CROP DIVERSITY AS THE DERIVED OUTCOME OF FARMERS' 'SURVIVAL FIRST' MOTIVES IN ETHIOPIA: WHAT ROLE FOR ON-FARM CONSERVATION OF SORGHUM GENETIC RESOURCES?

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ABSTRACT

Crop genetic resources are the building blocks of sustainable agricultural development due to their relevance not only as inputs for variety development but also as indigenous crop insurance mechanisms through traditional variety portfolio management. Their continuous survival is, however, threatened by natural and human driven factors. This threat has induced the need for designing conservation measures. Among the in situ and ex situ conservation options available to conserve crop genetic resources, on-farm conservation has recently attracted enormous attention. To make this option operational, placing incentives (that link conservation with utilization) and removal of perverse incentives are believed to be crucial so that landraces of no immediate interest to farmers can be conserved. However, before designing sound incentives and/or removing perverse incentives, we have to understand farmers' motives for managing a portfolio of traditional varieties.

To address our objective, 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. To empirically test the relationships, a Poisson regression model is estimated using rural household survey data collected from 198 sorghum growing farmers in East Ethiopia.

The results have shown the most important diversity promoting factors and those factors detaching the link between farmers' 'survival first' motives and their spillover effects on sorghum diversity. Based on the results, the paper concludes outlining the policy implications of the findings.

Keywords: On-farm conservation, sorghum genetic resources, incentives, Poisson regression, Ethiopia

INTRODUCTION: BACKGROUND AND RESEARCH QUESTION

Crop genetic resources (CGRs)[1] are the building blocks of sustainable agricultural development for their role not only as inputs for variety development but also as indigenous crop insurance mechanisms through traditional variety portfolio management. CGRs have current use values and option values. One of their main use values for Ethiopian smallholders is that managing a portfolio of traditional varieties ensures the survival in marginal areas. As to their option value, CGRs are the raw materials for breeding to deal with any potential agricultural problems.

Despite existing uncertainties concerning the extent and rate of the diversity decline in CGRs (Virchow, 1999), the conservation of CGRs is taking place.

[1] Plant genetic resources are resources including farmers' varieties (crops as cultivated species) and non-cultivated species from other plant species (Heywood, 1995). CGRs in this paper refer to farmers' varieties.

It is based on two pillars: ex situ and in situ conservation[2]. Although ex situ conservation is still dominantly utilized, in situ conservation has recently entered the stage for conservation of intra-species diversity of CGRs[3]. Among the different in situ conservation options for CGRs, conservation on farmers' fields (on-farm management) has recently received a considerable attention by governments, NGOs and the international community. However, despite a lot of discourse in its favor, there is no adequate contextual research done as to how on-farm management can be made feasible complement to ex situ conservation. Because on-farm management of CGRs cannot be undertaken in a vacuum, farmers' diversification motivations and the effect of their working environment on the level of their contribution to crop diversity have to be understood for justified and efficient interventions. This will enable decision-makers to comprehend how policy (through different incentive mechanisms) can better influence farmers' variety management behavior.

Many studies acknowledge that farmers play a key role in maintaining traditional varieties. Indeed, on-farm maintenance of CGRs is a positive externality of the farm activities driven by farmers' survival first motives involving issues far from simple profit maximization. As farmers are not maintaining diversity for its own sake, their conservation efforts are usually coined in the literature as 'de facto conservation' (Meng et al., 1998). However, 'de facto conservation' is less than what society wants to have because for one thing no farmer produces diversity for its own sake; secondly, each farmer decides independently based on his or her expectations. Moreover, farmers are using observable characteristics of the varieties for their decisions. For these reasons, there could be landraces not of interest for any farmer (resulting in extinction) and there could be landraces of interest for thousands of farmers (resulting in redundancy). Hence, although farmers have a role to play, governments cannot entirely depend on their derived conservation activities. Non-optimal diversity produced by farmers as an impure public good calls for the need to change the status quo. Moreover, due to missing markets and transaction costs, the social and private marginal benefits of maintaining crop diversity are not identical and therefore the level of conservation will again be sub-optimal. For those landraces which are either not conserved by farmers 'de facto' and are, hence, threatened by extinction, or are not conserved at a social optimal level, incentive measures are needed to improve the non-optimality through harmonizing their variety choice criteria with national CGRs conservation strategies (McNeely, 1988). However, before designing sound incentive mechanisms for promoting on-farm conservation and/or removing perverse incentives (like linking of access to fertilizer or credit with the adoption of specific cultivars), decision-makers have to be informed on how and why de facto conservation occurs.

As a first step in the incentive design, the focus of this paper lies on identifying the farm household, market and agro-ecological factors behind farmers' life long contribution to society in saving some of the country's genetic stock. The research questions to be addressed are, therefore, *'How do farmers' survival first motives promote diversity and what factors induce on-farm 'de facto conservation'?* and *'What role do these results play for on-farm conservation policy'?*

Ethiopia, as the center of origin and diversity for many crops (for instance, teff, *coffea arabica,* enset, 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). Moreover, 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). Thus, addressing Ethiopia's increasing food production demand requires maintaining the agro-biodiversity for present and future potential use.

The remaining part of this paper is structured as follows: Section 2 considers the theory and the econometric model to be followed by data description in section 3. The regression results are presented in section 4. Finally, conclusions and policy implications are drawn in section 5.

[2] Promoting ex situ and in situ conservation activities are two of the 20 priority areas of the 'Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture' (see FAO, 1996).
[3] Ex situ refers to conservation of genetic resources outside their natural habitats while in situ involves conservation of these resources in their natural environment.

THE THEORY: FARMERS' UTILITY MAXIMIZATION CONSTRAINED BY SURVIVAL MOTIVES LEADING TO ON-FARM DIVERSITY

The theoretical formulation of the utility based household multiple variety (crop) decision model follows van Dusen (2000) who derives the diversity function inculcating missing markets and risks in steps. 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:

$$Max\!: \; U = U(G_f, G_p / \varpi_0) \qquad (1)$$

where $\underline{G_f}$ and $\underline{G_p}$ refer to aggregate consumption of on-farm produced and purchased goods, respectively, and $\underline{\varpi_0}$ refers to the vector of household level exogenous factors including input endowments and heterogeneity (land and labor), human capital (age and education), asset endowment (livestock and wealth), and access factors (extension and credit).
The utility is subject to the following constraints:

$$p_g\,(G - G_f) - c(G; \varpi_0) + \ddot{Y} \le Y \qquad \text{Full income constraint (2)}$$

where $\underline{G, p_g, c}$ and $\underline{\ddot{y}}$ are the aggregate produced good on-farm, price of the aggregate agricultural good, cost of production for the agricultural good and income from income sources outside agriculture, respectively. The full income constraint encompasses labor constraint, cash constraint, and livestock feed constraint.

$$L_F + L_{leisure} + L_{NF} + L_{Hired} \le L \qquad \text{Labor constraint (3)}$$

where L_F, $L_{Leisure}$, L_{NF}, L_{Hired} and L refer to labor used on the farm, labor used for leisure, labor used for non-farm economic activities, and household labor endowment, respectively.

$$L_{own} + L_{rentin} - L_{rentout} = \sum_{i=1}^{n} d_i E_i + \sum_{i=n}^{m} d_i V_i + L_{fallow} \le Land \qquad \text{and constraint (4)}$$

$$P\,(G_f, G_m) = 0 \qquad \text{Production technology constraint (5)}$$

where $\underline{G_m}$ refers to aggregate on-farm produced good sold in the market. The production technology is conditional on choices (varieties and crop enterprises). Assuming perfect markets and risk free environment, the first order conditions of this problem lead, among other things, to the following optimum level of production:

$$G = \; G(G_f^*, \, G_m^*; \varpi_0) \qquad (6)$$

Quantities of goods produced are aggregated here for simplifying the exposition. Multiple output production can also be derived similarly (Singh and Janakiram, 1986). The household chooses a set of varieties, crop enterprises and inputs to arrive at the optimum level of production of each enterprise. While trying to meet their household objectives, farmers not only produce and consume crop output but also maintain diverse set of traditional varieties of crops year after year as a positive externality of their farm decisions.
Utility optimization results not only in an optimum level of production but also the derived demand for crop and variety diversification ($\underline{D_{dd}}$) or number of varieties and crops planted subject to the factors motivating farmers to diversify i.e.

$$D_{dd} = \left[v_1 + v_2 + v_3 +, \ldots, + v_n / c_1 + c_2 +, \ldots, + c_n ; \varpi_0 \right] \qquad (7)$$

where $\underline{v_i}$'s index varieties and $\underline{c_i}$'s index crop enterprises, respectively, so that $\underline{v_i}$ and $\underline{c_i}$ take 1 if the household chooses the variety or the crop enterprise, and zero otherwise, respectively. If the only farm household´s concern is income, with constant returns to scale, perfect markets, and homogeneous land, the household will plant a single variety in a risk free environment that leads to specialization and no diversity on-farm[4].

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[4] Diversity may or may not occur at the regional or national level depending on the diversity among households.

If the farmers' working environment is given, the genetic composition of crop diversity on-farm (D_{hh}) is a function of their on-farm management practices (M_p) and natural factors affecting the ecological interactions (N_f) i.e.

$$D_{hh} = f(D_{dd}; M_p, N_f) \quad (8)$$

Market access and lower transaction costs simplify farmers' life and nullify the need for farmers to be self-sufficient (de Janvry et al., 1991). When farmers have access to markets, extension, roads, etc., many of the goods and services provided by crop diversity can be substituted by alternatives that can be purchased in the market. Thus, the production of diversity will shrink (Bellon, 1996). Missing markets bring additional input and output constraints by forcing farmers to be self-sufficient.

Thus, utility maximization under missing markets requires farmers to balance input demand with own supply *i.e.*

$$Max: \; U = U(G_f, G_p, NM_g / \varpi_1) \quad (9)$$

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

$NM_g = HH_{dd}$ Output constraint with missing markets (10)

As a result of this constraint, the production technology constraint above also includes NM^*_g.

$L_{HH} = L_F + L_{leisure} + L_{NF}$ Labor constraint with missing markets (11)

$L_{own} = \sum_{i=1}^{n} d_i E_i + \sum_{i=n}^{m} d_i V_i + L_{fallow}$ Land constraint with missing markets (12)

The optimum level of production from traded and non-traded enterprises will then be:

$$G = G(G^*_f, NM^*_g; \varpi_1) \quad)$$

From each crop enterprise, the number of traditional varieties is still the derived outcome of household utility maximization.

The next most important variable worth considering is risk. Farmers' risk aversion behavior is governed by the extent to which it affects their livelihood. While risk is forcing farmers to take cautionary measures, their reaction to it mainly depends on their sensitivity to potential shocks that, in turn, is highly dependent on their wealth status. While wealthy farmers can smoothen consumption, non-wealthy farmers are highly sensitive to potential farm income variability (Murduch, 1995). One of the indigenous means for farmers to deal with risk is traditional variety portfolio management.

Taking the results of previous literature that synthesizes relationships among risk, consumption smoothing and wealth (Rosenzweig and Binswanger, 1993; Murduch, 1995) and adapting Roy's safety first model (Roy, 1952), farmers are trading expected return for reduced risk. 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 traditional varieties), the farmer's decision depends on the extent to which the household is able to fulfill basic needs ($Basic_{req}$) from its internal endowment (wealth plus expected 'risk free' farm and non-farm income denoted as FN_{income}). The farmer's objective is thus to:

$$\text{Min Prob. } (FN_{income} < Basic_{req}) \Rightarrow \text{Prob.}(FN_{income} - Basic_{req} < 0) \quad (14)$$

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 value of livestock, annual income from ch'tat[5] (Chata Edulis) and annual estimated income from non-farm income sources[6]. 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[7],

$$Risk_{proxy} = GAPPC = SAFTYPC - REQPC \qquad (15)$$

Inculcating risk in the derivation of the optimum level of production, first order conditions lead to:

$$G = G(G_f^*, NM_g^*; \varpi_2) \qquad (16)$$

where ϖ_2 is ϖ_1 and 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 the portfolio of traditional varieties maintained (to stabilize farm income) by a farm household. In the context of the utility function, risk can be considered as part of the full income constraint.

Farmers' variety management decisions involve both discrete (whether or not to plant) and continuous (how much) decisions. Diversity is mainly a function of the discrete decision (van Dusen, 2000). Thus, we shall consider the process of diversity production as involving a set of discrete choice decisions by farmers. Accordingly, the number of varieties and/or crop enterprises on each farm is given by:

$$D_{dd} = \left[v_1 + v_2 + v_3 +, \ldots, + v_n / c_1 + c_2 +, \ldots, + c_n ; \varpi_2 \right] \qquad (17)$$

Consider, for simplicity, a farmer who is planting only sorghum and getting income only from this crop. If the farmer's utility is derived from 'n' varieties that are the combination of varieties that provide the total satisfaction, then the total utility is apportioned among the 'n' varieties. If each variety is contributing equally to the farmer's utility, each one is taking equal share of the farmer's resources. If a farmer decides to have a single variety, he is satisfying all his utility and household concerns only with a single variety.

Thus, there are multiple variety use decisions (by millions of farmers) resulting in multiple varieties on-farm and cumulatively contributing to regional or national diversity. Repetition of a series of binomial choices by thousands of farmers asymptotically converges to a Poisson distribution. The summation of a series of discrete choices can be approximated using a Poisson regression for a count of the total number of varieties produced (Pudney, 1989; Hellerstein and Mendelsohn, 1993). As a result, we are using the Poisson model not only because it is consistent with the theoretical framework but also because the number of traditional varieties maintained on-farm (diversity index used in this paper) are integer counts. Count diversity index is computed as the number of traditional varieties identified minus one (Taillie and Patil, 1982). Poisson regression model is the benchmark for analyzing count data (Cameron and Trivedi, 1998).
The Poisson regression model assumes that y_i given x_i is Poisson distributed with density:

$$f(y_i / x_i) = \frac{e^{-\lambda_i} \lambda_i^{y_i}}{y_i!}, \; y_i = 0,1,2 \qquad (18)$$

and mean parameter, $E[y_i|x_i] = \lambda_i = \exp(x_i'\beta)$.

Having independent observations, the model to be estimated is:

$$y_i = e^{x_i'\beta} + \varepsilon_i = e^{(\beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \ldots + \beta_k x_{ki})} + \varepsilon_i \qquad (19)$$

where the x_i's are the variables (described in section 3) affecting on-farm diversity (y_i).
The 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. $var(y_i/x_i, \beta) = E(y_i/x_i, \beta)$.

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[5] Cht'at is a very important stimulant and perennial cash crop in the study area.
[6] We used not only income but also wealth to compute FN_{income} because farmers sell their wealth when income falls short of current consumption needs. Data were collected from the head of each household on the $Basic_{req}$ and components of FN_{income}.
[7] Consumption requirements of household members have been adjusted.

Checking this in our data set using regression based tests for over or under-dispersion suggested by Cameron and Trivedi (1990) consistently shows under-dispersion.

The easiest way to solve this problem is to use the Poisson model with the robust (sandwich) covariance matrix because the Poisson model stays consistent under violation of the equi-dispersion assumption (Winkelmann, 1995). For this reason, the robust methods of estimating Poisson models have been used to compute the Huber/White robust standard errors reported in Table 2.

DATA DESCRIPTION

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. Farmers were interviewed in 2001/2002 using a structured questionnaire.

There are six major purposes (food, cash, animal feed, fuel wood, house construction, and fence construction) of growing sorghum in the study area. The average number of traditional varieties of sorghum grown is 1.84 for the sampled households. 74 of the households had reported to have a single traditional variety; the other 84 had 2 varieties; 33 of them had 3 local varieties, and the last 5 had 4 varieties. For the estimation purpose, the last ones are censored to 3 since they are very few.

Table 1. Variable definitions and expected signs.

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

Notes: NI = Not important; UN = unpredictable.
Source: 2001/2002 own survey

Table 1 defines the variables used in the regression, gives the expected signs based on the theoretical predictions, and provides descriptive statistics for the respective variables. The variable 'totlabor' is computed excluding the dependents (children below 9 and inactive household members because of age or permanent sickness). Household members aged 16-59 get value 1.

Children between age 9-15 get an equivalence of 40%, and household members above the age of 60 get 60% equivalence. Children going to school are assumed to spend 40% of their time on-farm. All these conversions are based on the discussions made with the key informants during the survey.

Only 41% of the sampled households have reported to have earned non-farm income that is rather low. The average grade of schooling for the heads of the sampled households is 1.37 with a maximum of 11 and minimum of zero. Farmers' experience with improved varieties ranges from 0 to 10 with a mean of 2 years. 35.4 percent of them have reported to have been involved in formal or informal credit.

The mean 'GAPPC' is positive implying that on average all households can more than satisfy $Basic_{req}$ if incomes are equally re-distributed. However, the variation is very high ranging from -1098 to +1090 mainly due to the income from a cash crop cht'at. Those farmers who produce and sell cht'at are exceptionally better-off which could inflate the average figure. The details of the data description can be found in Wale (2003).

ESTIMATION RESULTS AND RELATED DISCUSSIONS

Table 2 below reports the parameter estimates of the model and the relative importance of the different variables considered (marginal effects). The variables *Belinarba* (24), *Kerodeda* (34), *Asselliso, 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[8]. The village *Umerkule* is left as a reference.

Table 2. Poisson regression results to explain farmers' motivations to diversify on traditional sorghum varieties.

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: 2001/2002 own survey

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

The goodness of fit tests have given insignificant χ^2-tests indicating that the Poisson is an appropriate model to explain count diversity. The LR test has been used to check significance of the inclusion of a set of variables. 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*) [9]. The test fails to accept H_0 in all cases implying that all sets of variables are important in explaining on-farm diversity. Most of the results confirm *a priori* expectations showing that factors such as diversity of farmers' concerns being met by producing sorghum, farmers' sensitivity to income shocks, land heterogeneity, land size, and age are the key factors for variety diversification. These factors are significantly motivating farmers to produce diversity by managing a portfolio of traditional sorghum varieties. According to the results, farmers are not able to get multiple traits they want from a single variety and the increase in the relative importance of sorghum to household utility is one of the motivating factors for diversification of traditional sorghum variety. On the contrary, access to extension and market integration, experience in using improved varieties and growing cash crops are detaching the link between *'de facto'* conservation and farmers' economic decisions.

This result demonstrates one of the challenges in the seemingly simple on-farm conservation being advocated and sends a pre-cautionary message so that government and other concerned organizations should attempt to address both conservation and agricultural productivity objectives. As a poor man's crop, the financially non-rewarding sorghum is liable for replacement by cash crop farming. Heterogeneity of the farming system (cash crop farming and food crop farming) as well as the coexistence of crops of different importance in a region lead to endangering the less important and less rewarding crops which, in turn, requires costly interventions due to higher opportunity costs of maintaining food crop diversity in the presence of high value crops such as Cht'at.

The variable *'educate'* has unexpected sign. Running a two-limit Tobit regression on the proportion of use of improved varieties has shown that education does not significantly affect use of improved varieties, which could partly explain the unexpected sign in Table 2.

CONCLUSIONS AND POLICY IMPLICATIONS

Overall, the empirical results have shown that *'de facto'* conservation is mainly a poor man's undertaking with no access to cash crop farming, markets, credit, and extension. CGRs diversity is mainly produced by subsistent and marginal farmers as a positive externality of their 'survival first' strategies. These farmers are maintaining a level of crop diversity through their farm-specific production system according to the individual optima of the decision-making process at the farm level.

Economic development, poverty reduction and income distribution argue that the economically and ecologically marginalized areas, where most of CGRs diversity is produced until now, need external investment in infrastructure and technology to improve the production limitations. However, as rural development interventions are put in place (improved access to extension, markets, use of improved varieties, and growing cash crops), the amount of area utilized by traditional varieties, the amount of varieties per farm and, therefore, the level of diversity will decrease. As long as farmers' contribution to agrobiodiversity is not valued[10], and as long as CGRs are not valued by their own right, the level of crop diversity produced by marginalized farmers will be negatively correlated to the over-all agricultural development in a specific region, leading to an uncontrolled loss of CGRs.

If it is the political will of the Ethiopian government to maintain the diversity of CGRs on farmers' fields at a social optimum, on-farm conservation demands crediting farmers and linking conservation with utilization. However, incentive instruments should only be applied in areas, where the threat exists of an uncontrolled loss of CGRs. Hence, there is a need to first develop an 'early warning system' through identifying 'endangered crops' and 'hot-spots'. This early warning system should be based on the factors influencing farmers' behavior.

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[9] Variables are defined in Table 1.

[10] With all the institutional implications involved such as property rights.

As discussed, the most important motivating factors for variety diversification are mainly farmers' multiple objectives and concerns, risk and yield insurance considerations, land heterogeneity, labor endowment, and lack of access to markets and transaction costs. On the contrary, access to extension and market integration, experience in using improved varieties and growing cash crops are detaching the link between 'de facto' conservation and farmers' economic decisions. 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. If there are unique landraces sufficiently important for conservation, in a setting where farmers plant multiple crops, the less important crops should be targeted. It is extremely difficult or costly to conserve the CGRs of a less rewarding food crop (like sorghum) in an area, where planting a highly rewarding cash crop like cht'at is also an option for farmers. The compensation could go far more than the utility farmers expect from growing the less rewarding crop.

After identifying the 'endangered crops' and 'hot spots', the conservation initiatives could follow targeting principles to harmonize on farm conservation with farmers' survival first motives. There is a need for flexible incentive structures to maintain CGRs diversity at a social optimum and to offset the negative effect of development interventions. Policy can, for instance, start with creating awareness and rewarding farmers who have maintained unique traditional varieties of traditional crops.

If the point of interest is to target farmers who have higher propensity to plant multiple traditional varieties, then those farmers who are using sorghum for many purposes, with less potential in using improved varieties, and less market orientation are worth targeting. The results of this study imply that on-farm conservation gives more sense with farmers who are using crop variety portfolio as a risk management strategy. On the other hand, if the objective function is to target areas with high probability of losing traditional varieties, localities and farmers with better market access and better comparative advantage in improved variety use are the priority for action. In this scenario, in situ conservation can be more costly as it will be harder to convince these farmers to stick to traditional varieties for the sake of diversity.

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