Incentives, opportunity costs and contract design for on-farm conservation in Ethiopia

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The Economics of Incentive Mechanisms for Biodiversity Conservation:
Contract Mechanisms

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Abstract

Among the in-situ and ex-situ conservation options available to conserve crop genetic resources (CGRs), on-farm conservation has recently attracted massive attention from concerned organizations. To make this option operational, placing incentives and removal of perverse incentives are believed to be crucial so that landraces of no immediate interest to farmers can be conserved. However, before placing sound incentives and designing contracts with farmers, we have to understand farmers' motives for managing portfolio of traditional varieties and the opportunity costs they face when they are expected to use landraces. This paper empirically examines farmers' incentives and generates the opportunity costs they are facing based on a household survey data collected from 198 sorghum growing farmers in Eastern Ethiopia.

To study farmers' incentives to maintain native varieties, we have adopted a utility-based model that considers on-farm diversity as a positive externality of farmers' livelihood decisions. Accordingly, on-farm diversity is considered as the derived outcome of farmers' revealed preferences subject to their concerns and constraints. Using such a framework, Poisson regression model is estimated. Opportunity costs are generated using different homogeneous treatment statistical models and further they are examined using switching regression model. As usual the paper concludes outlining the policy implications of the empirical findings to design contracts for on-farm conservation of CGRs.

Key words: Incentives, opportunity costs, contract design, on-farm conservation of CGRs, Ethiopia

1. Introduction

Crop genetic resources (CGRs) are the building blocks of sustainable agricultural development for their role not only as inputs for variety development but also as indigenous crop insurance

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mechanisms through traditional variety portfolio management. The success of agriculture as the mainstay of the Ethiopian economy is closely related to the potential of the different crop varieties to perform under various stress conditions (disease, pests, and drought) and in marginal areas.

Many official documents show that CGRs loss is one of the problems in Ethiopia mainly driven by human and natural factors (FDRE, 1997, 1998). Although ex situ conservation is still dominantly utilized for CGRs conservation, on-farm conservation has recently received a considerable attention by governments, NGOs and the international community. Taking ex-situ and in-situ as complementary, the preference for on-farm conservation is due to its dynamic feature to allow the genetic resources to adapt themselves to the natural and socio-economic environment. Recently, Ethiopia is experiencing new on-farm conservation ventures through diligent initiatives of the Institute of Biodiversity Conservation and Research (IBCR). For instance, in South Welo, nine sorghum and three teff farmers' varieties are being conserved on-farm (Demissie and Arega, 2000). However, the activities are yet far from being institutionalized. Despite a lot of discourse in favor of on-farm genetic resource conservation, there is no adequate contextual research done as to how feasible contracts can be designed with farmers.

The crop diversity existing in Ethiopia has largely developed through thousands of years of farming practices by the local farmers and conservation on-farm by local farmers has been there since the cradle of agriculture in Ethiopia (Demissie and Arega, 2000). Of course, farmers know more than any one else that diversity means security (Bayetta, et.al, 1998). While farmers are planting indigenous varieties of their interest, there could be TVs not of interest for any farmer (resulting in possible extinction). Hence, the government needs to undertake conservation ventures of which one is designing contract mechanisms meant for on-farm conservation. However, before designing sound contract mechanisms for promoting on-farm conservation, decision-makers have to be informed as to why or why not farmers are diversifying on TVs varieties and what opportunity costs they are paying when they plant TVs.

If farmers do not maintain certain TVs because they do not fit to their survival strategies and the society still wants them to maintain those TVs, the government can influence their variety choice behavior. To this end, one needs to face the following issues: Which farm households should be targeted? Where should the on-farm conservation site be? How high should the financial compensation be? What other types of non-financial incentives are required?

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Currently, even though the IBCR is undertaking on-farm conservation, selection of farmers for the purpose is rather ad-hoc. For instance, in Tigray, the farmers selected for on-farm conservation were said to be open minded and highly motivated, rich in indigenous knowledge, ready and willing to participate in the conservation of their crop varieties and maintaining their cultural heritage (Demissie and Arega, 2000). The criteria of site selection for in-situ conservation is ad hoc not only in Ethiopia but in other countries too. For instance, in India (Saxena et.al, 2003) it is done based on the availability of a wide range of diversity, ecological heterogeneity, possibility of monitoring, and accessibility for monitoring and management. Most morphological and molecular diversity studies identify sites with high diversity index and consider those sites as ideal sites for in-situ conservation strategy (Engels and Hawkes, 1991).

As a first step in the contract design, the paper first identifies the farm household, market and agro-ecological factors behind farmers' motives to diversify on traditional variety (ies) (hereafter TVs). To get insight on the level of compensation, the paper then generates opportunity costs and examines the factors affecting them. Thus, the specific objectives of the paper include:

1. Study farmers' incentives to diversify on indigenous varieties;
2. Estimate the opportunity cost (in terms of GM foregone) of maintaining traditional varieties and the contextual factors affecting them; and
3. Based on 1 and 2, generate information required for designing different contractual mechanisms for on-farm conservation of sorghum genetic resources in Ethiopia.

Sorghum in Ethiopia is taken as an example for the empirical estimation. Ethiopia, as the center of origin and diversity for many crops (e.g., teff, coffee arabica, enset and sorghum), can be a very good example of genetic resource rich countries with meager financial means to undertake costly conservation programs (von Braun and Virchow, 1996).

To achieve its objectives, the remaining part of this paper is structured as follows. Section 2 deals with the potential role of understanding farmers' incentives and the opportunity costs in the contract design. The theoretical framework for the models considered and the institutional actors in the contract design are presented in section 3. Data description, the regression results and the contract design are the subjects of section 4. Section 5 concludes and presents the policy implications.

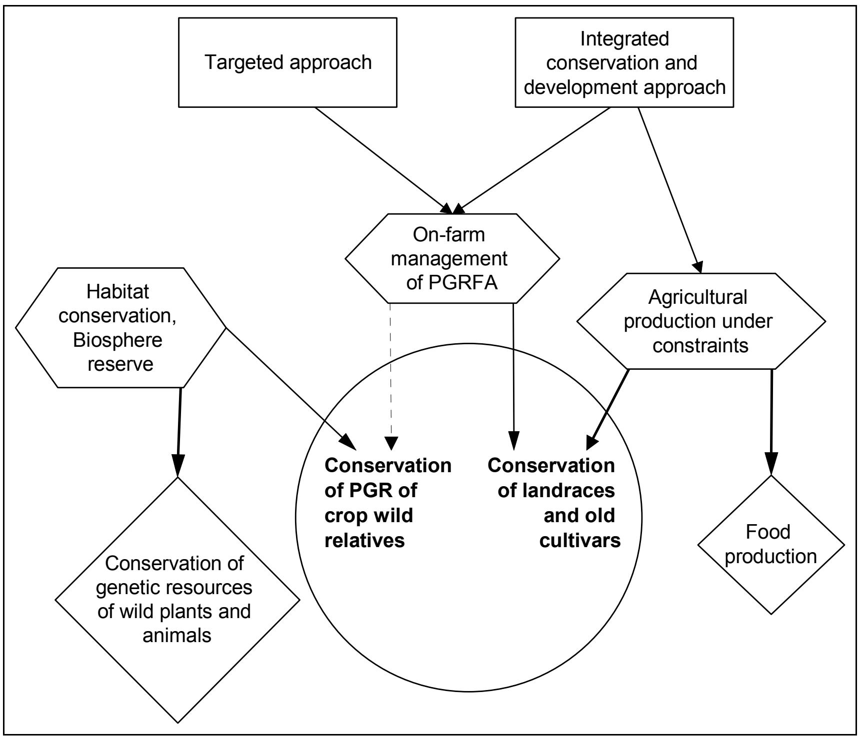
2. Incentives and the opportunity costs in the contract design

The issue that policy faces is how to select the farmers to work with and impose an optimal level of effort by the farmers (number and types of TVs to be maintained on-farm). Analyzing their incentives will be an input to the first endeavor and the opportunity costs will be an input to the second. Hence, the empirical results of section 4 are the inputs to design contracts that are in line with farmers' expectations. But to begin with, the conceptual framework of in situ conservation for CGR is discussed.

2.1. The conceptual framework for in situ conservation for CGRs

The conceptual framework for in situ conservation for CGRs is just emerging. In situ conservation for CGRs is conceptualized here as on-farm management of TVs. The different in situ conservation methods can be systematized according to the major objective of the activity (see Fig. 1). On the one hand, there is the conservation of crop wild relatives, mainly a by-product of conservation of general natural areas in kind of - among others - biosphere or natural reserves and habitat conservation. Only seldom and more in recent times, natural reserves are established explicitly for the conservation of crop wild relatives. The other major part of in situ conservation is the on-farm management for the conservation of TVs. Until now programs for on-farm management of CGRs have been rarely implemented and rarely documented in the scientific literature (Virchow, 1999).

Figure 1: In situ conservation of CGRs



Source: Virchow, 1999

In addition to these designed and implemented programs, on-farm conservation of crop genetic resources is carried out by numerous farmers all over the world. These farmers live in complex, diverse, risk-prone environments, where local livelihoods depend on subsistence farming. They do not have the explicit objective to conserve TVs, but rather to produce food and other agricultural products.

The concept of on-farm management and improvement *provides a mechanism by which the evolutionary systems that are responsible for the generation of variability are conserved* (Worede, 1992). The level of intra-species diversity in CGRs is a result of manifold impacts and does not remain static, but rather continues to evolve.

The advocates of on farm management stress the importance of local systems of knowledge and management, local institutions and social organization as well as several other cultural and socio-economic factorswhich determined the diversity development in the past and which will continue to maintain and develop the diversity at present and in the future.As depicted in Figure 1, existing on-farm management programs can be categorized into (Virchow, 1999):

*Targeted approaches*which prioritize the conservation impact of TVs with significant interest at local, national, regional, or global levels. Furthermore, the increased supply of enhanced seed for breeders and farmers revolving from the activities are also of relevance (Altieri et al., 1987). One of the first "targeted approaches" was initiated in 1988 in Ethiopia. In the drought-prone areas of Welo and Shewa provinces 21 farms were selected for the project, covering sorghum, chickpeas, teff, field peas and maize[4] (Cooper and Cromwell, 1994).

*Integrated conservation and development approaches*which usually link the conservation of TVs with specific values to the cultivation of these varieties directly. These valuable varieties are introduced or reintroduced to a certain agro-ecological region or production systems. Additionally, these valuable varieties are promoted for breeding and adaptation purposes on farmers' sites, the so called participatory plant breeding. Breeders have increasingly turned to such sources and turned away from traditional collections, in which variability is stored in a static state (NRC, 1993). Programs with this approach involve often NGOs in "grass roots" CGRs activities, e.g., the MASIPAG Program (Farmer-Scientist Partnership for the Advancement of Science and Agriculture) (Vicente, 1994).In the following sub-sections, the discussion concentrates on the targeted approaches.

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[4] In collaboration with the IBCR, farmers select populations grown in their fields by phenotype. The populations are maintained as distinct from each other, although the system allows for pooling similar landraces and even the introgression of valuable genes from exotic sources (Cooper and Cromwell, 1994).

2.2. The role of understanding farmers' incentives for contract design

Understanding farmers' incentives to manage multiple traditional varieties is important, among other things, to identify farmers for on-farm conservation, to harmonize farmers' objectives with conservation endeavors, to locate where government can do the on-farm conservation itself and where it can delegate, to efficiently conserve crop genetic diversity, and to design specific types of contracts to be put in place.

Once we identify the incentive factors facilitating or impeding the contract, the next step is to find representative farm household types (risk averse farm households, risk taking farm households, farm households in accessible areas, farm households in remote areas, resource poor farmers, resource rich farmers and so on) and representative localities for on-farm conservation (hot-spots, endangered areas, areas where the CGR to be conserved is a minor crop, areas where the CGR to be conserved is a major crop, drought prone areas, relatively risk free areas, land abundant areas, and land scarce areas). Once representative farmers and localities are selected from each stratum, the last step is to start the negotiation and the contract design. Before starting the contract design, we need to ask, 'what do farmers expect?' The next sub-section argues that their expectations and thereby the compensations are determined by the opportunity costs they are facing.

2.3. The role of opportunity costs for contract design

One of the means to create incentives for farmers to participate in on-farm conservation ventures is to compensate what they are losing when we want them to change their variety choice behavior. Any loss (which can be monetary or non-monetary) faced by farmers when they change their variety choice behavior is what we call the opportunity cost of changing variety use.

Of course, farmers can not afford to maintain diversity on their farms just for the sake of conservation alone. If government recognizes their role for safeguarding indigenous TVs, in-built incentives should be available. Many incentive schemes are based on cost data (Laffont and Tirole, 1993). In the present case, the cost data is considering what happens to the farm household when the contract is implemented *i.e.* the farmer is expected to plant TVs worth maintaining on-farm.

Considering the gross margin from the improved variety (ies) (here after IVs) as the next best alternative use sorghum farmers' land, we will compute the financial opportunity costs of maintaining traditional varieties. In doing so, the intention is to understand which farmers are paying higher opportunity costs and the vice versa. The lower the predicted probability of TV survival (higher incentive for the society to maintain TVs), the higher will be farmers' opportunity costs (Smale, 2003). Thus the incentives (section 2.3) are inversely related with opportunity costs.

Computing opportunity costs will have important role in the contract design because the bargaining power of the farm households is mainly a function of the opportunity costs they face.

If the compensation is linear payment based on the opportunity cost at a point in time, fulfilling farmers' expectations in the contract design requires paying the opportunity costs of maintaining TVs on-farm. While computing the average opportunity costs can give indication on the levels of compensation, analysis on the factors affecting opportunity costs can help us to understand the conditions under which lower (higher) payments are called for.

2.4. The stakeholders in the contract design

The purpose of participatory rural development approaches like participatory plant breeding (PPB) is to inculcate farmers' tastes, preferences and values into the breeding process. By the same token, if one envisages promoting participatory on-farm conservation ventures, farmers' incentives have to be part of the endeavor in line with the interests of other stakeholders.

As far as contracts are concerned, we need to address the following questions. How should the stakeholders interact? On what basis should the government set the level and type of payment to farmers? What factors determine the decision to follow either a fixed payment schedule or flexible incentive schemes? Given that long-term contracts are incomplete, should the government follow long-term or short-term contracts[5]? When is it better for the government (or a responsible governmental organization like IBCR in Ethiopia) to undertake conservation on-farm by itself and when is it better to delegate to the farmers?

A contract is an agreement under which two parties (in our case farmers and the government) make reciprocal commitments in terms of their behavior to coordinate (Laffont and Tirole, 1993). It is meant to solve the conflict of interests between the contracting parties (Theilen, 1996). Is there any incentive for farmers to act against the interest of the government (conservation of CGRs on-farm)? If there is any moral hazard problem from the farmers' side, it can be reduced by fulfilling their expectations in the "without contract scenario".

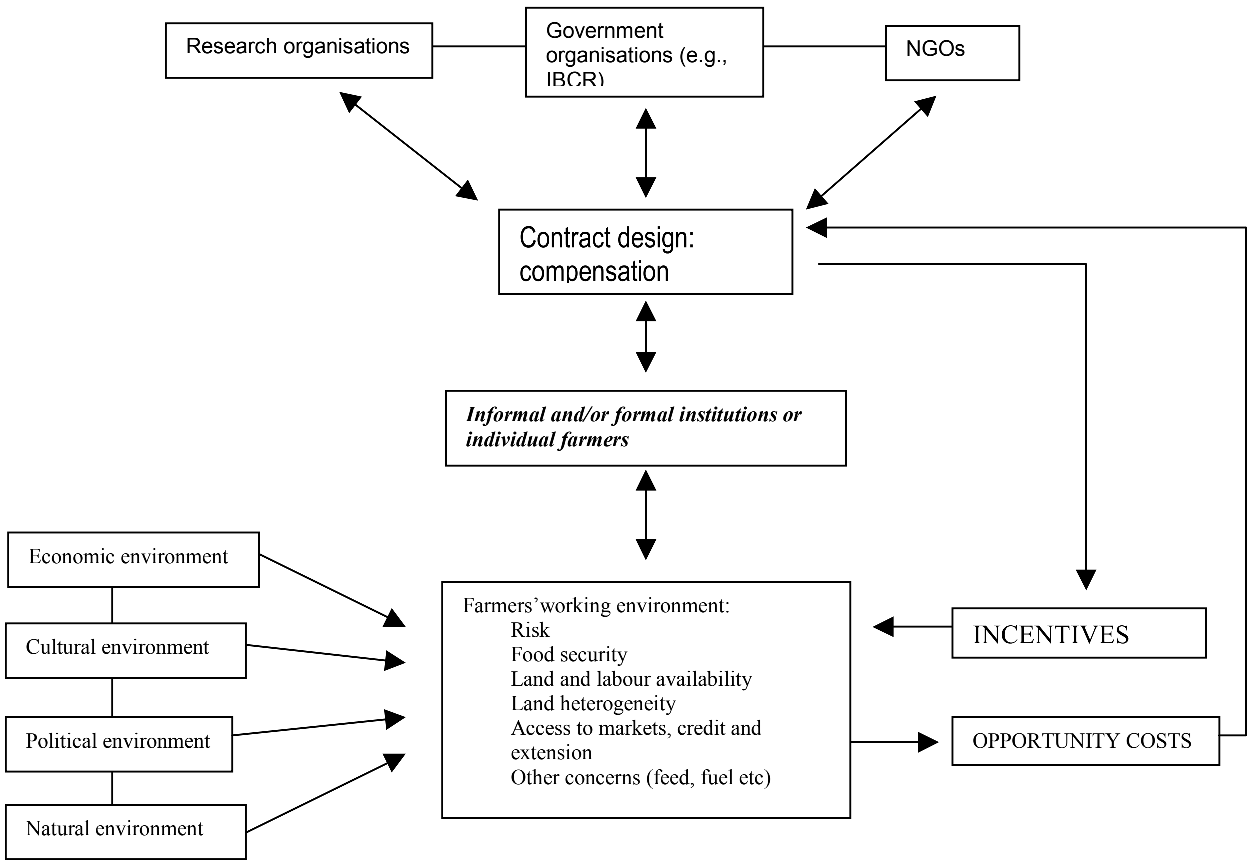
For those farmers who are *de facto* conserving CGRs, there is no strong incentive to act against the interest of the government while for those farmers who are not maintaining TVs *de facto*, it may give sense to default even after the contract. One step in reducing the effect of this problem on the outcome (conservation of CGRs) is to understand factors motivating farmers to conserve traditional varieties *de facto* and those which have an unfavorable role. Once this is done, the other subsequent step is to compare farmers' livelihood in the 'with' and 'with-out' the contract

[5] *Ceteris paribus*, long-term contracts may be called for perennial crops like coffee.

scenarios and put in place the rules of the game depending on the welfare losses farmers are making in the 'with' contract case.

Regarding on-farm conservation of crop diversity, there are different stake-holders that need to coordinate and harmonize their efforts. Accordingly, the contract design could involve besides the IBCR and the farmers, local community groups and informal institutions, research organizations, local and national government organizations, NGOs, the business community, and private seed companies (national or international). Figure 2 depicts the possible interaction among the potential stakeholders in the contract design.

Figure 2: Institutional interactions among the stakeholders in the contract design for on-farm conservation



Source: Own schematic presentation

As depicted in Figure 2 above, the political, policy, economic, cultural and natural settings along with farmers' conditions (sensitivity to potential risk, resource endowment, access to markets and so on) determine their incentives to maintain traditional varieties and the level of opportunity costs they face. Depending on their incentives and the opportunity costs, contracts and the levels of compensation will have to be set preferably taking informal institutions as intermediaries to reduce transaction costs. The stake-holders on the top of the scheme are those concerned with loss of diversity in the country.

If it is the political will of the Ethiopian government to maintain the diversity of CGRs on farmers' fields, on-farm conservation demands linking their conservation and utilization by farmers with benefit sharing and utilization by companies or research centers so that the latter can take part in the cost recovery process.

What is the role of informal and / or formal institutions? To make on-farm conservation more long lasting and to reduce costs of negotiation and contract formation, the incentive structures could involve not just individual farmers but communities. To this end, there are indigenous informal and formal institutions established by the local community or existing formal institutions utilized to discharge different socio-economic activities (including labor sharing, rural finance, funeral and other self-help institutional arrangements). Instead of dealing with many farmers individually, these institutions can be used as mediators in the design of sensible contracts for transaction cost reasons.

In general, there are two groups of stake-holders in the above scheme – the farmers and the rest. For our purpose, we shall assume that the objectives of the other stakeholders are the same, at least regarding on-farm conservation. Hence, we will have two contracting parties *i.e.* the government and its alliances and the farmers. To make the contract operational, we basically need to understand farmers' behavior and working environment. To the subsistent farmers, the value of conserving diversity lies in its use and the benefits and services they gain from its conservation (Regassa, 2002). Due to their long lasting role in the on-farm conservation exercise, the rest of the stakeholders need to be informed on incentives and opportunity costs so that they can face the challenging task of finding the optimal mix of contractual design mechanisms that can harmonize farmers' objective functions.

In the framework of the principal agent theory, which is the subset of contract theory, there is said to be problem of asymmetric information *i.e.* the principal (government or its agencies) does not know fully the factors that motivate the agent (farmers) to act in a certain way. Thus, the empirical results of this paper (section 4) are meant to reveal this information to the principal in such a way that it can be used to select the farmers for the contract, to determine the types and levels of compensation and to monitor their ex-post behavior. The problem for the principal in designing a contract should be reduced if policy is informed as to why or why not the agent behaves in a certain way.

3. Conceptual framework and methodology

3.1. Farmers' utility maximization and the contract design process

There are two extreme options for farmers, which should be seen as a continuum, as far as variety choice is concerned: specializing in a single variety or dealing with all the available set of varieties in the area. For a farmer to opt for a single variety, the following ideal conditions have to be in place. A single variety should satisfy all farmers' concerns. There should be a well functioning market to exchange the different varieties. Farmers should be indifferent between using own produced and bought crop varieties. Their input endowments should be equally suitable for a single variety. Had profit been farmers' single household objective and had there been *constant returns to scale* for every variety, specialization would have been the rule and species diversity on each farm would have been zero[6]. Of course, these conditions do not hold in almost all the cases.

Reviewing the available literature reveals that the possible factors under play are markets, income diversification motives, heterogeneity of farmers' resources (mainly land), resource endowment (education, labor, and wealth), multiplicity of farmers' concerns (livestock ownership, poverty and risk) and the impossibility to address these concerns with a single variety. Depending on the prevalence of these factors, we can define mutually exclusive farm household types with whom different contractual schemes can be designed.

The theoretical formulation of the utility-based household model follows van Dusen (2000) who derives the diversity function inculcating missing markets and risk step by step. Farmers' preferences for varieties are conditioned on different preference parameters. Assuming a well behaved utility function, the farmers' utility maximization problem can be set as:

$$Max:\ U = U(G_f, G_p / \varpi_0) \qquad \text{Utility function (3.1.1)}$$

where G_f and G_p refer to aggregate consumption of on-farm produced and aggregate purchased goods, respectively[7]. ϖ_0 refers to the vector of household level exogenous factors. The utility is subject to full income, cash, labor, livestock feed, land, and production technology constraints. Given its objective and the constraints, the household chooses a set of varieties, crop enterprises and input levels to arrive at the optimum level of production from each enterprise. While trying to meet their objectives, farm households not only produce and consume crop output but also

[6] Diversity may or may not occur at the regional or national level depending on the diversity across locations.
[7] Quantities of goods produced are aggregated here for simplifying the exposition. Multiple output production can also be derived similarly (Singh and Subramanian, 1986).

maintain diverse set of crops and TVs of crops (D_{dd}) year after year as a positive externality of their farm decisions *i.e.*

$$D_{dd} = \left[\sum_{i=1}^{n} v_i / \sum_{i=1}^{m} CE_i ; \varpi_0 \right] \qquad \text{Indigenous variety diversification (3.1.2)}$$

where v_i's index TVs and CE_i's index crop enterprises selected from the opportunity set, respectively, so that v_i and CE_i take 1 if the household chooses the variety or the crop enterprise, and zero otherwise, respectively.

Market access and lower transaction costs simplify farmers' life and nullify the need for farmers to be self-sufficient (de Janvry, Fafchamps and Sadoulet, 1991) and as a result the production of diversity on each farm will shrink (Bellon, 1996). Thus, missing markets bring additional input and output constraints by forcing farmers to be self-sufficient. Given this constraint, the utility function is:

$$Max: \; U = U(G_f, G_p, NM_g / \varpi_1) \qquad \text{Utility function with missing market (3.1.3)}$$

ϖ_1 includes ϖ_0 plus constraints related to access to input and output markets. Missing markets force farmers to balance the quantity of non-marketed goods (NM_g) to houseold demand (HH_{dd}), labor demand to own labor supply, cash demand to own cash sources, and land use to own land.

The optimum level of production of the traded and non-traded goods with incomplete markets will then be:

$$G = G(G_f^*, G_m^*, NM_g^*; \varpi_1) \qquad \text{Optimum production with missing markets (3.1.4)}$$

Replacing ϖ_0 with ϖ_1, the diversity outcome represented by equation 2.1.B will then follow.

The next most important variable worth considering is risk. While risk is forcing farmers to take cautionary measures, their reaction to it mainly depends on their sensitivity to potential shocks which, in turn, is highly conditioned by their wealth status. While wealthy farmers can smoothen consumption, non-wealthy farmers are highly sensitive to potential farm income variability. Moreover, the marginal pain from the potential loss is more important for the resource poor farmers.

One of the indigenous means to deal with risk is traditional variety portfolio management. To study the linkage between farmers' variety diversification and risk, we take the results of previous literature that synthesize relationships among risk, consumption smoothing, crop choice and wealth (Rothenzweig and Binswanger, 1993; Murduch, 1995; Dercon, 1996) and adapt Roy's safety first model (Roy, 1952).

According to the safety first model, farmers are assumed to be trading expected return for reduced risk *i.e.* if there is expected higher net return with higher yield risk (say from adopting an improved variety) and / or lower expected net return with lower yield variability (say from using multiple TVs), the decision of the farmer depends on the extent to which the household is able to fulfill basic household needs ($Basic_{req}$) from its internal endowment (wealth plus risk free income denoted as FN_{income}). The farmer's objective is thus to minimize the probability that FN_{income} falls short of $Basic_{req}$ *i.e.*

$$\text{Min } P(FN_{income} < Basic_{req}) \Rightarrow P(FN_{income} - Basic_{req} < 0) \qquad \text{Farmers' 'survival first' motive (3.1.5)}$$

Accordingly, the farmer will gamble with nature if $FN_{income} > Basic_{req}$ and he/she will take more cautionary measures if $FN_{income} < Basic_{req}$. In our case, FN_{income} is computed as the sum of the value of livestock, annual ch'tat income and annual estimated income from non-farm income sources[8].

Given this framework, risk is proxied by the extent to which the farm household is able to satisfy $Basic_{req}$. Putting both FN_{income} and $Basic_{req}$ on per-capita basis,

$$Risk_{proxy} = GAPPC = SAFTYPC - REQPC \qquad \text{Risk derived from 'survival first' (3.1.6)}$$

where SAFTYPC and REQPC are $\text{FN}_{\text{income}}$ and $\text{Basic}_{\text{req}}$ divided by number of household members, respectively. Inculcating risk in the derivation of the optimum level of production:

$$G = G(G_f^*, G_m^*, NM_g^*; \varpi_2) \qquad \text{Optimum production with risk and missing markets (3.1.7)}$$

where ϖ_2 refers to ϖ_1 and other household concerns (risk and safety first). As far as risk is concerned, the hypothesis to be tested is, therefore, the more negative *GAPPC* is the higher will be farmers' incentive to diversify to stabilize farm income.

What kind of econometric model can be used? To explain farmers' incentives to diversify, we shall consider the process of diversity production as involving a set of discrete choice decisions by millions of farmers. Suppose the number of varieties on each farm (D_{dd}) is given by:

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[8] We used not only income but also wealth variables to compute FN_{income} because farmers sell their wealth when income falls short of current consumption needs. Farm income during the cropping season is not part of FN_{income} because it is not risk free income based on which future variety choice decisions can be made. Household level data were collected on $Basic_{req}$ and components of FN_{income}.

$$D_{dd} = \left[\sum_{i=1}^{n} v_i \,\varpi_2 \right]$$ Farmers' incentives for indigenous variety diversification (3.1.8)

where v_i takes 1 if a farmer has the variety and zero other wise.

Thus, there are multiple variety use decisions (by millions of farmers) resulting in multiple varieties on-farm (D_{dd}) and cumulatively contributing to *'D_R'*. The summation of a series of discrete choices can be approximated using a Poisson regression for a count of the total number of indegeneous varieties produced (Pudney, 1989; Hellestein and Mendelsohn, 1993).

This well known relationship between the Poisson and binomial distribution justifies our choice of the Poisson regression model to explain farmers incentives to diversify on traditional varieties. We are using the Poisson model not only because it is statistically consistent but also the number of TVs maintained on-farm (incentive indicator) is integer count. Count diversity index is computed as the number of TVs identified minus one (Taillie and Patil, 1982).

The Poisson regression model assumes that y_i given x_i is Poisson distributed with density:

$$f(y_i / x_i) = \frac{e^{-\lambda_i} \lambda_i^{y_i}}{y_i!}, \; y_i = 0,1,2$$ Poisson distribution

(3.1.9)

and mean parameter, $E[y_i|x_i] = \lambda_i = exp(x_i^{'}\beta) = exp(\beta_0) + exp(\beta_1 x_{1i}) + exp(\beta_2 x_{2i}) + ... + exp(\beta_k x_{ki})$.

Since $\beta_j = \frac{\partial E[y_i \mid x_i]}{\partial x_{ji}} \frac{1}{E[y_i \mid x_i]} = \frac{\partial \log E(y_i \mid x_i)}{\partial x_{ji}}$, the coefficients of the Poisson model can be interpreted as the proportionate change in the conditional mean if the j^{th} regressor changes by one unit (semi-elasticity).

The conventional Poisson model is, however, typically restrictive as it imposes the restriction that the variance of the data is equal to the conditional mean (*i.e.* $var(y_i/x_i, \beta) = E(y_i/x_i, \beta)$. To check this in our data set, we have followed regression based tests for over or under-dispersion suggested by Cameron and Trivedi (1990). All the test results consistently show under-dispersion in our count data. For this reason, we have used the Poisson model with the robust[9] (sandwich) covariance matrix as the Poisson model stays consistent under violation of the equi-dispersion assumption (Winkelman, 1995).

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[9] The robust estimation is the model estimation that accounts for heteroscedasticity and autocorrelation by transforming the dependent variable, the regressors and the error term. This estimation enables us to make statistical inferences even if the data are not iid.

3.2. Theoretical framework to analyze opportunity costs

Choice and use of any variety, be it local or modern, involves trade-offs and opportunity costs. While choosing certain variety (ies) to meet certain objective (s), a farmer loses other important traits from the set of varieties not selected. Correcting for potential econometric problems like self-selection, the financial opportunity cost can be defined as:

$$OPPORTUNITY\ COST = (IVGMPH - TVGMPH) \quad (3.2)$$

where *IVGMPH* and *TVGMPH* refer to gross margin per hectare (in Birr) of the IVs and TVs, respectively.

The difficulty in computing opportunity costs, however, is that neither the improved nor the TVs are unanimously superior with respect to non-monetary traits. Moreover, we do not know the equivalence of different variety traits *i.e.* how many times is disease resistance more important than food quality or the *vice versa*. One more factor that complicates the issue is that the relative importance of the different variety traits varies across farmers. For all these reasons, this paper is confined mainly to financial opportunity costs.

The size of the opportunity cost depends on the suitability of farmers' environment to the production and marketing of TVs and IVs (See Figure 2). The factors determining the suitability include access variables (input and output markets, extension, credit, irrigation); resource endowment (land, education, labor); and natural factors (soil quality, rainfall, drought, disease, pests *etc.*). The more favorable these conditions are to the production and marketing of the IVs, the higher the size of the opportunity cost will be. Inputs and local conditions affecting both varieties equally do not affect opportunity costs.

Of course, the simple GM difference is not the result only of use of improved variety (ies). There are other household and environment related factors that affect the outcomes which are not randomly distributed among used IVs (hereafter UIVs) and used TVs (hereafter UTVs). Due to non-random distribution of the non-variety factors and unobserved variables, selection bias should be dealt with.

Selection bias could potentially arise due to selection on the observables or un-observables. Better educated farmers, better quality land and better farm management practices could be skewed towards the UIVs. The GMs achieved by farmers using IVs or TVs are, accordingly, affected differently by the explanatory variables. This is selection on the observables. Regarding selection on the un-observables, the essence of the problem is that UIVs and UTVs are not the same with respect to variables that we relegate to the error term. Given that GMs for UIVs and UTVs are observed conditional on different unobservable factors, there will be a self-selectivity problem in the observed data (Huang, Raunikar and Misra, 1991).

Splitting each data-set into two, a simple Chow test was run to test whether coefficients differ across by variety use status. The test rejects the hypothesis that the two regressions are the same and this supports the use of a heterogeneous treatment effects model (see section 3.3.2).

3.3. Methods of generating and analyzing opportunity costs

For our purpose, we are using homogeneous treatment effects statistical procedures (matching, instrumental variable regression and treatment regression) to generate average opportunity costs. These methods assume that every farmer benefits equally from improved variety use. However, the more interesting questions could be 'Who benefits most from IVs?' or 'Who pays the most opportunity cost?' or 'What factors determine the size of the opportunity cost?' Addressing these questions requires estimating the effect of improved and TVs for each specific farmer. The switching regression model is used to study the effect of different contextual factors on the opportunity costs.

If one believes that improved variety use does not have only an intercept effect, but also a slope effect (*i.e.* the coefficients differ according to variety use status as well), then a switching regression model can be used (Goldfeld and Quandt, 1973; Quandt, 1988). Essentially, this model allows a full set of interaction terms between variety use status and the *x*'s.

Let us consider the usual linear regression problem:

$$y_i = x_i \beta_i + e_i \tag{3.3.1}$$

Taking this basic equation, we can split it into two regimes which generate our dependent variable (GM per hectare from sorghum farming). Now the GMs generated by the two regimes can be given as (Maddala, 1983, page 261):

$$y_{1i} = \sum_{j=1}^{k} \beta_{1j} X_{ji} + u_{1i} \quad \text{(Regime 1 which holds if } C = 1\text{)} \tag{3.3.2}$$

$$y_{0i} = \sum_{j=1}^{k} \beta_{0j} X_{ji} + u_{0i} \quad \text{(Regime 0 which holds if } C = 0\text{)} \tag{3.3.3}$$

$$C^* = \gamma_j Z_{ji} + u_i \tag{3.3.3}$$

$$C = 1 \;\; iff \;\; C^* > 0 \Rightarrow C = 1 \; iff \; u_i > -\gamma_j Z_{ji}$$
$$C = 0 \;\; iff \;\; C^* \le 0 \Rightarrow C = 0 \; iff \; u_i \le -\gamma_j Z_{ji}$$

where the errors, u_{1i} and u_{0i}, are assumed to be distributed normally and independently, with mean zero and constant variance, σ^2. The γ_j are unknown coefficients to be estimated and Z_{ji}'s determine in which regime the i^{th} observation is generated. The X_{ji} refer to factors affecting GM in the respective regimes.

4. Empirical results and discussion

4.1. Data collection and descriptive statistics

The data were collected based on a stratified random sampling technique to draw a sample of 198 sorghum growing farmers in Eastern Hararghe, Western Hararghe and Dire Dawa zones of Ethiopia. The survey was undertaken from July 2001 to April 2002 using a structured questionnaire. Among the 198 sorghum farmers, 104 of them were using improved and traditional variety (ies) side by side and 94 were using only TVs. No farmer was using only IVs. The following table defines the variables used in the Poisson regression, gives the expected signs based on the theoretical predictions and provides descriptive statistics.

Table 1: Variable definitions and expected signs

Variable name	**Description**	**Mean**	**SD**	**Expected sign**
Dependent variables				
Count	The No. of TVs on-farm less 1	0.81	0.74	NI
Explanatory variables				
Age	Age of the HH head (Years)	41.4	11.97	+
Totlabor	Total household labor endowment	3.53	1.93	UN
Lancrops	Qtty of land allocated for all crops (Has)	1.51	0.96	+
Nopurpos	No. of purposes for which sorghum is used	2.54	1.31	+
Nonffarm	Income source outside agriculture (Dummy)	0.41	0.49	-
Educate	Education level of the HH head	1.37	2.08	-
Impexep	Experience with IVs (years)	2.05	1.89	-
Credit	Participation in credit (Dummy)	0.35	0.48	-
Plots	Number of plots operated by the household	1.75	0.83	+
Access	The average time required to reach (on foot) the extension agent, dry weather road, and local market (Minutes)	47.6	24.6	+
GAPPC	Income gap per capita that each household fails to satisfy REQPC (if negative) and the vice versa (if positive) (Birr)	121.8	399.2	–
Cht'at	0 – no ch'tat at all; 1 – only for own use; 2 – also for village sales; 3 – also for sales in the cities	1.21	1.18	-

Notes: NI = Not important; UN = unpredictable.
Source: Wale, 2002

Farmers' experience with IVs ranges from 0 to 10 with a mean of 2 years. 35.4 percent of the households have reported to have been involved in formal or informal credit. Farmers need on average about 50 minutes walk to reach the nearest market, dry weather road and extension agent. This figure ranges from 5 minutes to 2.5 hours. The following table reports descriptive statistics for the variables used latter in the switching regression model.

Table 2: Descriptive statistics of the variables used to explain opportunity costs

VARIABLE	DESCRIPTION	MEAN (SD) – USERS OF BOTH (104)	MEAN (SD) – UTVS (94)
Visits	Number of visits by the extension agent during the last cropping season	2.98 (3.1)	1.27 (2.8)
Access2	The average time required to reach (on foot) the extension agent, dry weather road, and local market (Minutes)	49.47 (28.7)	51.1 (27.9)
Package (dummy)	1 if the household takes part in the package and 0 other wise	0.62 (0.5)	0.26 (0.4)
Impexep	Experience in growing IVs (years)	3.5 (2.1)	1.27 (1.5)
Educate1	Education level of the HH head	1.27 (2.2)	1.48 (1.9)
Chat1	0 – no ch'tat at all; 1 – only for own consumption; 2 – also for village sales; 3 – also for sales in the cities	1.33 (1.2)	1.26 (1.1)
Allfert	Fertilizer used per hectare (kg)	161.68 (515.2)	86.4 (178.8)
Rainfall	Rainfall distribution (3 – bad, 2- medium, 1- good)	2.21 (0.7)	2.30 (0.6)
Oxen	Number of oxen owned by the household	0.86 (0.9)	0.69 (0.8)
Inputindex	Input price index	0.99 (0.2)	1.01 (0.3)
Allquality1	Plot quality (3 – good, 2- medium, 1-bad)	1.22 (0.8)	0.86 (0.7)
Sorgindx	Sorghum price index	1.03 (0.4)	0.97 (0.3)
Gmm	Gross margin per hectare	427.58 (943.2)	-65.8 (533.3)

Source: Wale, 2002

4.2. Estimation results

The following table reports the parameter estimates of the Poisson regression results meant to explain farmers' motivations to diversify on traditional sorghum varieties.

Table 3: Poisson regression results

Variable	Coefficient	Marginal effects: Dy/dx
Age	0.0072^{*} (1.72)	0.005
Ch'tat	-0.174^{***} (-3.08)	-0.110
Lancrops	0.167^{***} (3.50)	0.105
Impexep	-0.186^{***} (-4.55)	-0.118
Nopurpos	0.318^{***} (6.80)	0.201
Totlabor	0.021 (0.95)	0.013
Access	0.0026 (1.47)	0.002
Educate	0.0382^{*} (1.69)	0.024
Plots	0.0908 (1.44)	0.057
Gappc	-0.0003^{**} (-2.24)	-0.0002
Belinarba*	0.1653 (0.98)	0.111
Kerodeda*	0.363^{**} (2.20)	0.259
Asseliso*	0.537^{***} (2.70)	0.408
Ejeaneni*	0.612^{***} (3.19)	0.479
Chachole*	-0.086 (-0.33)	-0.053
Gurbo*	-0.6059 (-0.92)	-0.299
Credit*	-0.006 (-0.06)	-0.004
Nonffarm*	0.0282 (0.22)	0.018
Constant	-1.86 (-5.60)	
Dependent variable is count Wald $Chi^2(18)$ = 210.78 Loglikelihood = -162.72	Number of obs = 178 Prob chi^2 = 0.00 Pseudo R^2 = 0.185	

NOTES: ***-Significant at 1%; **- Significant at 5% and *- Significant at 10%. Values in parenthesis are the ratio of the coefficient to the estimated asymptotic standard error. The method of estimation is Stata's Robust option following Huber/White standard errors and covariance. (*) dy/dx is for discrete change of dummy variable from 0 to 1.

Source: Wale, 2002

The variables Belinarba (24), Kerodeda (34), Asselliso (36), Ejeaneni (34), Chachole (36), and Gurbo (15) are all the village dummy variables meant to capture any village differences not accounted by the other variables[10]. The village Umerkule (19) is left as a reference.

The goodness of fit tests have given insignificant chi^2-tests indicating that the Poisson is appropriate model to explain count diversity. To undertake the LR test, the variables considered were classified into safety factors (*GAPPC*), concerns (*nopurpose*), endowment factors (*lancrops*, *educate*, *plots*, and *totlabor*), village dummies (*Belinarba*, *Kerodeda*, *Asseliso*, *Ejeaneni*, *Chachole*, and *Gurbo*) and access factors (*access*, *ch'tat*, *impexep*, *credit* and *nonffarm*). The test fails to accept H_0 in all cases implying that all set of variables are important in explaining farmers' incentives to diversify.

How do we interpret the results? Our point of interest is the expected count and accordingly our focus is on what happens to the expected number of TVs as either of the independent variables change. For instance, if age increases by 1 unit, the expected value of on-farm sorghum diversity increases by 0.72 % and if experience in growing IVs increases by 1 year, diversity on-farm decreases by 18.6 %. Coming to the dummy variables, being in Kerodeda increases on-farm sorghum diversity by a factor of 1.44 (= exp[0.363]) or increases by 44 percent (1.44 - 1), holding all other variables constant.

Most of the results confirm *a priori* expectations. They show that factors such as diversity of farmers' concerns being met by producing sorghum, farmers' sensitivity to income shocks, land heterogeneity, land size, and age of the household head are the key factors motivating farmers to diversify. On the contrary, access to extension and market integration, experience in using IVs and growing cash crops are detaching the link between farmers' incentives to diversity and their utility maximization[11].

Coming to the issue of opportunity costs, the following table reports the average opportunity costs generated from different homogeneous treatment statistical procedures.

Table 4: Average opportunity costs: sorghum

Method	**Opportunity costs computed (in Birr /HA.)**
Simple OLS[a]	168.2
Mean difference[b]	151
Matching	433.8
IV regression	537.7
Trt regression	659.2

[10] The numbers in brackets are the number of households sampled in each village.

[11] The result that adoption of IVs could endanger diversity demonstrates that on-farm conservation is far from simple and sends a pre-cautionary message so that government and other concerned organizations should attempt to find a compromise between conservation and agricultural productivity objectives.

Source: Wale, 2002
[a]We are considering variety use as an exogenous dummy variable.
[b]In this case, we are considering users of both varieties side by side on similar quality plots.

The average opportunity cost ranges from 151 to 659 Birr /Ha[12]. Comparing the traditional and improved variety GMs during good and bad seasons shows that UIVs gain 203.5 Birr /Ha. more during a good season while they lose 121 Birr /Ha. more if the season is bad. Thus during bad season scenario, UIVs are losing more than UTVs.

If their plots have to be used for on-farm conservation purpose, the minimum sorghum farmers can expect is 272.46 Birr /Ha. (GM /Ha. from the improved variety considering all costs except land) and the maximum is 803.76 Birr /Ha. (the GM /Ha. from the improved variety considering only paid-out costs). From the above results and assuming 100 landraces with three replications of 1 hectare each, compensation costs range from 45,300 Birr to 197,760 Birr. On the other hand, using 300 hectares of farmers' land for the same purpose could need a compensation that ranges from 81,600 to 240,900 Birr per annum. In other words, maintaining one landrace of sorghum would cost between 453 Birr (which equals about € 50) and 2409 Birr (=€ 268) annually.

The above results are assuming that the the next best alternative use of a sorghum plot for each household is the IVs. The other alternative could be to use the value of land. In the absence of official land market for policy reason, farmers were asked their willingness to accept if they rent out a hectare of land and their willingness to pay if they rent in a hectare of land[13]. The following table reports (re-enforcing the above results) the results of such an exercise for each peasant association (PA).

Table 5: Sorghum farmers' willingness to pay and accept for a hectare of land (in Birr)[14]

PA	MEAN VALUE OF LAND RENT IN	MEAN VALUE OF LAND RENT OUT
Belina Arba (N= 15)	386.00	399.64
Umerkule (N=11)	321.67	381.36
kerodeda (N=20)	510.50	523.00
Asseliso (N=18)	679.17	706.94
Eje Aneni (N=27)	448.22	456.04
Chachole (N=22)	325.00	343.18
Gurbo (N=12)	366.67	366.67
Total (N= 123)	454.15	468.75

Source: Wale, 2002

There is an impressive difference on the value of land across villages. Land quality, productivity of land, the opportunity to use the land for more profitable crops could be the reasons. The lowest value of farmers' willingness to pay for a hectare of land is 321 Birr and the highest is 679 Birr. These values are 343 and 707 Birr, respectively, for their willingness to accept if they have to rent out. Using the willingness to pay figures and making the same assumptions as above, the annual cost of on-farm conservation ranges from 102,900 to 212,100 Birr per annum.

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[12] By the time this version of the paper is drafted, 1Euro is about 9 Birr.
[13] In drought prone areas land is relatively cheap to the extent that most of these farmers were willing to give a certain portion of their land for free.

On top of this, there are a variety of informal land renting arrangements in the rural areas which can be used for on-farm conservation contract design. The most common being sharing equally both labor input and farm output. The sharing arrangement for renting in land ranges from 25 to 67 percent depending on the quality of the land and the type of crop the land is suited to. The sharing arrangement for renting out land, on the other hand, ranges from 34 to 80 percent. The average sharing arrangement used for renting in and out is 50 percent and the sharing arrangement common in most of the PAs is equal sharing. If government takes part in sharing inputs with farmers and farmers contribute only their land and labor, such sharing arrangements can be used putting a mark-up compensation for the foregone gross margin.

Coming to the factors affecting opportunity costs, all UIVs are not equally enjoying the benefits of IVs and neither are all UTVs facing equal opportunity costs. The following table reports full information maximum likelihood estimates of a switching regression model meant to explain opportunity cost of growing TVs of sorghum.

Table 6: FIML estimates of a switching regression model

Variable	**Coefficient**	**Variable**	**Coefficient**
Regime 1 – Users of IVs		**Regime 0 – Users of TVs**	
Constant	696.7 (1.7)	Constant	1412.6 (3.0)
ACCESS2	-6.4** (-2.3)	ACCESS2	-1.1 (-0.34)
CHAT1	72.9 (1.1)	CHAT1	94.3 (1.4)
RAINFALL	-189.6* (-1.8)	RAINFALL	-266.6*** (-2.7)
EDUCATE1	9.4 (0.25)	EDUCATE1	18.1 (0.51)
ALLQUALI	-91.1 (-0.88)	ALLQUALI	-351.3*** (-3.4)
INPUTIND	-919.5*** (-3.0)	INPUTIND	-684.3* (-1.9)
ALLFERT	0.24 (0.93)	ALLFERT	-0.23 (-0.74)
VISITS	51.0** (2.3)		
IMPEXEP	266.5*** (7.3)		
PACKAGE	342.2** (2.1)		
OXEN	79.4 (1.0)	OXEN	195.3** (2.3)
SORGINDX	598.4*** (3.2)	SORGINDX	644.8*** (3.1)
Sigma(1)	603.3 (13.0)	Sigma(0)	678.7 (10.9)
Dependent variable GMM		Number of observations 175	
Log likelihood function -1440.82		Sample separation variable is USER	

Source: Wale 2002

The GM difference between the UIVs and UTVs in the two regimes is our definition of opportunity cost. Hence, the factors which have a net positive (negative) effect on the difference between GM in regime 1 and 0 are affecting opportunity cost positively (negatively). Accordingly, opportunity costs increase with access to market and extension, number of visits by the extension agent, participation in the extension package, fertilizer use and experience in growing IVs. On the contrary, opportunity costs decrease with rainfall distribution, land quality, education level of the household head, input price index, oxen ownership, sorghum price index, and cash crop farming (cht'at).

[14] Figures in parenthesis refer to the number of respondents in each PA.

Cash crop farming reduces the opportunity cost because these farmers are typically better-off farmers to whom sorghum plays very little role in the household. Better output prices reduce the opportunity cost because better prices are hard to prevail for sorghum and lower prices hurt more the UIVs as they have to meet immediate loan and household expenditures right after harvest. Moreover, as sorghum is mainly a poor man's crop, the prospect for a price increase once the price collapses is very meager.

Compensating for opportunity cost, among other things, can involve designing contracts of different sorts which could involve financial incentives, benefit sharing arrangements, or compensating the traits lost. In the absence of a single contract that works in all contexts, it is optimal for the government to provide a menu of incentive contracts to different farm household types. In this regard, there is a need to make a distinction between contracts that involve renting land for the purpose of on-farm conservation and compensating the opportunity costs of changing variety use behavior. While the former calls for compensating the opportunity cost of the sorghum land for the year (which is the GM per hectare from the improved variety[15] or farmers' willingness to accept for land), the latter involves comparing GMs from what the farmer is planting versus what he/she is expected to plant.

Depending on the features of the farm household types, levels of opportunity costs, and the prevailing socioeconomic conditions, one can think of different contractual arrangements that involve farmers' *land, labor, government's financial and technical support, premium payment to farmers' unique varieties and cost recovery arrangements with potential seed users* (research organizations, seed companies or pharmaceuticals abroad or within the country). In all the cases, the required compensation should be based on the opportunity costs involving each contract.

5.Conclusions and policy implications

5.1. Conclusions

The paper has argued and presented a case that studying farmers' incentives is an input to identify and design sensible contextual contract with farmers for on-farm conservation. Further more, analyzing opportunity costs is crucial to determine the size and type of the compensation in the contract design.

Overall, the empirical results have shown that most of the incentives to conserve TVs are with poor, subsistent and marginalized farmers having limited access to cash crop farming, markets,

[15]Provided that the IVs are on average better yielding, we are assuming that the next best alternative use of each sorghum plot is the improved variety.

credit, and extension. If resource degradation includes the loss of agrobiodiversity, this is one clear case against the commonly sited tradeoff between poverty and resource degradation.

Based on the empirical results the opportunity costs have been estimated in terms of the gross margine foregone of maintaining traditional varieties. The average opportunity cost ranges from 151 to 659 Birr /ha which equals € 17 to € 73/ha depending on the seasonal fluctuations. Based on the opportunity cost computations, the paper has estimated the annual cost for on-farm compensation. Based on the calculated results maintaining one landrace of sorghum would cost the government compensation between 453 and 2409 Birr annually (which equals € 50 and € 268 respectively). As these figures indicate, not all farmers need equal compensation and some may not even need compensation at all to keep on planting TVs. The switching regression results have shown the most important factors affecting opportunity costs.

Based on the research results one can generate information required for designing different contractual mechanisms for on-farm conservation of sorghum genetic resources in Ethiopia. The empirical results lead us to conclude that designing a contract with subsistent and marginalized farmers is more easily done with less cost implications. According to the Poisson regression results, designing a contract with older farmers, farmers with multiple concerns, farmers with larger land holding and more number of plots is relatively easy and less costly as compared to farmers of the opposite features. These same results also imply that it is either difficult or costly to negotiate and design contracts with farm households characterized by better access to markets, extension, inputs and cash crop farming possibilities.

If the government has to conserve TVs found in both accessible and in-accessible areas, the compensation will be higher for farmers of accessible areas. Lower compensation for farmers found in areas characterized to be inaccessible generates an incentive for the government (driven by the need for reducing relative deprivation) to improve access differences in the long-run. As rural development interventions (improved access to extension and markets, improved seeds and high value crops) are put in place, the level of diversity will shrink calling for the need to harmonize conservation and development ventures especially in areas where most of CGRs diversity is produced *de facto*.

In areas where a certain crop (that needs diversity conservation) plays little role to farmers' livelihoods, delegating farmers will increase the moral hazard problem. If sorghum is a minor crop playing little role for satisfying household objectives in a given village, the probability of losing its genetic diversity will be high. Conserving a less rewarding crop genetic resource (like sorghum), in an area where planting a highly rewarding cash crop like cht'at is also an option for farmers, is extremely difficult or costly because compensation may require considering the benefits of the profitable crop.

5.2. Policy implications

Before implementing any of the policy recommendations, government should set the level and type of effort expected from farmers. To implement on-farm conservation, the government can design contracts in such a way that representative farm household types can maintain TVs on-farm and the government (involving IBCR, NGOs, research organizations, and other governmental organizations) can compensate them the opportunity costs faced. To this end, contracts for on-farm conservation can better be designed building upon farmers' incentives to diversify. The contract design principles could be set to target farmers with high propensity to plant multiple TVs or to target endangered areas.

If the governmental point of interest is to design contracts with farmers who have higher propensity to plant multiple TVs, then those farmers sensitive to potential income shocks, using sorghum for many purposes, with less comparative advantage in using IVs, and less market orientation are worth targeting. On the other hand, if the governmental objective function is to target areas with high probability of losing TVs, localities and farmers with better market access and better comparative advantage in improved variety use are the priority for contract design. This is also the practice of the IBCR whereby the crops for the in-situ conservation were identified on the basis of the degree of threat from genetic erosion of the farmers' varieties. In this scenario, contract design for on-farm conservation can be more costly (due to higher opportunity costs) as it will be harder to convince these farmers to stick to TVs. Similarly, in a farming system where high value cash crops (like cht'at, coffee and vegetables) prevail, contract design (for maintaining TVs of food crops) could be costly as it requires compensation based on the benefits from high value crops.

If there are unique TVs sufficiently important for conservation, in a setting where farmers plant multiple crops, the less important crops should be targeted for prior conservation to safeguard possible genetic erosion. The diversity of the more important crops will be maintained *de facto* for incentive reason calling for no immediate concern.

In areas where *de facto* conservation is prevailing (poor and segmented localities with no access to markets and extension), the so called hot-spots, delegating the farmers could do better than getting it done by the government or its agency. This is mainly because the government is not the residual claimant of all the subsequent gains from conservation. Farmers in this case recognize benefits like risk reduction, food tastes, tolerance to environmental stress (weather, pests, and weed), addressing multiple concerns, and resource fixity benefits. On the contrary, in areas where there is meager *de facto* conservation because dis-incentive factors are prevalent (market oriented and commercial farmers using modern technologies), government could undertake conservation ventures by itself because from the point of view of farmers, the rest of society is the residual claimant of the benefits of conservation.

Contracts with farmers have to be designed in such a way that compensations can cover what farmers are losing when they have to change their variety choice behavior. Compensation should be based on expected GM differentials between the variety being used by farmers and the landraces that policy wants them to maintain.

Compensating for opportunity cost, among other things, can involve designing contracts of different sorts which could involve financial incentives, benefit sharing arrangements, or compensating the traits lost. In the absence of a single contract that works in all contexts, it is optimal for the government to provide a menu of incentive contracts to different farm household types. Following the opportunity cost calculations and switching regression results, the study has shown that the level of compensation should increase with an increase in opportunity costs. Accordingly, farm households, found in localities where factors increasing opportunity costs prevail, should get better compensation. However, contracts covering financial incentives should, in principle, be flexible depending on the variability of opportunity costs temporally and spatially. The contract design should also take into account the fact that area and farmer specific compensation structures are required for non-financial compensation schemes as the relative importance of the traits lost will vary across farmers and villages.

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