. CAB International, New York.

Gavian, S., Ehui, S. 1999. Measuring the production efficiency of alternative land tenure contracts in a mixed crop-livestock system in Ethiopia, *Agricultural Economics*, Vol. 20, 37-49.

Godfrey, L. G., McAleer, M. and McKenzie, C. R. 1988. *Variable addition and Lagrange Multiplier test for linear and logarithmic regression models*. The Review of Economics and Statistics 70(3), 492-503.

Goetz, S. J. 1993. Interlinked markets and the cash crop debate in land-abundant Tropical agriculture. Economic Development and Cultural Change 41, 343-361.

______. 1992. Economies of scope and the cash crop-food crop debate in Senegal. World Development 20(5), 727-734.

Govereh, J. and Jayne, T.S. 2003. Cash cropping and food crop productivity: synergies or trade-offs? *Agricultural Economics* 28, 39-50.

Govereh, J., Jayne, T. S. and Nyoroo, J. 1999. Smallholder commercialisation, interlinked markets and food crop productivity: Cross-country evidence in eastern and southern Africa. Michigan State University.

Gujarati, N. D. 1995. *Basic Econometrics*. McGRAW-Hill International Editions.

Haileslassie, A., Pries, J., Veldkamp, E., Teketay, D., and Lesschen, J. P. 2005. Assessment of soil nutrient depletion and its spatial variability on smallholders' mixed farming systems in Ethiopia using partial versus full nutrient balance. Agriculture, Ecosystems and Environment 108:1-16.

Hayami, Y. 1970. On the use of the Cobb-Douglass production function on the cross-country analysis of agricultural production. *American Journal of Agricultural Economics* 52, 327-329.

Heckman, J. 1979. *Sample bias as a specification error*. Econometrica 47(1), 153-161.

Heltberg, R. 1998. Rural market imperfections and the farm size-productivity relationships: Evidence from Pakistan. World Development 26 (10), 1807-1826.

Imam, S. A., Hossain, A. H. M. D., Sikka, L. C., and Midmore, D. J. 1990. *Agronomic management of potato/sugarcane intercropping and its economic implications*. Field crops Research 25, 111-122.

Kelingele, R. 1998. Hararghe farmers on the crossroads between subsistence and cash economy. University of Pennsylvania-African Study Center. (www.africa.upenn.edu/Hornet/hararghe998.html#heading5) (Accessed April 2007)

Kelly, V., Diagana, B., Reardon, T., Gaye, M. and Eric, C. 1996. *Cash crop and food grain productivity in Senegal: Historical view, new survey evidence and policy implications*. Policy Synthesis No. 7. USAID, Africa Bureau.

Liu, Z. and Zhuang, J. 2000. Determinants of technical efficiency in post collective Chinese agriculture: Evidence from farm level data. *Journal of Comparative Economics* 28, 545-564.

Maddala, G. S. 1998. *Introduction to Econometrics*. MacMillan Publishing Company, New York.

Maxwell, Simon and Fernando, A. 1989. Cash cropping in developing countries: The issues, the facts, the policies. World Development, Vol. 17 (11), 1677-1708.

Mukherjee, C., White, H. and Muyts, M. 1998. *Econometrics and data analysis for developing countries*. Routledge, London.

Mushtaq, K. and Dawson, P. J. 2002. Acreage response in Pakistan: a cointegration approach. *Agricultural Economics* 27, 111-121.

Parker, B. 1995. *Everything about Khat*. University of Pennsylvania-African Study Center. (www.Africa.upen.edu/Hornet/qat.html.) (Accessed April 2007)

Place, F., and Hazel, P. 1993. Productivity effects of indigenous land tenure systems in Sub-Saharan Africa. *American Journal of Agricultural Economics*, 75: 10-19

Rahmato, D. 1996. *Resilence and vulnerability: Enset-based agriculture in southern Ethiopia*. In: Abate, T., Hiebsch, C., Brandt, S., and Gebremariam, S. (eds.). Enset-based sustainable agriculture in Ethiopia. Addis Ababa. Institute of Agricultural Research.

Rao, v. and Chotigeat, T. 1981. The inverse relationship between size of landholdings and agricultural productivity. *American Journal of Agricultural Economics*, 63: 571-74.

Sadoulet, E. and de Janvry, A. 1995. *Quantitative development policy analysis*. The Johns Hopkins University Press, Baltimore and London.

Shively, G. E. 1997. Consumption risk, farm characteristics and soil conservation adoption among low-income farmers in the Philippines*. Agricultural Economics* 17, 165-177.

Singh, I., Squire, L., and Strauss, J. 1986. *Agricultural household models: extensions, applications and policy.* Johns Hopkins University Press, Baltimore, M. D.

Smith, N. J. H, Alvim, Paulo de T., Serrão, E. A. S. and Falesi, I. C., 1995. *Amazonia.* In: Kaperson, J. X., Kaperson, R. E., and Turner II, B. L. (eds.). *Regions at risk: Comparisons of threatened environments.* United Nations University Press, Tokyo, N.Y., Paris.

Strasberg, P. J., Jayne, T. S., and Yamano, T. 1999. *Effects of agricultural commercialisation on food crop input use and productivity in Kenya.* Policy Synthesis No. 41, USAID, Africa Bureau.

Taylor, J. E., and Adelman, I. 2003. *Agricultural household models: Genesis, evolution, and extension*. Review of Economics of the Household, 1, 33-58.

Timmer, C. P. 1997. Farmers and markets: the political economy of new paradigms. *American Journal of Agricultural Economics*, 79, 621-627.

Wooldridge, J. M. 2002. *Econometric analysis of cross section and panel data*. Massachusetts Institute of Technology, London.

Table 1: Overview of main crops, production intensity and market orientation

Crops	Percent of sample households producing	Percent of growers who sold crops
Enset	77	9.7
Wheat	0.68	0
Coffee	71	17.1
Barley	1.4	0
Maize	69	8.8
Sugarcane	54	84.4
Chat	29	46.5
Soya bean	15	4.5
Sweet potato	8	75
Teff	6	11

Table 2: Overview and description of variables

Variable	Description	Expected sign: Probit for food crop production	Expected sign: Food crop production	Expected sign: Food crop productivity	Mean	Std. error
A. endogenous variables						
Fcropvalue (y_i)	Aggregate Value of food crop production				480.82	1789.48
Fcropdum	Dummy variable: 1=if fcropvalue>0, 0=other wise				0.74	0.44
Fcroppdvty ($\frac{y_i}{fland_i}$)	Aggregate value of food crop output (Fcropvalue) divided by total food crop area (fland)				1068.84	2222.06
Chathold (C_{ichat})	Land planted to chat divided by total operated holding (tophold) times 100	-	-	+	0.059	0.16
Cofhold (C_{icof})	Number of coffee trees over total operated holding (tophold)	-	-	+	17.49	27.88
Sughold (C_{isugar})	Area of sugarcane over tophold times 100	-	-	+	0.276	0.33
Ensethold(C_{ienset})	Number of enset trees over tophold	-	-	-	171.69	328.30
B. Exogenous variables						
Age	Age of household head in years	?	?	?	44.22	14.27
Sex	Household head sex dummy: 1=male, 0=female	?	?	?	0.9	0.30
Mwf	Size of male workforce in standardized unit	+	+	+	2.22	1.44
Fwf	Size of female workforce in standardized unit	+	+	+	1.52	0.99
Cwr	Ratio of consumer unit to worker unit	+	-	-	1.72	0.34
Edu	Educational level of household head in years	?	?	+	2.19	2.90
Rrl	Ratio of rented in land to tophold	+	+	-	0.09	0.25
Tlu	Size of livestock holding in tropical livestock unit	?	+	+	1.68	1.67

Variable	Description	Expected sign			Mean	Std. error
Cu	number of consumers in standardized unit	+	+	-	6.14	2.80
Oxen	Number of oxen owned by household	+	+	+	0.25	0.64
Tophold	Total operated holding (in timad)	+			1.64	1.03
Fland	Size of land planted to food crops (in timad)*		+	?	0.58	1.01
Fertland	Cost of fertilizer used in food crop production in Birr over fland		+	+	37.63	153.50
Labland	Amount of labour in man days used in food crop production over fland		+	+	36.44	51.52
Oxland	Number of oxen days used in food crop production over fland		+	+	2.44	9.83
Seedland	Value in Birr of seed used in food crop production over fland		?	?	101.82	241.93
Mktdist	Average distance of households from markets in hours	+	+	-	1.99	3.48
Padum	Dummy variable for location of household: 1=Wesha, 0=Chuko	?	?	?	0.7	0.46
Lnvarname	Logarithmic transformed variable where varname is the name of one of the above variables					

*Timad is a local measure of land, equivalent to what an adult male can plough in a day using a pair of oxen: on average it is approximately equal to 0.25 hectare of land.

Table 3: Characteristics of households based on their cash crop and enset production indices in Southern Ethiopia, 1998/99[7]

Characteristics	Cash crops and enset production Indices					
	Chathold			Sughold		
	Nongrowers	≤average	>average	Nongrowers	≤average	>average
Sample size	111	15	12	62	49	27
Dummy variable: 1=produces food crops, 0=no food crops	0.721	0.866	0.75	0.79	0.714	0.666
Total value of food crops (Et Birr)	564.63	139.83	131.88	572.89	221.23	740.51
Age of household head in years	44.25	43.14	45.25	46.33	43.5	40.7
Sex of household head: 1=male, 0=female	0.88	0.93	1	0.9	0.89	0.88
Male work force (mwf)	2.13	2.15	3.1	2.16	2.18	2.38
Female work force (fwf)	1.49	1.75	1.46	1.45	1.58	1.56
Consumer-worker ratio (cwr)	1.71	1.84	1.65	1.69	1.73	1.75
Education of household head	2.36	1.17	1.75	2.16	1.85	2.92
Ratio of rented in land to operated holding (rrl)	0.10	0.04	0.1	0.1	0.1	0.16
Livestock holding in tropical livestock unit	1.66	1.43	2.13	1.54	1.88	1.61
Total value of food crops over total food crop area (fcropdvty)	1262.1	334.13	433.84	947.53	1021.6	1484.3
number of consumers in standardized unit (cu)	5.9	7.08	7.2	5.86	6.22	6.64
Number of oxen owned by household (oxen)	0.27	0.133	0.166	0.27	0.27	0.15
size of total operated holding in timad (tophold)	1.58	1.99	1.78	1.45	1.84	1.69
Land allocated to food crops in timad (fland)	0.59	0.65	0.46	0.65	0.47	0.64
Value of fertilizer in Birr over fland (fertland)	47.28	1.23	5.56	53.15	27.73	15.49
Labour in days applied per timad of fland (labland)	40.18	21.6	25.1	25.52	46.89	45.24
Number of oxen days per fland (oxland)	2.98	0.77	0.00	0.77	2.29	7.16
Value of seed per fland (seedland)	118.84	35.8	47.76	58.21	135.47	152.68
Distance of household from market in hours (mktdist)	1.92	2.31	2.24	1.85	2.28	1.81

Table 3. (continued)

Characteristics	Cash crops and enset production Indices						Total
	Cofhold*			Ensethold*			
	Nongrowers	**≤average**	**>average**	**Nongrowers**	**≤average**	**>average**	
Sample size	45	66	27	42	65	31	138
Dummy variable: 1=produces food crops, 0=no food crops	0.8	0.742	0.629	0.666	0.707	0.903	0.739

[7] The figures in the cells show average values of the variables based on the criteria

Total value of food crops (Et Birr)	828.33	368.28	176.75	531.94	305.1	202.86	352.51
Age of household head in years	42.1	44.5	46.96	44.87	42.84	45.32	44.22
Sex of household head: 1=male, 0=female	0.88	0.92	0.85	0.83	0.89	1	0.89
Male work force (mwf)	1.98	2.49	1.92	1.81	2.39	2.41	2.22
Female work force (fwf)	1.48	1.55	1.52	1.3	1.761	1.33	1.52
Consumer-worker ratio (cwr)	1.74	1.71	1.7	1.68	1.73	1.76	1.72
Education of household head	2.18	1.95	2.81	2.32	2.49	2.48	2.19
Ratio of rented in land to operated holding (rrl)	0.13	0.1	0.1	0.18	0.1	0.03	0.1
Livestock holding in tropical livestock unit	1.45	1.86	1.62	1.58	1.6	2.02	1.68
Total value of food crops over total food crop area (fcropdvty)	1001.8	1231.2	722.53	1561.0	1092.43	342.77	1068.8
number of consumers in standardized unit (cu)	5.83	6.56	5.63	5.1	6.78	6.37	6.14
Number of oxen owned by household (oxen)	0.27	0.29	0.11	0.26	0.25	0.23	0.246
size of total operated holding in timad (tophold)	1.56	1.9	1.13	1.46	1.72	1.74	1.64
Land allocated to food crops in timad (fland)	0.7	0.6	0.33	0.64	0.49	0.7	0.58
Value of fertilizer in Birr over fland (fertland)	18.1	60.88	10.45	71.97	27.52	20.27	37.63
Labour in days applied per timad of fland (labland)	29.94	40.96	37.22	46.1	39.7	21.77	36.44
Number of oxen days per fland (oxland)	0.42	4.68	0.1	0.5	5.0	0.23	2.44
Value of seed per fland (seedland)	70.88	108.74	150.24	122.28	125.77	44.19	101.82
Distance of household from market in hours (mktdist)	1.93	2.19	1.62	1.52	2.34	1.93	1.99

* coffee and enset do not include trees less than two years old

Table 4: Results of econometric estimation of impacts of cash crops and enset on food crop production and productivity

Variables	Model 1: Probit model for probability of food crop production		Model 2: Value of food crop production per household in Eth Birr		
	(a) 2SLDV (predicted indices)[a,+]	(b) one-stage Probit [p]	(c) Heckman 2SLDV	(d) OLS	(e)OLS [p]
	coefficient (std. errors)	coefficient (std. errors)	Coefficient (Std. errors)[a]	Coefficient (Std. errors)[b]	Coefficient (Std. errors)[c]
Imr	-	-	-.2238(.5224)	-	-
Lnchathold	-.1344(.2894)	.0639(.1238)	-.0318(.1488)	-.1217**(.0564)	-.1217* (.0646)
Lncofhold	.0270(.0427)	-.1939*(.1043)	-.0135(.0147)	-.0137(.0505)	-.0137(.0553)
Lnensethold	.0658(.5518)	.0563(.0655)	-.2950**(.1459)	.0023(.0356)	.0023(.0356)
Lnsughold	-.1174(.3177)	-.0762(.0817)	-.0285(.0749)	.0801*(.0417)	.0801*(.0439)
Lnage	-1.3735(1.3967)	-.4095(.5862)	.4316(.4705)	.2497(.3275)	.2497(.2966)
Sex	.7011(.5334)	.5517(.4925)	-.0607(.4329)	-.0775(.3692)	-.0775(.3683)
Lnmwf	3.3722*(1.7664)	3.6351**(1.7416)	.9258***(.3270)	.8065**(.2685)	.8065***(0.304)
Lnfwf	2.1364(1.3312)	2.2476*(1.3437)	-.2177(.3099)	-.5791*(.3138)	-.5791**(.2769)
Cwr	2.6709* (1.4813)	2.9167**(1.2178)	.2727(.3985)	-.2102(.3447)	-.2102(.3181)
Edu	-.1281(.0900)	-.0698(.0554)	.1045**(.0438)	.0843***(.0292)	.0843**(.0334)
Rrl	-.3158(1.5889)	-.8572(.5943)			
Lntlu	.3781(.6282)	.4834(.3519)	.2965(.2827)	.1340(.2004)	.1340(.1954)
Lncu	-3.4269*(1.9263)	-3.4913*(1.8539)			
Oxen	.1958(.5380)	.3069(.3383)	-.1881(.2046)	.0234(.1673)	.0234(.1679)
Lntophold	.2836(.7084)	-.3435(.2818)			
Lnfland			.3837(.3264)	.5053(.3647)	.5053*(.2751)
Infert[±]			.0597(.0620)	.0687(.0618)	.0687(.0589)
Inflab[±]			.3105**(.1436)	.2674**(.1345)	.2674**(.1309)
Infoxen[±]			.0693(.1466)	.0590(.1291)	.0590(.1192)
Infseed[±]			.1517*(.0794)	.1525**(.0599)	.1525**(.0702)
Constant	.5387(5.3606)	-2.8132(3.3137)	1.9731(1.4707)	2.6758**(1.187)	2.6758**(1.283)
No.of observations	124	124	94	94	94
No.of replications			100	100	100
Log likelihood	-58.5683	-56.4719			
Pseudo R2 (R-squared)	0.1463	0.1769		(0.6663)	(0.6663)
LR chi2(15)	20.08	24.27			
Breusch-Pagan/Cook-Weisberg test for heteroskedasticity				Chi2(1)=0.8 Prob>chi2=0.774	
Endogeneity test for crop indices		chi2(4) = 6.66 Prob >chi2=0.1551		F(4,73) = 1.96 Prob >F=0.1098	F(4,73)=1.61 Prob.>F=0.1797
F				F(17,76)= 12.05	F(17,76)= 8.93

[a] numbers in parentheses are bootstrap standard errors; [b] numbers in parentheses are robust standard errors; [c] numbers in parentheses are ordinary standard errors; [p] preferred model; *, ** and *** denote significance at or below 10%, 5% and 1% levels.[+] indices predicted based on separate regressions. [±] these inputs are normalized by the size of land planted with food crops in Model 3.

Table 4. continued

Variables	Model 3: Value of food crop production per timad of land (Eth Birr/timad)		
	(f) Heckman /2SLDV	(g)CLAD (without prediction)	(h) OLS [P]
	Coefficient (Std. errors)[a]	Coefficient (Std. errors)[a]	Coefficient (Std. errors)[b]
Imr	-.2577(.5612)	-	-
Lnchathold	-.1783(.1565)	-.2002***(.076)	-.1682***(.063)
Lncofhold	-.0184(.0177)	-.0359(.0730)	-.0031(.0570)
Lnensethold	-.2709(.3477)	.0225(.0465)	.0199(.0413)
Lnsughold	-.0259(.1646)	.1360**(.0676)	.0995** (.0445)
Lnage	.7233(.5552)	.6519(.5269)	.5788(.3706)
Sex	-.2351(.4331)	-.4654(.6255)	-.2648(.4663)
Lnmwf	.8288(.5908)	.8806**(.4191)	.7524**(.3166)
Lnfwf	-.0587(.3999)	-.1363(.5357)	-.4968(.3237)
Cwr	.4200(.9540)	-.1218(.4476)	-.2008(.4134)
Edu	.1113**(.0435)	.0885*(.0497)	.0907***(.0322)
Rrl	.2830(1.1507)	1.2719*(.7215)	.9466*(.5050)
Lntlu	.3809(.4005)	.1213(.2412)	.1667(.2247)
Lncu			
Oxen	-.2844(.3101)	-.0861(.3550)	-.0173(.1994)
Lntophold			
Lnfland	-.9534***(.335)	-1.053***(.390)	-1.052***(.307)
Infert±	.0435(.0634)	-.0012(.0716)	.0567(.0553)
Inflab±	.3237** (.1455)	.3501*(.2008)	.2671*(.1384)
Infoxen±	.1033(.1565)	.1829(.1651)	.0760(.1065)
Infseed±	.1583**(.0787)	.1958*(.1078)	.1671***(.0611)
Constant	1.8728(1.6004)	1.7624(2.0875)	2.6369*(1.3391)
No.of observations	94	136	94
No.of replications	100	100	-
Log likelihood			
Pseudo R2 (R-squared)			0.5315
LR chi2(15)			
Breusch-Pagan/ Cook-Weisberg test for heteroskedasticity			chi2(1) = 4.31 Prob>chi2=0.038
Endogeneity test for crop indices			F(4,71) =1.74 Prob >F=0.1514
F			F(18,75)=4.18

Table 5: Results of econometric estimation of impacts of cash and food crop production on enset intensification: Dependent variable: laensethold

Explanatory Variable	Model 4. 2SLDV estimates of number of enset plants per operated holding	Model 5. OLS estimates of number of enset plants per operated holding
	Coefficient (Standard error) [a]	**Coefficient (standard error)**
mktdist	-.0353(.0987)	-.0538(.0294)*
lfcropvalue	-.00004(.0002)	-.1412(.1455)
lacofhold	-.0068(.0292)	.2237(.09383)**
lchathold	.0139(.0075)*	.0619(.0967)
lsughold	.0032(.0064)	-.0616(.0670)
lage	.8806(.8407)	.1281(.4773)
sex	.9082(.5996)	.8945(.5376)
fwf		-.5745(.2726)**
mwf	-.1473(.1812)	-.2179(.1920)
Edu	-.0150(.0819)	-.0758(.0539)
Cu	.0301(.0984)	.2530(.1395)*
rrl	.3876(2.7426)	.8783(.6571)
oxen	.4370(.5272)	.2123(.2103)
ltophold	-.6340(.4016)	-.2741(.2585)
_cons	2.5334(2.8977)	4.4211(1.9348)**
Breusch-Pagan/Cook-Weisberg test for heteroskedasticity.H0: constant variance		$chi^2(1)$ =2.13 prob> $chi^2(1)$ =0.0.1442
Simultaneity test for cash and food crops. H0: No simultaneity	F(4,74)=1.15 Prob>F=0.3385	
Adjusted R^2		0.1382
Number of observations	93	93
F		F(15,78)=2.05 Prob>F=0.0238
Number of replications	100	

[a]standard errors are bootstrapped