Chapter 2

Economic Analysis of Ethiopian Farmers’ Preferences for Crop Variety Attributes: A Choice Experiment Approach

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Summary

Ethiopia has immense wealth of crop genetic resources, which is due to its diverse agro-ecology and cultural diversity. The country’s genetic resources are, however, subject to serious erosion and irreversible losses due to policy, institutional and market failures. This study aims to contribute to a better understanding of the challenges with bearings on the sustainable management of crop genetic diversity through analysing farmers’ crop variety attribute preferences and identifying the key socio-economic factors that condition their attribute preferences. The study applied a choice experiment (CE) method to elicit preferences and estimate the relative importance of the attributes in defining the perceived utility to be derived from four traits of sorghum and teff varieties, the two major food crops in the country (as a source of staple food for many parts of the country, teff, an annual grass, is primarily grown to prepare Ethiopian bread known as ‘injera’, porridge and some native alcoholic drinks). The attributes included selling price, productivity, environmental adaptability (resistance to drought, poor soil and frost occurrences) and yield stability of the variety despite occurrences of disease and pest problems. The analysis of farmers’ preferences was based on primary data collected from farmers growing 131 teff and sorghum in the northeastern part of Ethiopia. Farm households attached the highest private value to the environmental adaptability trait of both sorghum and teff crops. This was followed by yield
stability and productivity attributes of the same crops. The results also reveal that
differences between farm households, in terms of household characteristics, their
endowments and constraints, and the level of development integration (in the
areas of basic infrastructure and agricultural extension) affect farmers’ private
valuation of crop variety attributes. Based on the empirical results, the chapter
derives policy implications in the areas of on-farm conservation and improved
variety use in Ethiopia.

**Introduction**

Many societies around the world depend on agricultural innovation processes for
their daily livelihoods, particularly food supply. Crop genetic resources, embodied
in the diversity of seeds planted by farmers, are important to secure food produc-
tion and supply (di Falco et al, 2010). Different stakeholders such as farmers and
breeders as well as gene-bank managers and crop scientists draw on diverse crop
genetic resources to innovate, support and benefit society as a whole (Smale,
2006).

Sustainable management of crop genetic resources means assuring their
diversity, both in trust collections or gene banks (ex situ) and on farms (in situ)
(Smale, 2006; Bezabih, 2008). For farmers crop biodiversity is important to
combat risks, from plant diseases to pests, and to adapt to changing production
systems and changing environments (di Falco et al, 2010). Crop biodiversity is
essential for the functioning of ecosystems and the provision of ecosystem
services (e.g. Naeem et al, 1994) and also provides dietary needs and services that
consumers demand as economies change (Smale, 2006).

Crop genetic resources are environmental goods that are renewable but
vulnerable to losses from either natural or human-made interventions. Crop
 genetic improvement and the increase in farm inputs, such as pesticides and
fertilizers, were driven by the goal to increase yield and yield stability, and have
transformed rural societies in many parts of the world (Smale, 2006). There is,
however, a growing concern about potential loss of crop biodiversity associated
with social and economic change. The common challenge now is to develop
strategies that enable crop genetic resources to be managed in ways that satisfy the
needs of farmers and consumers at present and in the future. Crop biodiversity is
a quasi-public good (Bezabih, 2008) and its conservation also benefits society as a
whole, including future generations. The provision of crop biodiversity is largely
on-farm, in particular in low-input agricultural systems in developing countries,
and therefore the level of conservation is highly dependent on the preferences and
decisions of farmers.

The purpose of this study is to contribute to a better understanding of the
challenges of crop genetic conservation by providing an insight into Ethiopian
farmers’ preferences for crop variety attributes and to identify the key socio-
economic characteristics that influence these preferences. Ethiopian
policy-makers have to be informed about, *inter alia*, ‘Who prefers what kind of
variety attributes the most?’ and ‘How much are farmers willing to trade-off one variety attribute for another?’ if on-farm conservation programmes are to be undertaken successfully. This study deals with these two questions by analysing farmers’ attribute preferences, expressed by their willingness to pay for varieties of the two major crops in the country: sorghum and teff.

Similar questions about the WTP for certain attributes and about preference heterogeneity have already been raised in the context of evaluating animal genetic resources (AnGRs). These studies have attracted considerable attention, starting off with the work by Scarpa et al (2003a, 2003b). The most recent studies in East Africa are on the evaluation of cattle (Zander and Drucker, 2008), goats (Omondi et al, 2008a) and sheep (Omondi et al, 2008b), all based on choice experiments. For crop genetic resources, we are aware of only a few studies that use CE. Birol et al (2006) applied a CE to study farmers’ demand for agricultural biodiversity in the home gardens of Hungary’s transition economy, while Ruto and Garrod (2009) investigated farmers’ preferences in a wider perspective, not on crop attributes but on agri-environment schemes. It is, therefore, important to conduct further research using stated preference methods such as CE on crops and their preferred attributes. Having knowledge about the holistic value of Ethiopian indigenous flora and fauna, and in particular its total agro-biodiversity, can inform conservation priority setting. Understanding the role of farmers in cultivating specific local crops or keeping unique farm animals in the conservation process is essential if improved varieties/breeds developed by breeding programmes are to address the concerns of farmers and their well-being.

For this study, a CE was conducted to estimate the individual utility farmers derive from four attributes of sorghum and teff varieties including:

- producers’ price;
- productivity;
- environmental adaptability; and
- yield stability.

In a CE, individuals are given a hypothetical setting and asked to choose their preferred alternative among several options in a choice set, and they are usually asked to perform a sequence of such choices. Each alternative (a teff or sorghum variety in this case) was described by a number of attributes and their levels. Crop varieties possess private as well as public benefits, together accounting for the total economic value of crop genetic resources. Maintaining local crop varieties in Ethiopia provides a quasi-public good benefit with the external effect of conserving a genetic pool that has global significance for breeding and biodiversity. However, given the approach taken in this study, only internal (private) values to farmers, which are mainly use values, were captured. Assessing such use values plays a key role in orienting conservation and breeding strategies as conventional economic analyses often ignore the importance of indirect use values (e.g. sociocultural/medical use, their ability to withstand biotic and abiotic stresses)
associated with local varieties (see Zander and Drucker, 2008). The empirical analysis of farmers’ preferences for the above attributes was based on primary data collected from farmers growing 131 teff and sorghum in the northeastern part of Ethiopia.

The remaining part of this paper is structured as follows. A relationship between farmers’ concerns and variety attribute preferences is drawn in the next section. The third section outlines the theoretical underpinnings behind the choice experiment approach. The fourth section explains the data generation process followed by a description of the study sites and sampled farm households. The design and administration of the choice experiment is explained in the fifth section. The penultimate section discusses the findings from the analysis of the choice experiment data. Policy implications are drawn in the final section.

**Farmers’ concerns and preferences for variety attributes**

Understanding farmers’ preferences for crop attributes and their incentives to grow diverse varieties are critical to the success of on-farm conservation (di Falco et al, 2010). Such an understanding will also help in the areas of research priority-setting and improved breeding (Wale and Yalew, 2007). Preferences for variety attributes are, in turn, shaped by farmers’ economic (resource constraints, markets and risk) and non-economic (religion, culture, norms and attitudes) concerns. For example, when local variety attributes satisfy farmers’ concerns, their de facto conservation is the outcome of the correspondence between variety attributes and farmers’ concerns. The preference for a variety and land allocation decision is dependent on farm household characteristics, their attitudes and concerns (Wale, 2004).

The probability that farmers choose to cultivate a certain crop variety, on the other hand, is dependent on the key attributes the farmers associate with the variety. Each farmer, however, derives different utility from consuming different varieties with different attributes based on the farm household’s characteristics and attitudes. The survival of a variety on-farm, or the successful adoption of a newly introduced improved variety, is mainly a function of the maximized benefit to the farm household (Wale and Yalew, 2007).

**The choice experiment and welfare measures**

Since most of the attributes that characterize the varieties of crops are not directly tradable, non-market valuation methods must be used to determine their relative economic value. These benefits primarily accrue to farmers in non-market values or utility. The preferences of farmers, who are both producers and consumers of crop variety outputs, determine the implicit values they attach to crop varieties and their attributes (Louviere et al, 2000).
Of the range of environmental valuation approaches, the choice experiment method is appropriate for valuing crop varieties, considering their multiple benefits and functions. This method makes possible the estimation not only of the value of the environmental asset as a whole, but also of the implicit values of its attributes (Hanley et al., 1998; Bateman et al., 2003).

The approach, upon which the framework for choice modelling is based, has a theoretical grounding in Lancaster’s model of consumer choice (Lancaster, 1966), and an econometric basis in models of random utility (Luce, 1959; McFadden, 1974). From random utility models, welfare measures can be obtained, expressed as farmers’ willingness-to-pay (WTP) or willingness-to-accept (WTA) compensation for a change in crop varieties’ attribute levels. The estimates for these welfare measurements are obtained from applying a conditional logit (CL) model, whose specification is detailed in many textbooks (e.g. Greene, 2000; Freeman, 2003). With one attribute being price, the implicit price (IP) for a change in any attribute, all else being equal, can be calculated. If the IP for an attribute is negative, then we obtain a WTA estimate, because farmers will be worse-off with a utility change and require compensation to be left at the same utility level. If the IP has a positive sign, then farmers have a WTP for the attribute in question. The IP is calculated by the ratio of coefficients of the attributes in question $\beta_{\text{attribute}}$ as obtained from the CL model and the coefficient of the monetary variable $\beta_{\text{monetary variable}}$ (see e.g. Rolfe et al., 2000; Zander and Holm-Mueller, 2007).

$$IP = -\frac{\beta_{\text{attribute}}}{\beta_{\text{monetary variable}}}$$ (Eqn 2.1)

The assumptions about the distributions-of-error terms implicit in the use of the conditional logit model impose the independence of irrelevant alternatives (IIA) property (Louviere et al., 2000). This property states that the probability of a particular alternative being chosen is independent of other alternatives, whether or not IIA property holds can be tested by dropping an alternative from the choice set and comparing parameter vectors for significant differences (Louviere et al., 2000). A common test to detect violation of the IIA property is the Hausman test (Hausman and McFadden, 1984), as applied to our data.

The data generation process

Survey data was drawn from farmers residing in two peasant associations (PAs) in the northeastern part of Ethiopia (North Wollo zone of Amhara Regional State). Two phases of data collection procedures were implemented for this study within the framework of the Ethiopian component of Bioversity’s GRPI project. As noted in Chapter 1, this project aimed to support the development of policy options for sustainable conservation and utilization of crop genetic resources in
Ethiopia. All the socio-economic characteristics employed in this study were collected in the first phase of data collection (from October 2006 to January 2007). Piloting of the first draft of the CE questionnaire and the actual CE survey were conducted in the second phase during June and July of 2007.

Stratified multistage sampling was adopted to identify Zones, Districts, PAs, villages and farm households. Overall, a total of 131 farmers were selected and interviewed from the two PAs found in the Guba Lafto district of North Wollo zone. The next part discusses the characteristics of the selected study sites (PAs) covered in this study. See ‘Design and administration of the choice experiment’ section below for the design of the CE survey.

Study site description

A summary of the main characteristics of the two PAs surveyed is reported in Table 2.1. Teff, sorghum and maize were among the most important food crops in both PAs. Agro-ecologically, the midland area (locally known as ‘Woina dega’) is the dominant agro-ecology in Woinye PA, covering 83 per cent, whereas the lowland area (locally known as ‘Kola’) is the major agro-ecology in Ala Wuha PA, covering 95 per cent. This should, however, increase the representativeness of our surveyed farm households since our sample covers farmers from the three major agro-ecologies of the country (midland, highland and lowland) growing the two major crops (sorghum and teff).

<table>
<thead>
<tr>
<th>Study site characteristics</th>
<th>Woinye PA</th>
<th>Ala Wuha PA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agro-ecological coverage</td>
<td>Midland 83%, Highland 10% and Lowland 7%</td>
<td>Midland 5% and Lowland 95%</td>
</tr>
<tr>
<td>Most important food crops</td>
<td>Teff, sorghum, finger millet, maize, wheat and barley</td>
<td>Teff, sorghum, maize and cow beans</td>
</tr>
<tr>
<td>Livestock assets owned by an average household in the PA</td>
<td>1 ox, 1 cow, 2 calves, 3 sheep and 3 goats</td>
<td>2 oxen, 2 cows, 2 calves and 4 goats</td>
</tr>
</tbody>
</table>

Source: Agricultural bureaus in Woinye and Ala Wuha PAs

Farm household characteristics in North Wollo

The characteristics of the surveyed households and farm decision-makers are indicated in Table 2.2. The descriptive statistics for the binary variables (e.g. Gender) are reported in percentage terms. Assuming that the variables reported in Table 2.2 have the same direction of influence on preferences of attributes of both crops, their hypothesized effects on the demand for attributes considered in this study are also included in Table 2.2. Definition of each farm household characteristic reported in Table 2.2 is given below:
1. gender of the household head (denoted as ‘Sex’ in the model estimation, where 1 denotes male and 0 denotes female);
2. the number of household members who share the same food stock (denoted as ‘Household size’);
3. farming experience of the household head in years (denoted as ‘Experience’);
4. whether or not any member of the farm household works off-farm (denoted as ‘Off-farm work’, where 1 denotes at least one member working off-farm and 0 otherwise);
5. whether or not the farm household has been participating in the agricultural extension package programme (denoted as ‘Agri. extension’, where 1 denotes participating and 0 otherwise);
6. average walking distance (in minutes) the household head takes to reach electricity, piped water, telephone, primary school, secondary school, all-weather roads and irrigation infrastructures (denoted as ‘Access services’);
7. whether or not the household head considers land shortage as the most important problem facing the household (denoted as ‘Land shortage’, where 1 denotes land shortage considered as the most important problem and 0 otherwise);
8. total land size operated by the household in hectares (denoted as ‘Total land size’);
9. total value of livestock (including hives and poultry), in Birr, that is currently owned by the household (denoted as ‘Livestock value’);

### Table 2.2 Descriptive statistics of farm household contextual characteristics and their hypothesized effects on the demand for attributes of crop varieties

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Mean (SD)</th>
<th>Producers’ price</th>
<th>Productivity</th>
<th>Environmental adaptability</th>
<th>Yield stability</th>
</tr>
</thead>
<tbody>
<tr>
<td>N = 131</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Household characteristics
- Gender: 90.1% ±±±±
- Household size: 5.38 (2.04) ++++
- Experience: 25.38 (11.64) ++++
- Off-farm work: 32.3% + + _ _
- No. dependants: 1.15 (1.45)++++
- Poverty status: 85.5% + + _ _

#### Farm and livestock characteristics
- Land shortage: 64.8% ++++
- Total land size: 0.75 (0.52) ±±±±
- Livestock value: 5016.5 (4745.5) + + – –

#### Development integration Characteristics
- Access services: 48.24 (27.07) _ _ + +
- Agri. extension: 70.2% + + _ _

Source: GRPI, Ethiopian survey, 2006/2007
whether or not the household considers itself to be at least self-sufficient in relation to other households in the area (denoted as ‘Poverty status’, where a value of 1 means the households consider themselves to be self-sufficient and 0 if they consider themselves poor or very poor); and number of dependants with no labour or money contribution in the household (denoted as ‘No. dependants’).

The average characteristics suggested that a typical farm household in North Wollo zone was male-headed and medium-sized with six members, two of which were economically dependent. The experience of the primary decision-maker was about 25 years. The typical farm household had no members working off-farm, lived 50 minutes walking distance away from basic infrastructures and participated in the agricultural extension programme. The average land size operated by a farm household was 0.75 hectares and most farm households considered scarcity of land as the primary problem. The average farm family had 5000 Birr worth of livestock (including hives and poultry).

**Choice experiment design and administration**

**Setting the scene: attributes and levels for the choice experiment**

The crop variety attributes and levels used in this study are reported in Tables 2.3 and 2.4. These very important attributes and their levels were identified in consultation with experts (crop breeders and researchers with hands-on experience and practical knowledge of the relevant variety attributes), by reviewing previous studies and historical data, and by identifying the most important seed selection criteria put forward by a focus group of surveyed farm households and extension workers in the villages. Apart from their importance to farmers, these attributes (‘Producers’ price’, ‘Productivity’, ‘Environmental adaptability’ and ‘Yield stability’) are also policy-relevant for designing an incentive mechanism to undertake on-farm conservation ventures at least cost (for example, by identifying farmers who are demanding attributes embedded in local varieties) or for successful rural interventions like crop variety development and diffusion.

Inclusion of monetary attribute(s) is necessary for the welfare analysis (see ‘The choice experiment and welfare measures’ section above). Producers’ price and productivity attributes can be used as a direct monetary attribute or as a proxy for monetary attribute depending on the socio-economic setup of farmers participating in the choice experiment survey. For farmers actively participating in the local markets by supplying their teff and/or sorghum output to the local market, it would be appropriate to use producers’ prices as direct monetary attribute. However, for farmers whose output is less than or just enough to satisfy their household food consumption needs, productivity seems to be more appropriate as a proxy for monetary attribute. The levels for these attributes were based on the
Zone’s minimum, average and maximum values of producers’ price and productivity of the crops during the last decade.

With more than 92 per cent of the surveyed households reporting that they have faced drought problems at least once during the last ten years, the choice of environmental adaptability trait of both crops was appropriate. The same can be said about the attribute yield stability of both crops: about 90 per cent of the surveyed households stated that they have faced disease or pest problems (causes of yield instability in our attribute definition) at least once during the last ten years. These attributes had two levels representing the existence or absence of the attributes in each crop (see Tables 2.3 and 2.4).

### Table 2.3 Sorghum variety attributes and their levels used in the choice experiment

<table>
<thead>
<tr>
<th>Variety attributes</th>
<th>Definition</th>
<th>Attribute levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Producers’ price</td>
<td>The amount of money the farmer earns by selling 100kg of harvested sorghum of a particular sorghum variety</td>
<td>110 Birr, 150 Birr, 200 Birr</td>
</tr>
<tr>
<td>Productivity</td>
<td>Average production harvested per hectare from planting a particular sorghum variety</td>
<td>14 quintals/hectare, 19 quintals/hectare, 25 quintals/hectare</td>
</tr>
<tr>
<td>Environmental adaptability</td>
<td>Whether the variety is adaptable/tolerant to drought, poor soils and frost</td>
<td>The variety is adaptable vs the variety is not adaptable</td>
</tr>
<tr>
<td>Yield stability</td>
<td>Whether the variety gives stable yield year-after-year; despite occurrences of crop disease and pest problems, in the absence of drought and frost</td>
<td>The variety gives stable yield year-after-year vs the variety gives variable yield year-after-year</td>
</tr>
</tbody>
</table>

### Table 2.4 Teff variety attributes and their levels used in the choice experiment

<table>
<thead>
<tr>
<th>Variety attributes</th>
<th>Definition</th>
<th>Attribute levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Producers’ price</td>
<td>The amount of money the farmer earns by selling 100kg of harvested teff of a particular teff variety</td>
<td>210 Birr, 270 Birr, 330 Birr</td>
</tr>
<tr>
<td>Productivity</td>
<td>Average output harvested per hectare from planting a particular teff variety</td>
<td>8 quintals/hectare, 15 quintals/hectare, 20 quintals/hectare</td>
</tr>
<tr>
<td>Environmental adaptability</td>
<td>Whether the variety is adaptable/tolerant to drought, poor soils and frost</td>
<td>The variety is adaptable vs the variety is not adaptable</td>
</tr>
<tr>
<td>Yield stability</td>
<td>Whether the variety gives stable yield year-after-year; despite occurrences of crop disease and pest problems, in the absence of drought and frost</td>
<td>The variety gives stable yield year-after-year vs the variety gives variable yield year-after-year</td>
</tr>
</tbody>
</table>
Design and administration of the choice experiment

A large number of unique crop variety profiles can be constructed from these set of attributes and levels. However, in this study, fractional factorial design was used to capture only the main effects, yielding nine alternatives which were allocated to different choice sets. These nine alternatives were created using an orthogonal design. The choice sets were then completed using a cyclical design principle (Bunch et al, 1996). A cyclical design is a straightforward extension of the orthogonal approach. First, each of the alternatives from a fractional factorial design is allocated to different choice sets. Attributes of the additional alternatives were then constructed by cyclically adding alternatives into the choice set based on the attribute levels. That is, the attribute level in the new alternative became the next, higher attribute level to the one applied in the previous alternative. If the highest level was attained, the attribute level was set to its lowest level (Carlsson et al, 2007).

We then assigned the initially created 9 alternatives from our fractional factorial design to nine choice sets and constructed 2 other alternatives per choice set (hence 18 others) following the procedure mentioned above. In total, we constructed 27 alternatives for sorghum and 27 alternatives for teff divided between 9 choice sets per crop. An example of a choice set is presented in Figure 2.1.

<table>
<thead>
<tr>
<th>Sorghum Variety Characteristics</th>
<th>Sorghum Variety 1</th>
<th>Sorghum Variety 2</th>
<th>Sorghum Variety 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Producers’ price</td>
<td>150</td>
<td>200</td>
<td>110</td>
</tr>
<tr>
<td>Productivity</td>
<td>14</td>
<td>19</td>
<td>25</td>
</tr>
<tr>
<td>Environmentally Adaptable</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Stable-in-yield</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

I prefer to plant Sorghum variety 1..... Sorghum variety 2..... Sorghum variety 3 ......

(Please tick (✓) one option)

Figure 2.1 Sample choice set for sorghum
To check the relevance of the choice experiment questions about local conditions, farmers’ expectations and level of understanding, the questionnaires were pre-tested on a focus group of 16 farmers (8 from each PA). The pre-test results were discussed with the enumerators and necessary changes were made, taking into account farmers’ responses. During the actual data collection, enumerators explained, using the local language, the context in which choices were to be made; that attributes of crop varieties had been selected as a result of prior research and were combined artificially; and defined each attribute and choice set using visual aids to ensure uniformity. Respondents were informed that completion of the exercise would help agricultural policy-makers in the design of variety development and local variety conservation interventions. Out of the 131 households interviewed for the choice experiment survey, 66 of them were randomly chosen and presented with choice sets containing sorghum variety options while the remaining 65 were given teff variety options. All of the surveyed households answered all of the 9 choice sets (either sorghum or teff version) presented to them and hence a total of 1179 choices were elicited from our survey.

Bateman et al (2003) suggest restricting the number of attributes chosen for the design to a relatively small number (such as 4, 5 or 6). This is because the minimum required sample size increases exponentially in the number of attributes. Given our constraint to a relatively small sample size of about 130, we hence decided to include 4 attributes in the profiles.

Results and discussions

The choice experiment was designed with the assumption that the observable utility function would follow a strictly additive form (Louviere et al, 2000). The model was specified so that the probability of selecting a particular crop variety was a function of attributes of that variety. That is, for the population represented by the sample, indirect utility from crop variety attributes takes the form of Equation 2.2:

\[ V_j = \beta_0 + \beta_1 Z_{\text{price}} + \beta_2 Z_{\text{productivity}} + \beta_3 Z_{\text{adaptability}} + \beta_4 Z_{\text{yield stability}} \]  
(Eqn 2.2)

where \( \beta_1 \) to \( \beta_4 \) refer to the vector of coefficients associated with the vector of attributes describing crop variety attributes and \( \beta_0 \) is the alternative specific constant.

To begin with the estimation of Equation 2.2, two conditional logit models were fitted for each crop (for either teff or sorghum variety options). The Independence of Irrelevant Alternative (IIA) property was tested, which is implicit in the error structure of the conditional logit (CL) model, using the Hausman and McFadden (1984) test contained within LIMDEP Nlogit. The tests, however, provided inconclusive results for both crops by failing to find a positive definite difference matrix for any two alternatives; and this was the case for all three tests conducted by dropping a different alternative each time,
indicating that the models do not fully conform to the underlying IIA property. Models that relax the IIA property, such as Random Parameter Logit model (RPL, also referred to as Mixed Logit), have to be estimated as it is done in this paper (Hensher et al, 2005). In the RPL model estimated for each crop, all of the attributes except for the monetary attribute (producers’ price) and the proxy for monetary attribute (productivity) were defined to be normally distributed. The models were estimated with simulated maximum likelihood with Halton draws using 500 replications (see Train, 2003 for details on simulated maximum likelihood and Halton draws). The models were estimated using Nlogit 4.0.

Although the experiment was generic, we included two alternative specific constants, since the purpose was to test if there were any other factors than the attributes themselves that affected farmers’ variety choices. The results are presented in Table 2.5.

The results in Table 2.5 show that all of the sorghum and teff variety attributes were highly statistically significant factors in the choice of both crop varieties, and that they had the expected signs in that the fulfilment of any single attribute increases the probability that a sorghum (or teff) variety was selected, other attributes remaining equal. The overall fit of the model for each crop, measured by McFadden’s $R^2$, was good. The estimated standard deviations of the random parameters were also significant, and in relation to the mean estimates they were not as large as the mean coefficients, suggesting relatively low preferences heterogeneity for these attributes. The only unexpected finding was that the two alternative specific constants were significant. This indicates that all else being equal, respondents were more likely to choose alternative 1 or 2, compared to alternative 3. This might be due to the design of the choice experiment questions.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sorghum</th>
<th>Teff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative 1</td>
<td>0.364*** (0.163)</td>
<td>–</td>
</tr>
<tr>
<td>Alternative 2</td>
<td>1.293*** (0.271)</td>
<td>–</td>
</tr>
<tr>
<td>Producers’ price</td>
<td>1.841*** (0.225)</td>
<td>–</td>
</tr>
<tr>
<td>Productivity</td>
<td>0.272*** (0.024)</td>
<td>–</td>
</tr>
<tr>
<td>Environmental adaptability</td>
<td>4.703*** (0.720)</td>
<td>2.920*** (0.606)</td>
</tr>
<tr>
<td>Yield stability</td>
<td>4.220*** (0.660)</td>
<td>2.6257*** (0.583)</td>
</tr>
<tr>
<td>Number of observations</td>
<td>594</td>
<td>585</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.566</td>
<td>0.530</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>–283.263</td>
<td>–301.915</td>
</tr>
</tbody>
</table>

Notes: *** significant at 1% level; ** significant at 5% level; * significant at 10% level.
Source: GRPI, Ethiopian survey, 2006/2007
In Table 2.6 we report the estimated mean marginal willingness-to-pay (MWTP) for each of the attributes. These are simply the ratio between the attribute coefficient and producers’ price coefficient (expressed by MWTP1) or the ratio between the attribute coefficient and coefficient for productivity (expressed by MWTP2). Note that the attributes for environmental adaptability and yield stability were binary variables, and thus they could be directly compared. For productivity, it is the MWTP in Birr for an increase in productivity by 1 quintal per hectare.

The productivity attribute may also be used as a proxy for monetary attribute, and may even be more appropriate in cases where only a small portion, if any, of the agricultural output of a farm family makes it to the market after satisfying household food consumption needs of the family. The MWTP2 values reported in Table 2.6 are based on productivity attribute taken as a proxy for monetary attribute.

The results of both measures of MWTP showed that farm households in North Wollo zone seemed to be very risk averse since they were willing to pay a rather substantial amount for more adaptable and/or stable varieties of both crops. This is perhaps reflected in their strong willingness to diversify the crops they plant between different kinds of traditional and improved varieties to buffer the impact of drought and/or disease problems.

The MWTP1 and MWTP2 values for environmental adaptability were higher than their counterparts for yield stability for both crops, and for teff the difference in WTP was significant using a t-test. The MWTP1 values for the productivity attribute showed that respondents were willing to pay 15 Birr and 25 Birr for an increase in productivity by 1 quintal per hectare.

To account for observed heterogeneity of preferences across farm households, we also estimated models where a set of socio-economic characteristics are interacted with the attributes. However, in random utility models the effects of

<table>
<thead>
<tr>
<th>Attribute</th>
<th>MWTP1 Sorghum</th>
<th>MWTP1 Teff</th>
<th>MWTP2 Sorghum</th>
<th>MWTP2 Teff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Productivity</td>
<td>14.77</td>
<td>25.16</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Environmental adaptability</td>
<td>255.50</td>
<td>515.66</td>
<td>17.29</td>
<td>20.50</td>
</tr>
<tr>
<td>Yield stability</td>
<td>229.27</td>
<td>360.28</td>
<td>15.52</td>
<td>14.32</td>
</tr>
</tbody>
</table>

Note: MWTP1: marginal willingness-to-pay values measured in terms of Birr per quintal of the respective crop (producers’ price used as the monetary attribute). MWTP2: marginal willingness-to-pay values measured in terms of quintals of the respective crop per hectare (productivity attribute used as a proxy for the monetary attribute).

Source: GRPI, Ethiopian survey, 2006/2007
social and economic characteristics on choice cannot be examined in isolation but as interaction terms with choice attributes. Due to possible multicollinearity problems, it was not possible to include all the interactions between the explanatory variables collected in our survey and the four crop variety attributes when estimating the random logit models with interactions (Breffle and Morey, 2000). The results of the two models with socio-economic characteristics are presented in Tables 2.7 and 2.8.

The results in Table 2.7 showed that the interaction between the demand for higher levels of productivity in sorghum varieties and the sex of the household head was positive. This showed that male-headed households demanded more productive sorghum varieties than female-headed households. This may be because households with male heads have larger sizes (and hence demand more output from their land) than households with female heads and those females usually assume this position in a family when they are either widowed or separated from their husbands.8

Farm households with at least one member working off-farm demanded more productive sorghum varieties compared to those households with no members working off-farm. At least two explanations can be forwarded here. First, the opportunity cost of labour in crop production is higher for farm households with an off-farm job opportunity compared to those without, reflected in their higher demand for highly productive sorghum varieties. Second, production of sorghum by resource-poor farmers is usually at least partly for home consumption. However, the percentage of sorghum grain produced and then marketed may be greater for farm households with off-farm job opportunity since they are more likely to be better integrated into the local markets, prompting them to demand higher productivity from their sorghum variety options to get more marketable surplus. The results in Tables 2.7 and 2.8 also showed that farm households with more experienced heads demanded higher environmental adaptability trait from both sorghum and teff variety options. In the drought-prone areas of North Wollo zone (such as the PAs covered in this survey), more experienced farmers were likely to have gone through a greater number of recurrent drought encounters in the past, inducing them to look for varieties that are better resistant to such environmental pressures.

The results in Table 2.7 may also shed light on why farmers choose to participate in the agricultural extension package programme, with the positive interaction term between productivity attribute and agricultural extension participation. Farmers might be motivated to participate in the extension because they demand high-yielding sorghum varieties from these services.

The results in Table 2.7 also showed that farmers operating a relatively large land size also demanded less environmental adaptability trait in sorghum varieties compared to those operating smaller lands. Smaller land size can be translated into smaller total output and less scope to diversify into different crop varieties, and farmers were particularly risk averse towards non-adaptable varieties planted on these plots since, otherwise, they put at risk the much needed output that these plots provide to the vagaries of nature.
The results of the RPL model for teff variety choices with socio-economic characteristics are presented in Table 2.8.

The RPL results for teff variety choices showed that farmers with larger land size to operate also demanded more productive teff varieties compared to those operating smaller lands. This is unexpected because with more than 63 per cent of the surveyed households reporting land shortage as a primary problem, households with smaller land sizes were expected to compensate for this by demanding more productive teff varieties. This might be because teff is a highly commercial crop and the perceived utility from more productive teff varieties was higher for farm households operating larger land sizes and who were likely to produce a greater proportion of their output for the market, i.e. marketable surplus.

The results further showed that farmers who reported higher drought frequency in the past also demanded more productive teff varieties compared to those with fewer drought encounters. This might reflect their uncertainty about the future production prospect and the need to hoard maximum teff production output for household consumption in the coming season.

Households with larger livestock assets demanded less environmentally adaptable and stable yielding teff varieties compared to those with smaller livestock assets. Crop production is the single most important source of livelihood for farmers who cannot rely on their livestock assets as an insurance against crop

### Table 2.7 Random parameter logit estimates for sorghum variety traits interacted with socio-economic characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>St. error</th>
<th>Coeff. Stdv</th>
<th>St. error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random parameters</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yield</td>
<td>-0.097</td>
<td>0.126</td>
<td>0.117***</td>
<td>0.035</td>
</tr>
<tr>
<td>Environmental adaptability</td>
<td>7.847</td>
<td>354.403</td>
<td>2.065***</td>
<td>0.606</td>
</tr>
<tr>
<td>Yield stability</td>
<td>11.898</td>
<td>354.405</td>
<td>2.370***</td>
<td>0.590</td>
</tr>
<tr>
<td>Non-random parameters</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative 1</td>
<td>0.188</td>
<td>0.196</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Producers’ price</td>
<td>0.019***</td>
<td>0.003</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative 2</td>
<td>1.691***</td>
<td>0.332</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heterogeneity in mean parameters</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Productivity * Sex</td>
<td>0.146*</td>
<td>0.082</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Productivity * Off-farm work</td>
<td>0.113*</td>
<td>0.068</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Productivity * Agri. extension</td>
<td>0.111*</td>
<td>0.065</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Env. adaptability * Experience</td>
<td>0.137**</td>
<td>0.065</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Env. adaptability * Land size</td>
<td>-3.519***</td>
<td>1.325</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of observations</td>
<td>513</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\rho^2$</td>
<td>0.611</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log likelihood</td>
<td>-219.231</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: *** significant at 1% level; ** significant at 5% level; * significant at 10% level.

Source: GRPL Ethiopian survey, 2006/2007
failure. Therefore, they are very risk averse and less inclined to take up non-adaptable and/or non-stable teff varieties.

Results in Table 2.8 also showed that the demand for environmental adaptability attribute of teff varieties increased with the household size. The shock to output associated with growing non-adaptable varieties has a much larger negative effect on larger households than smaller ones, inducing bigger households to be more risk averse towards such crops.

### Conclusions and policy implications

The aim of this study was to estimate the private values that farmers attached to crop variety traits and to identify the most important farm household contextual factors that condition their variety attribute preferences. Data was collected in personal interviews from sorghum and teff growing farmers in two peasant associations (PAs) of North Wollo zone. The choice experiment method was applied to investigate farmers’ demand for crop varieties and their attributes conditional on the characteristics of the households and the main decision-makers.

### Table 2.8 Random parameter logit estimates for teff variety traits interacted with socio-economic characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>St. error</th>
<th>Coeff. Stdv</th>
<th>St. error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random parameters</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yield</td>
<td>0.160</td>
<td>0.207</td>
<td>0.190***</td>
<td>0.038</td>
</tr>
<tr>
<td>Environmental adaptability</td>
<td>–10.252*</td>
<td>5.411</td>
<td>2.950***</td>
<td>0.980</td>
</tr>
<tr>
<td>Yield stability</td>
<td>7.787</td>
<td>6.124</td>
<td>3.826***</td>
<td>1.264</td>
</tr>
<tr>
<td>Non-random parameters</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative 1</td>
<td>0.513***</td>
<td></td>
<td>0.186</td>
<td></td>
</tr>
<tr>
<td>Producers’ price</td>
<td>0.012***</td>
<td></td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>Alternative 2</td>
<td>1.379***</td>
<td></td>
<td>0.344</td>
<td></td>
</tr>
<tr>
<td>Heterogeneity in mean parameters</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Productivity* Land size</td>
<td>0.276***</td>
<td></td>
<td>0.095</td>
<td></td>
</tr>
<tr>
<td>Productivity* Drought frequency</td>
<td>0.088***</td>
<td></td>
<td>0.030</td>
<td></td>
</tr>
<tr>
<td>Env. adaptability* Livestock value</td>
<td>–0.553***</td>
<td></td>
<td>0.178</td>
<td></td>
</tr>
<tr>
<td>Env. adaptability* Household size</td>
<td>1.440**</td>
<td></td>
<td>0.657</td>
<td></td>
</tr>
<tr>
<td>Env. adaptability* Experience</td>
<td>0.096*</td>
<td></td>
<td>0.052</td>
<td></td>
</tr>
<tr>
<td>Yield stability* Livestock value</td>
<td>–0.396**</td>
<td></td>
<td>0.163</td>
<td></td>
</tr>
<tr>
<td>Number of observations</td>
<td>531</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p²</td>
<td>0.6002</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log likelihood</td>
<td>–233.2257</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: *** significant at 1% level; ** significant at 5% level; * significant at 10% level.
Source: GRPI, Ethiopian survey, 2006/2007
The results of both measures of MWTP (with producers’ price and productivity taken as the monetary attributes alternatively) revealed farmers’ strong preferences for environmental adaptability for both teff and sorghum. Yield stability was also more important than increased productivity. These findings may explain the low adoption rates of high-yield variety seeds in Ethiopia over the last several decades. The fact that farmers attached sizeable values to both environmental adaptability and yield stability traits of sorghum and teff points to the need for supplying a crop genetic variety with additional attributes of resilience to harsh environmental conditions, rather than a breeding strategy that solely targets enhanced agricultural productivity. The results also revealed that there were differences among farm households in terms of household characteristics, resource endowments, extension participation and off-farm job opportunities that affect farmers’ private valuations of crop variety traits. There were significant differences between farmers that manage larger and smaller lands, between experienced and less experienced farmers, and between households with low and high values of livestock.

These results have important implications in the areas of on-farm conservation and variety adoption. First of all, farm households who attached the highest values to attributes already embedded in traditional varieties would maintain the varieties *de facto*. Targeting these farmers would minimize conservation costs and enhance compliance in on-farm conservation activities. For instance, *de facto* conservation of environmentally adaptable sorghum varieties by more experienced farmers with small land areas implies that there is little need to design external incentives for these varieties. This strategy, however, needs close follow-up and is likely to change in the medium to long run with farmers’ incentives. For instance, the transformation of Ethiopia’s rural infrastructure such as roads and markets that is occurring in the country will increasingly provide farmers with the incentive to shift from environmentally adaptable and stable yielding varieties towards highly productive and commercial crops. In such instances external incentives will have to be in place to ensure on-farm conservation of these crops.

Second, understanding farmers’ variety trait preferences also informs decision-makers about the variety attributes that have to be considered in on-farm conservation. For instance, more experienced farmers and small farm holders with smaller livestock assets were affected the most when they had to forego teff and/or sorghum varieties with better yield stability and environmental adaptability. They are, therefore, less likely to cooperate with on-farm conservation activities that expect them to replace varieties with these attributes unless they get equivalent compensation.

The third important policy implication relates to the area of variety adoption. For agricultural technologies to be successful, their attributes should address farmer concerns. Clearly, understanding farmers’ variety trait preferences is an input to this end. For instance, according to the results, to target and address variety demand for asset-poor, experienced and larger farmers, the priority variety attributes are environmental adaptability and yield stability of both teff and sorghum varieties.
Notes

1. A peasant association (PA), often comprised 400 to 500 people, is the smallest rural unit in the government’s organizational structure in Ethiopia.

2. Respondents were asked to specify the walking distance (in minutes) for each type of infrastructure and then an average walking distance (in minutes) was calculated for each household.

3. Birr is Ethiopia’s currency where Ethiopian Birr 8.93 = US$1 at the time of the experiment (June and July of 2007).

4. Even though environmental adaptability and yield stability are linked, we separated them because a ‘non adaptable’ variety can still be conceived to give ‘stable yield’ in the absence of drought and frost problems. In designing choice experiments, one assumes that the alternatives are mutually exclusive (Hensher et al, 2005) while the attributes need not be mutually exclusive. Some level of inter-attribute correlation is unavoidable, which is the case in this study for yield stability and environmental adaptability attributes.

5. The number of crop varieties that can be generated from 4 attributes, 2 with 3 levels and the remaining 2 with 2 levels is \(3^2 \times 2^2 = 36\).

6. Fractional factorial designs or main effects involve the selection of a particular subset or sample (i.e. fraction) of complete factorials (possible combinations), so that particular effects of interest can be estimated as efficiently as possible (Louviere et al, 2000).

7. This procedure makes the variations of the attributes of the crop descriptions (profiles) uncorrelated in all choice sets (Alpizar et al, 2001).

8. After running a Pearsonian bivariate correlation between household size and sex of the household head, it was found that the two variables are positively and significantly correlated (0.01 significance level).

9. Despite huge investments and extension programmes to promote improved seeds, the use of improved seeds is still very low – only 3 to 5 per cent of Ethiopia’s cultivated agricultural area is covered with improved seeds – leaving a great proportion of the farm households to depend on traditional varieties (World Bank, 2005).

References


Economic Analysis of Ethiopian Farmers’ Preferences for Crop Variety Attributes


44 Variety Trait Preferences and On-farm Conservation Policy


