Farming or burning? shadow prices and farmer's impatience on the allocation of multi-purpose resource in the mixed farming system of Ethiopia

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Abstract

In crop-livestock mixed farming system where farm yard manure (FYM) is considered as important multi-purpose resource such as source of soil organic matter, additional source of income and household source of energy, soil fertility depletion could takes place within the perspective of the household allocation pattern of FYM. This paper estimates structural FYM-allocation model in the presence of corner solution, with the objective of examining the role of various returns to FYM and farmer's impatience on the propensity to allocate FYM for alternative purposes. We illustrate the model using data based on a random sample of 493 farm households in the central highlands of Ethiopia. We find that the higher the selling price of FYM is the higher the incentive for farmers to divert the resource from farming to marketing for burning outside the farm households. A farmers' decision to turn FYM from farming to marketing due to heterogeneity in time preference is also an alternative account to explicate the correlation between farmers' impatience and resource allocation. The implication is that the high discount rate and the rise of price encourage current consumption that has long term effect on the sustainable management of soil resource. The results are of paramount importance for the design of sustainable land management policy where soil fertility depletion is salient for low agricultural productivity.

Key words*: *impatience, shadow price, allocation, farm yard manure, Ethiopia
JEL Classification: Q01, Q12

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Introduction

The problem on sustainable development in developing countries has been closely associated with the extent of resource degradation (Pender 1996). In countries where agriculture is the main stay of the economy, soil fertility depletion is an important source of resource degradation causing low agricultural productivity and declining per capita income. Basically in the ideal agrarian economy, productive and sustainable production system requires a combination of inorganic fertilizers together with organic fertilizers such as crop residues and farm yard manure (FYM) to replenish soil and maintain the soil organic matter level (Place et al 2003; Heerink 2005). However, limited use of nutrient inputs among small holder farmers exacerbates soil nutrient deficiency (Place et al 2003). Under constrained supply of FYM, consumption of FYM are intricately interlinked with sustainable soil fertility in such a way that the demand for FYM for energy within and outside farm households shifts the resources to the extent that the application of FYM to the farm is limited for improving soil fertility.

Understandably the use of FYM as source of energy for the farm households and used for farming as ameliorating soil fertility is well documented (Mekonnen and Kohlin 2008). However, previous studies were neglecting the role of FYM as source of additional income for smallholder farmers allocated for selling for use mostly by peri-urban dwellers outside the farming community. There is a growing evidence (Mekonnen and Kohlin 2008) and observation in most rural and peri-urban areas that despite the knowledge of alternative energy resources such as kerosene, electricity and liquefied petroleum gas, high prices and lack of access hinder their wide application as source of domestic energy. As a consequence, due to substitutability of animal dung to these alternative sources of energy (Heltberg et al 2000), the demand for FYM and its price in the market has risen. As other scarce resources, FYM is allocated to different activities based on the estimate of the expected benefit obtained in comparison with the opportunities forgone. According to standard economic theory, households allocate FYM to the market if the market return from selling manure is higher than the value of marginal product of FYM in farming.

Naturally, due to the long time for the mineralization process in which the nutrients in the organic compounds can become available to the crop (Place et al 2003) and the seasonality for the agricultural production, the benefit from farming with FYM is not forthcoming in short time compared to the benefit earned from selling FYM. The discounted utility model states that later returns should be discounted by a fixed proportion of their utility for every time interval that they are to be delayed. Basically, this devaluation should generally closely relate to the market interest rate. However, in the presence of credit market failure and constrained access to financial resources, farmers' subjective discount rate routinely deviates and usually higher than from the prevailing market interest rates (Yesuf and Bluffstone 2009). Thus, this delay in return coupled with credit constraints in developing countries (Pender 1996; Yesuf and Bluffstone 2009) might makes selling FYM as an important strategy of additional source of income for farmers. The implication here is that allocation of FYM depends on the extent to which farmers' degree of impatience to wait the returns from FYM among the various alternatives. In terms of resource degradation, farmers' rate of time preference is the critical factor affecting the sustainability of resource use, which indicates by how much agents discount the utility of consuming in the next period relative to the utility of consuming now (Lence 2000; Pender 1996; Holden et al 1998). A widely accepted conjecture in the literature is that heterogeneity in farmers' discount rate arises in response to poverty (Becker and Mulligan 1997; Holden et al 1998; Pender 1996; Tanaka et al 2010) and imperfection in credit markets (Pender 1996; Yesuf and Bluffstone 2009).

The fact that the multi-purpose use of FYM for farming or burning is generally considered as link between farmers' behavior and resource degradation, the causes of soil fertility depletion extend beyond the farm, receiving effects from household economic conditions. The main focus of this paper is the consideration on the tradeoff between using FYM as inputs to agricultural production or burning them for fuel within and outside farm household with the objective of examining the role of shadow prices for FYM and farmer's rate of time preference on the propensity to allocate FYM for alternative purposes. This study took place in the central highlands of Ethiopia and involves farm household operating the mixed crop-livestock farming system. Due to limited agricultural intensification that constrained the availability of FYM, farmers face the problem of allocation of FYM among the different alternatives. The data supports the predictions and shows that farmer's time preference and the shadow price of FYM are important predictors of the allocation of this multi-purpose resource. Individuals with high rate of time preference allocate less FYM to the farm and the higher the selling price of the manure is the higher the incentive for the farm household to divert the resource to selling.

Conceptual framework

In order to identify the effects of the different return of FYM and farmer's impatience on individual allocation strategy, we construct a farm household model (Sadoulet and deJanvry 1995), assumed farmers as engaged simultaneously in agricultural production, consumption and marketing decision. Our approach is in the spirit of Fisher et al (2005) and Shively and Fisher (2004) who developed a labor allocation model in which households divide their labor resources among farming, forest employment and non-forest employment; and provide an improved assessment on the effect of household shadow price in a given activity for forest decline. However, we add two main features in the model: the return from FYM to allow for decisions driven by profit or consumption motives; and include an experimentally measured time-preference component to capture the farmers' impatience on the trade-off between current consumption or selling of FYM and farming with FYM.

Given a total amount of FYM at her disposal, the farmer decision consists of allocating $\boldsymbol{M}$ between farming $(\boldsymbol{m}_f)$, burning in the household $(\boldsymbol{m}_e)$ and selling in the market as source of fuel $(\boldsymbol{m}_s)$. The implication is that farm households in the area are semi-commercial where even if markets for FYM exist most kept some for home consumption and farm production. Observation of the data for this study has revealed that all farm households obtained FYM for burning $(\boldsymbol{m}_e)$ and farming $(\boldsymbol{m}_f)$ from their own production system without making any purchase. For a farmer who exhibit corner solutions in FYM selling or farming, then the shadow prices of FYM for selling $(\boldsymbol{p}_s^*)$ and farming $(\boldsymbol{p}_f^*)$ will be endogenously determined by parameters affecting the household's production and consumption decisions.

Investing FYM on the farm means postponing the current consumption originated from burning dung in the household or income earned from selling FYM in the market. This loss interpreted as the benefit obtained from selling or burning FYM now is assumed to be compared and offset by the discounted returns of FYM in farming at a later time. When financial capital is scarce and interest rates are high as in the case in Ethiopia (Yesuf and Bluffstone 2009), the high opportunity cost of capital coupled with liquidity constraints drives subjective discount rates above market interest rates. With the subjective discount parameter (δ) the relationship between time preference and allocation behavior are more pronounced. A farmer's discount rate is expected to affect a household resource allocation following the standard intuition: a higher δ should result in higher resources towards for current consumption.

From the households' optimization problem we can derive a set of estimable reduced form Marshallian demand functions of FYM for farming, for household energy and the supply of FYM for selling in the market. These are expressed as functions of shadow price of FYM for selling ($\boldsymbol{p}_s^*$) shadow price of FYM for farming ($\boldsymbol{p}_f^*$), farmer's time preference ($\boldsymbol{\delta}$) and other individual and community characteristics ($\boldsymbol{z}$):

$$\left.\begin{matrix} \boldsymbol{m}_f \\ \boldsymbol{m}_s \\ \boldsymbol{m}_e \end{matrix}\right\} = \boldsymbol{m}\left(\boldsymbol{p}_s^*,\ \boldsymbol{p}_f^*, \boldsymbol{\delta};\ \boldsymbol{z}\right)$$

Empirical strategy

Shadow prices

The empirical strategy involves a sequence of estimation stages. First, we estimate a production function to obtain the marginal product of FYM for those participating in FYM farming. Second, we use the marginal revenue product estimates from the above step and the observed selling price and employ sample selection model to compute shadow returns for the subsample of households that do not supply FYM for farming or market. Third, we estimate the structural FYM supply function. Following Jacoby (1993) and Skoufias (1994), the first step in the empirical analysis is to obtain the value of marginal productivity of FYM ($\boldsymbol{p}_f^*$) estimated at the slope of the production surface around the input use vector for each farm household. At the equilibrium point, the shadow price of FYM for each farm household is just the value of marginal product of FYM in agricultural production. The farm-level production function in logarithmic form is specified as:

$$\ln \boldsymbol{q} = \boldsymbol{\beta}_f \ln \mathrm{m}_f + \sum\nolimits_k \boldsymbol{\beta}_k \ln \mathrm{x}_k + \boldsymbol{\varepsilon}$$

where $\boldsymbol{q}$ refers the total value of agricultural outputs produced, m_f is quantity of FYM used as organic fertilizer and $\boldsymbol{\beta}_f$ is the estimated parameter for it; x_k are the quantity of other inputs used, $\boldsymbol{\beta}_k' \boldsymbol{s}$ are parameters estimated for other inputs, and $\boldsymbol{\varepsilon}$ is the error term. The specified production function also includes the following inputs: quantity of inorganic fertilizer, seed used, farm labor, cropped area, draft animal services, share of area covered with modern crop varieties; plot and location characteristics are also included to control farm and village specific factors.

In the empirical model fertilizer and improved seed use are usually considered as potentially endogenous (Kassie et al 2009). In line with Jacoby (1993) who worked on cross-sectional data and had rely on production and consumption side instruments that are valid under non-separability, the endogeneity (reverse causation) of farm inputs such as fertilizer and improved seed is controlled with instruments using two stages least square method (**IV-2SLS**). We instrumentalise these endogenous variables with village specific and household characteristics[2] and verify the statistical validity of the instruments by performing an over

[2] The instruments include: locational dummies, family size in adult equivalent, age of the head, frequency of extension contact, nearness to development agents, average distance to farming plots, participation in village saving and credit association.

identification test. Following the estimation of the production function, the estimated parameters for FYM is used to derive the value of marginal product $(\boldsymbol{p}_f^*)$ as follows:

$\boldsymbol{p}_f^* = \frac{\hat{\boldsymbol{q}}}{\boldsymbol{m}_f}\boldsymbol{\beta}_f$; where $\hat{\boldsymbol{q}}$ is the predicted value of output from the estimated coefficients.

If all farm households use FYM for farming or selling in the market then the standard resource allocation model emerges. However, as pointed out above the samples in this study are likely to be non-random due to the presence of corner solution. On average about 80 percent of the sample farmers participate in each option. A farmer's decision regarding her participation in FYM farming or selling may, however, be endogenously determined with the return from FYM. Hence direct estimation might lead to the potential sample selection bias. Therefore, following the approach of Shively and Fisher (2004) and Fisher et al (2005), a shadow value of FYM in on farm production is imputed by estimating participation in FYM farming and the value of marginal product jointly applying the maximum likelihood approach (Heckman 1974). The empirical identification of the model requires that, in addition to the exogenous variables both in the participation and outcome equations, one or more identifying variables are included only in the participation equation (Fischer et al 2005). The performance of the estimators arises from the existence of such exclusion restrictions. Consequently, in our enabling identification of the shadow value rests on certain potential variables, such as the average distance from home to farm; household's own means of transportation; off-farm income; herd size; distance to the most visited market center; size of cultivated land; whether household adopt stove and expenditure on alternative energy sources.

These variables hypothesized to affect the likelihood of participation in FYM farming through their influence on shadow values but not through the observed returns. Other variables enter both in participating and shadow value equations include: age, sex, education and marital status of the household head; location dummies; family size; proportion of area covered under legume for crop rotation and herd size. The estimated parameters from the marginal product equation are then used to estimate the shadow price of FYM in farming $(\boldsymbol{p}_f^*)$ for each farm household in the sample. A similar estimation method is motivated by an extension of Heckman's suggestion for imputing farmer's asking price for FYM or the shadow price in FYM marketing (the value that the farmer places on FYM for selling). Again, the estimation relies on two behavioral schedules: the function determining participation of a farm household in the market and the function determining the selling price equation.

Econometrics approach: FYM allocation

The specification of the econometric model for the analysis of FYM allocation is based on the three-way choice structure established in the previous section. Conceptually, farmer's FYM allocations are related one another among the available alternatives. This doesn't provide enough support to build separate models of allocation for each option, rather as a set to increase efficiency. But because these allocation outcomes are correlated statistically, it is expected that disturbance terms across models of each outcome might also be correlated. Such interconnectedness implies that OLS models, which assume absence of correlation among the disturbance terms, yield inefficient estimates of coefficients. A more efficient estimation technique in such case is the seemingly unrelated regression, or SURE (Zellner 1962). SURE relaxes the assumption of uncorrelated residuals and simultaneously estimates the three equations as set. The systems of equations for FYM farming, burning and selling respectively can be expressed more parsimoniously as:

$$m_f = \alpha_{ff} p_f^* + \alpha_{fs} p_s^* + \alpha_{f\delta}\delta + \alpha_{fz} z + \upsilon_f$$

$$m_e = \alpha_{ef} p_f^* + \alpha_{es} p_s^* + \alpha_{e\delta}\delta + \alpha_{ez} z + \upsilon_e$$

$$m_s = \alpha_{sf} p_f^* + \alpha_{ss} p_s^* + \alpha_{s\delta}\delta + \alpha_{sz} z + \upsilon_s$$

where α_{ik} is parameter to be estimated for the i^{th} equation and k^{th} variable

Each equation is expected to satisfy the assumptions of the classical regression model. However, if the regression disturbances in the different equations are mutually correlated then: $E\lfloor \upsilon_i, \upsilon_j \rfloor = \sigma_{ij}$ for *i, j = f, e, s*

That is, σ_{ij} is the covariance of the disturbances of the i^{th} and j^{th} equations, which is assumed to be constant over all observations, and is the link between the i^{th} and j^{th} equations.

The estimation procedure of SUR model was based on the Feasible Generalized Least Squares (FGLS[3]) approach. The Lagrange Multiplier test developed by Breush and Pagan (1980) will test the specification for SUR model with the null hypothesis of $\sigma_{mf} = \sigma_{ms} = \sigma_{sf} = 0$. The test statistic is given by:

$\lambda = N \sum_{i=2}^{3} \sum_{j=1}^{i-1} r_{ij}^2$; *where* $r_{ij}^2 = \frac{\sigma_{ij}^2}{\sigma_{ii}\sigma_{jj}}$, is the squared correlation. λ has χ^2 distribution with 3 degrees of freedom. If the test fails to reject the null hypothesis, estimation with SUR will be efficient.

Data and study areas

This study is based on data from household survey conducted in cereal-legume based mixed crop-livestock farming system of three zones in the central highlands of Ethiopia – east, west and north Shewa zones – fielded by the Ethiopian Institute of Agricultural Research (EIAR) in 2006. The three zones are found within the radius of 100 km from the main capital city of the country, Addis Ababa. This and the peri-urban areas surrounded the study areas are important market opportunities for farmers for their products and by-products. In particular the three zones are characterized by differences in the availability and use of the FYM resources and their access to FYM markets. The shorter the distance to the FYM market implies the higher the demand for FYM by the surrounding peri-urban communities and the lower the transaction cost and hence the higher the price of FYM. The empirical investigation is based on data acquired from 493 hundred farm households randomly selected and participated in this study. Table 2 contains the descriptions and summary statistics of the variables used in the analysis. Farmers also responded to hypothetical question elicited information regarding their time preferences using the experiment mentioned below.

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[3] The FGLS estimator of α is: $\alpha_{FGLS} = \left(y \hat{\Sigma}^{-1} y' \right)^{-1} y \hat{\Sigma}^{-1} m$; where y is vector of explanatory variable and $\hat{\Sigma} = \hat{\sigma}_{ij}$. The FGLS is a two-step estimator where OLS is used in the first step to obtain residuals and an estimator $\sum$. The second step compute α_{FGLS} based on the estimator $\sum$ in the first step.

In this study, for eliciting discount rates, choice task which is the most common experimental method for eliciting time preference (Frederick et al 2002; Holden et al 1998; Yesuf and Bluffstone 2009; Pender 1996; Bezabih 2009) is used. Here, subjects were asked to choose between a smaller, more immediate reward and a larger, more delayed reward. In this framework the respondents were asked to choose between the hypothetical future value payable after one year (almost one cropping season) equivalent to a fixed present value. A series of six binary choices between the specified amounts of wheat grain (50 kg) to be received now or the alternative amount of wheat grain (such as 65, 80, 105, 130, 160 and 195 kg) to be given a year later were presented in the order mentioned to show which option the farmer preferred within each choice pair (see annex 1 for basic structure). The choice of the alternative amounts for future rewards is based on taking the midpoint of the alternatives from the credit terms of the local merchant who often provide credit for cash constrained farmers for the purchase of farm inputs such as seed and fertilizer before planting; in agreement with repayment in kind with grain after harvest at about 100% rate of interest.

Empirical results

Shadow prices on FYM allocation

The estimated shadow prices predicted in the first stage of the analysis together with farmer's degree of impatience and other household demographic information were matched with the individual farm household FYM allocation data. The parameters of the various allocation equations for FYM are estimated by system of equations as a set of unrestricted seemingly unrelated regressions. The result is presented in Table 3. The statistical performance of the estimated models is quite appealing. The calculated χ^2-statistic of 2329.60 is statistically significant at 1% significance level, providing evidence for the hypothesis of joint significance of the explanatory variables across all equations. As expected, the Breush and Pagan (1980) test of independence confirmed the rejection of the null hypothesis that state the covariance of the error terms across equations are not correlated. The test[4] supports the estimation with SUR ($\chi^2(3)$ = 124.259 with the associated p-value of 0.000).

The point estimate of shadow price of FYM from selling $\left(\ell n\, p_s^*\right)$ and farming $\left(\ell n\, p_f^*\right)$ in the FYM farming equation is negative but individually statistically different from zero at 1% significance level for shadow selling price only. The negative sign of FYM shadow selling price in the farming equation indicates the expected cross-price elasticity that as the selling price of FYM increases allocation of FYM to farming decreases. The estimate for uncompensated elasticity is that a one percent increment of selling price of FYM leads to a more than one percent decline of FYM for farming. This is a negative response as far as the smallholder's soil fertility maintenance is concerned and implications on sustainable management of one of the most important natural resources. The available empirical evidence for expansion effect is the positive and statistically significant point estimates of off-farm income in FYM farming equation. As income increases by one percent, FYM for farming increases by about 1.3 percent. Hence the result conforms the negative uncompensated cross shadow selling price effect as a result of the negative compensated cross price effect dominated the positive expansion effect.

It is also worth noting the lack of statistical support for the effect of returns on FYM farming on FYM selling but the associated negative and significant effect on FYM burning. In the former case, there is no statistical evidence even that supports the income effects on FYM

[4] $\chi^2(3)$ = 106.57

selling. The negative cross-price effect on the latter (-0.21 percent) is due to the negative cross-price substitution effect that dominates the positive and significant expansion effect where the elasticity is estimated at about 4 percent due to a one percent increment in income. In fact, these results all together might imply that burning FYM is less beneficial relative to FYM farming and selling. Hence, with the change in returns of FYM in farming, farmers might consider the allocation of FYM for burning, considering the allocation of FYM for selling unchanged.

The point estimates for FYM selling price in FYM selling equation is positive and statistically different from zero at the 1% significance level. As expected, the finding reveals that farmers rationally responds to the change in shadow price of FYM selling in the allocation of FYM for selling. The positive uncompensated own price effect works primarily through the positive substitution effect which outweighs the income effect. According to this analysis, there is no statistical evidence that supports the significance of the income effects. Theoretically, holding any other variables constant, a change in selling price of FYM affects the rate of substitution between FYM burning at home and selling. As for allocating FYM for selling, it basically depends on the extent of the change in FYM for farming and the change in household's consumption of energy from FYM burning. The increase in shadow selling price of FYM increases the price in terms of burning at home, thereby making burning FYM more expensive. This substitution effect, therefore, tends to cut the amount of FYM allocated for household energy, while the expansion effect is positive and significant with an estimated elasticity of about 27 percent for a one percent increment of off-farm income. On the net, the uncompensated cross-price elasticity is positive, which is about 1.1 percent.

Farmer's impatience on allocation of FYM

When the respondent preference shifts from the early amounts to the amount for a later reward, the implicit one year rate of time preference was calculated as follows: $\boldsymbol{\delta} = \ell\boldsymbol{n}\left(\boldsymbol{f}/\boldsymbol{p}\right)$, where the respondent is indifferent between an amount of 'p' at the current time and a reward of 'f ' received one year in the future. The mean discount rate in this experiment is about 94%. Pender (1996), however, has reported a discount rate of 30 - 60% for Indian villages, whereas Holden et al (1998) found a mean discount rate of 93% for Indonesia, 104% for Zambia, and 53% for one village in Ethiopia. Similar to Holden et al (1998) and Pender (1996) who found an upward bias from their experiment that asked farmers to adjust a present value equivalent to a fixed future value, about 64 per cent of farmers in this study were found to have a high discount rate (95 – 135%), in an experiment that asks the future value equivalent to a fixed present value, however (Fig. 1).

The data enabled us to link survey responses on FYM allocations from farm households to experimental responses by the same farm households. The key factor for the allocation of FYM among the available options is the trade-off between farm profitability due to soil fertility enhancement but with delay; and immediate earning or energy consumption from direct selling or own burning. This lets the decision makers to make comparisons between alternative options that have immediate or delayed outcomes. From the foregoing discussions, the marginal returns of FYM in farming is higher than the price of FYM from selling in the market, but that the former is with delayed outcomes and the latter with immediate benefits. As an inter-temporal choices in terms of motives associated with time, the economic trade-offs is a decision about allocating resources between the competing interests, such as farming or burning, hence including the farmers' degree of impatience measured with subjective discount rate is of important. The parameter estimates for the farmer's time preference are in agreement with the expectation in the FYM allocation equations. The point estimate of farmer's degree of impatience in the FYM selling equation is statistically different from zero at the 90% confidence level. The positive sign indicates farmers that have high degree of impatience increase allocation of FYM for selling.

Noting the theory that people have a positive time preference shows preference for receiving a commodity immediately are perfectly observed in the FYM selling equation. In FYM selling, farmers usually receive the return immediately so that, it is a chosen option among the available ones as far as impatient farm households are concerned. On the contrary, farmer's degree of impatience negatively affects the allocation of FYM in farming and burning, but at 90 and 88 percent confidence level, respectively. The outcome of allocating FYM in farming is quite remote due to the seasonality in agriculture, forcing the impatient farmers to switch away from FYM farming. This result is in perfect agreement with other few studies that combine the time preference experiments with field observations for better understanding of field behavior. The empirical study in Ethiopia (Shiferaw and Holden 1998) found a negative correlation between individual's rate of time preference and adoption of soil conservation technologies. In Brazil, fishermen who are impatient in a time preference experiment exploit the fishing grounds more (Fehr and Leibbrandt 2008); and in Sri Lanka people with higher rate of time preference extract more non-timber forest products causing depletion of forest resources (Gunatilake et al 2007). Table 3 also provides several factors that are plainly to play as determinants of the allocation of FYM among the different options.

Conclusions

The causes of soil fertility depletion extend beyond the farm, receiving effects from household economic conditions in ways disregard by most economic models. Here, a fundamental question in sustainable resource management is the extent to which resource allocation is linked to market fundamentals and basic features of farmers' preferences. A better understanding of the determinants of farmer's FYM allocations is essential for informing policies and programs aimed at improving and maintaining soil management system. The returns from selling FYM will increase as the demand for biomass fuel rises and supply declines. In Ethiopia, because of the continuous lifting of subsidies and rising tariffs of kerosene, and poor electricity infrastructure and rapid population growth in the urban and peri-urban areas, sales of FYM to the consumers in these areas seems promising.

Even though time preference plays a substantial role in investment, as evidenced in this study, the relationship between other economic variables and time preference as indicated by Holden et al (1998) is an important policy direction. Poor people are less patient are well documented (Holden et al 1998; Pender 1996; Tanaka et al 2010) suggesting economic development could influence preferences. Poverty is playing important role in that poor farmers are degrading the natural resource base (Shively and Pagiola 2004) and poor are less likely to invest in environmental conservation (Holden et al 1998). The influence of poverty is irrational because the pressure of present needs blinds a person to the needs of the future (Becker and Mulligan 1997). This implies the appropriate policies targeted on poverty reduction can potentially reduce farmers' impatience.

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Table 1. Mean (standard deviations) for FYM shares by purposes and location

Purpose	North Shewa	West Shewa	East Shewa	Total
FYM produced (ton/annum)	9.33 (8.18)	12.67 (16.69)	6.98 (10.11)	9.17 (10.57)
Farming (m_f)	0.27 (0.26)	0.32 (0.20)	0.46 (0.23)	0.34 (0.25)
Selling (m_s)	0.42 (0.27)	0.36 (0.25)	0.31 (0.23)	0.38 (0.26)
Household Energy (m_e)	0.31 (0.25)	0.31 (0.24)	0.23 (0.22)	0.28 (0.24)
Number of observations	278	75	140	493

Table 2. Definitions, means and standard deviations of variables used in the regressions

Variable	Description	Mean	Std. Dev.
OUTVALU	Total output value (2006 ETB)	16658.81	17206.74
$\boldsymbol{p}_f^*$	Predicted shadow price of FYM for farming, ETB/ton	1018.30	568.82
$\boldsymbol{p}_s^*$	Predicted shadow price of FYM for selling, ETB/ton	667.26	92.49
DISCOUNT	Farmer’s discount rate	0.94	0.33
ZONE-1	Dummy: if location is north Shewa	0.42	
ZONE-2	Dummy: if location is west Shewa	0.15	
SEX	Dummy: 1 if male headed household	0.88	
MARITAL	Dummy: 1 if married	0.86	
EDUCATON	Years of education	4.08	4.11
AGE	Age of the household head, yrs	46.14	12.90
FAMLYSIZ	Total family size (in adult equivalent[5])	4.69	1.80
MALFAMLSIZ	Male family size (in adult equivalent)	2.62	1.34
FEMFAMLSIZ	Female family size (in adult equivalent)	2.07	0.98
FERTILIZER	Inorganic fertilizer applied, kg	38.72	37.31
FERTEXPEN	Total expenditure on commercial fertilizer, ETB	241.53	233.21
BULOCK	Bullock services, hrs	281.08	210.48
SEED	Seed used, kg	105.96	80.85
FARMLABR	Labor for farming, hrs	664.45	223.54
CROPAREA	Cropped area, ha	2.33	1.71
MODERNVAR	Fraction of area with modern crop varieties	0.89	0.57
PRIVATGRAZ	Private grazing area, ha	0.07	0.01
COMPOUND	Size of the compound/garden (sq. meter)	405.99	143.65
EXTNFREQ	Frequency of extension contact per month	0.49	0.44
DEMONVISIT	Dummy 1: if ever visited demonstration field	0.41	
DISTFARM	Average distance from home to farming plot, hrs	0.27	0.17
DISTMKT	Distance to market	0.16	0.16
ROTATION	Fraction of area rotated with legume crops	0.21	0.18
GOODSOIL	Fraction of area with good quality soil	0.35	0.05
EQUB	Dummy: 1 if participated on rotating saving and credit club	0.44	
DONKEY	Number of donkey owned	1.66	1.65
OFFINCOM	Offarm income, ETB	111.59	231.11
TLU	Herd size (in TLU[6])	6.73	4.09
KEROSEN	Annual expenditure on kerosen, ETB	173.02	157.18
TREE	Number of trees owned	98.40	124.11
STOVUSE	Dummy: 1 if use energy saving stove	0.49	

[5] Adapted the Amsterdam scale (see Deaton and Muellbauer 1980)
[6] 1 TLU (which equals 250 kg body mass) = 1 cattle = 6.67 sheep/goat = 1 horse = 1.15 mule = 1.54 donkey = 0.87 mule = 200 poultry

Table 3. Maximum likelihood estimates for FYM allocation

	Farming		Selling		Energy	
Variables	Coefficients	Std. Err.	Coefficients	Std. Err.	Coefficient	Std. Err.
CONSTANT	5.608***	2.291	-15.389***	5.345	-4.919	4.509
$\ell n\ p_f^*$	-0.055	0.059	0.193	0.138	-0.205*	0.116
$\ell n\ p_s^*$	-1.018***	0.338	2.365***	0.789	1.107*	0.666
DISCOUNT	-3.374*	1.874	10.161**	4.372	-5.802	3.689
OFFINCOM (10^{-3})	0.115	0.059	-0.074	0.138	0.243**	0.117
AGE	-0.005	0.007	-0.017	0.017	-0.044***	0.015
AGESQR (10^{-3})	0.071	0.071	0.139	0.166	0.332*	0.140
SEX	-0.118**	0.056	-0.042	0.130	-0.226**	0.110
MARITAL	0.046	0.048	-0.064	0.112	0.248***	0.095
MALFAMLSIZ	0.015	0.011	0.029	0.025	0.030	0.021
FEMFAMLSIZ	0.025*	0.014	-0.004	0.033	0.003	0.028
EDUCATION	0.006*	0.004	0.007	0.009	0.022***	0.007
FERTVALU (10^{-3})	0.075	0.066	1.181***	0.153	1.294***	0.129
ROTATION	0.067	0.082	0.273	0.191	0.631***	0.161
DISTMKT	0.039	0.530	0.838	1.237	-1.721*	1.044
DISTFARM	0.074	0.080	0.029	0.186	0.001	0.157
DONKEY	-0.043***	0.012	-0.034	0.028	-0.024	0.024
CROPAREA	-0.015	0.048	-0.119	0.112	0.242***	0.095
PRIVATGRAZ	2.562*	1.368	-2.844	3.192	0.384	2.693
COMPOUND	0.870***	0.289	-1.558**	0.674	0.901	0.569
KEROSEN (10^{-3})	0.061	0.115	-0.238	0.268	0.516**	0.226
TREE (10^{-3})	0.145	0.115	-0.164	0.267	0.056	0.225
TLU	0.023***	0.005	0.015	0.012	0.027***	0.010
STOVUSE	0.016	0.035	0.213***	0.083	-0.164***	0.070
ZONE-1	-0.046	0.068	0.444***	0.159	0.337***	0.134
ZONE-2	0.046	0.056	0.211*	0.130	0.187*	0.109
$\chi^2(25)$	3486.22		158.26		404.91	
p-value	0.000		0.000		0.000	
Observation	493		493		493	

Annex 1. Structure of the time preference experiment and farmer's discount rate

Instruction: We would like to know your preference about taking wheat grain now compared with a wheat grain after a year. Please indicate for each of the following certain number of choices, whether you would prefer the smaller amount of wheat to receive now or the bigger amount of wheat to take later one year from now. For instance, which one would you choose: 50 kg wheat now or 65 kg wheat exactly after one year?

Choice	Nominal Size in kg of wheat		Rate of time preference* (**δ**), %	Discount Rate Class
	Now (*p*)	12 months (*f*)		
1	50	65	26	Almost neutral
2	50	80	47	Slight
3	50	105	74	Moderate
4	50	130	96	Intermediate
5	50	160	116	Severe
6	50	195	136	Extreme

*The implicit one-year discount rate: $\delta = \ell n(f/p)$

Figure 1. Farmers' discount rate responses for future value equivalents