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ECONOMIC ANALYSIS OF FARMERS' PREFERENCES FOR CROP VARIETY TRAITS USING A CHOICE EXPERIMENT APPROACH: LESSONS FOR ON-FARM CONSERVATION AND TECHNOLOGY ADOPTION IN ETHIOPIA

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ACRONYMS

CBD	Convention on Biological Diversity (1992)
CE	Choice Experiment
CGIAR	Consultative Group on International Agricultural Research
CSA	Central Statistical Agency, Ethiopia
EIAR	Ethiopian Institute of Agricultural Research
EPA	Environmental Protection Authority, Ethiopia
FDRE	The Federal Democratic Republic of Ethiopia
GRPI	Genetic Resources Policy Initiative
IBC	Institute of Biodiversity Conservation
IFPRI	International Food Policy Research Institute
IPGRI	International Plant Genetic Resource Institute
MoARD	Ministry of Agriculture and Rural Development, Ethiopia
NBSAP	National Biodiversity Strategy and Action Plan (2005)
NGOs	Non-governmental organizations
PAs	Peasant Associations
UNDP	United Nations Development Program
WTA	Willingness to Accept
WTP	Willingness to Pay

TABLE OF CONTENTS

LIST OF TABLES

Pages

LIST OF FIGURES

Abstract

Societies depend on agricultural innovation processes for food security on local, regional and global scales. Crop genetic resources, embodied in the seed planted by farmers, are integral components of these processes. Ethiopia has immense wealth of crop genetic resources, which is part of its rich biological diversity. The country's genetic resources are, however, subject to serious erosion and irreversible losses due to policy, institutional, and market failures. It is, thus, both a challenge and an opportunity for Ethiopia to design conservation policies that enable its agriculture-based economy to make the best use of its crop diversity.

The purpose of this study is to contribute to a better understanding of the challenges by providing an insight into Ethiopian farmers' crop variety attribute preferences and by identifying the most important farm household contextual factors that condition their variety attribute preferences. The study argues that farmers are maximizing their household utility by consuming their preferred crop variety attributes not by directly consuming the varieties that embed those preferred attributes. Undertaking on-farm conservation ventures, therefore, requires understanding farmers' variety attribute preferences and this study contributes to that effect. The current study also underscores the importance of eliciting farmers' variety attribute preferences in the areas of crop breeding priority setting and targeted adoption of improved varieties.

The study applies the choice experiment (CE) method to estimate the private utility farmers derive from four traits of sorghum and *teff* varieties (the two major crops in the country) including sale price (marketability of the variety), productivity, environmental adaptability (resistance to drought and frost occurrences), and yield stability of the variety despite occurrences of disease and pest problems. Our empirical analysis of farmers' preferences for these attributes is based on primary data collected from 131 *teff* and sorghum growing farmers in North Wollo zone. The CE approach employed in this study involved asking farmers to make a hypothetical choice between different crop varieties offered in a choice set and differentiated by the levels the above attributes take.

Findings demonstrate variation in the private values farmers attach to crop varieties and their attributes across farmers and the two crops considered in this study. Farm households attach the highest private value to environmental adaptability trait of both sorghum and *teff* crops; this is followed by yield stability and productivity attributes of the same crops. The results of the empirical analysis also demonstrate that farmers are slightly more risk averse towards a non-adaptable variety of *teff* than towards a sorghum variety with a similar trait. The results 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 traits. *Teff* and sorghum varieties that are resistant to drought and frost occurrences are valued most highly by larger and poorer farm households residing far away from basic infrastructures and less so by medium sized, and moderately experienced farm households. Our results also show that the demand for yield stability trait in sorghum varieties is most noticeable in richer households living in easily accessible areas, whereas larger and poorer households derive

the highest positive utility from stable yielding *teff* varieties. Relatively richer farm households who have been participating in the agricultural extension package and who have at least one member working off-farm derive the highest positive utility from more productive sorghum varieties. On the other hand, poorer farm households who do not participate in the extension package and reside in less accessible areas derive the highest positive utility from more productive *teff* varieties. Marketable sorghum varieties *i.e.*, those that fetch the highest price for the farm family, are valued most highly by male headed farm households. Farm households with accumulated wealth in the form of higher total livestock value derive the highest private utility from marketable *teff* varieties.

The above empirical results have implications not only for on-farm conservation but also for improved variety adoption and breeding priority setting in Ethiopia. For farming systems operated by relatively rich farm households, and for those found in easily accessible areas, conservation should be target to environmentally adaptable varieties of both *teff* and sorghum crops. To target and address variety demand for income shock vulnerable and segmented farmers, the priority variety attributes are environmental adaptability, yield stability, and to a lesser extent the productivity traits of *teff* and sorghum varieties. Breeding should also target to satisfy demands of different farm household types classified by their resource endowments, preferences and constraints. The research priority setting should, therefore, also ask '*breeding for whom?*' not just only '*breeding for which environment?*', as it is mostly the case.

CHAPTER ONE

INTRODUCTION

1.1. General Background

Societies depend on agricultural innovation processes for food security on local, regional and global scales. Crop genetic resources, embodied in the seed planted by farmers, are important components of these processes. Farmers, plant breeders, gene bank managers and other crop scientists draw on diverse crop genetic resources to innovate, support, and benefit society at large (Smale, 2006).

Sustainable management of crop genetic resources means assuring their diversity, both in trust collections and on farms. In agricultural systems, crop biodiversity is essential to combat the risks farmers face from plant pests, diseases and climatic shocks. Crop biodiversity also underpins the range of dietary needs and services that consumers demand as economies change (Edilegnaw, 2004; Smale, 2006).

Crop genetic resources are natural assets that are renewable but vulnerable to losses from either natural or human-made interventions, including the disruptions caused by droughts, floods or wars, as well as the gradual process of social and economic change. Technological changes in agricultural production over the past century, spurred by crop genetic improvement combined with the use of other farm inputs, have transformed rural societies in many parts of the world (Smale, 2006). Not all of these changes have been positive. For example, there is 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.

Some countries with a high amount of unique crop diversity belong to the group of poorest countries in the world (Von Braun and Virchow, 1996). Ethiopia is among those countries that are economically poor but still rich in biological diversity. It is a center of origin and as well as a center of diversity for many crops including sorghum, *teff* (Eragrostis abyssinica), coffee (arabica), and *ensete* (ensete Ventricosum). As a result, the country is mostly described as a land of crop diversity (Harlan, 1969).

The benefits that Ethiopia may derive from its crop diversity endowments depend on how this *'rich but poor'* nation is able to address the challenges of poverty without further degrading its natural resources. It is, thus, both a challenge and an opportunity for Ethiopia to design conservation policies that enable its agriculture-based economy to make the best use of its crop diversity (Edilegnaw, 2004).

The purpose of this study is to contribute to a better understanding of the challenges by obtaining an insight into Ethiopian farmers' crop variety attribute preferences and identify the most important farm household contextual factors that condition their variety attribute preferences. Be it for undertaking on-farm conservation ventures[1] or for

[1] On-farm conservation refers to the sustainable management of genetic diversity of locally developed indigenous crop varieties, with associated wild and weedy species or forms, by farmers within traditional agricultural systems (Maxted *et al*., 1997). The dynamic nature of the conservation, its participatory nature,

successful rural interventions like contextual crop variety development and diffusion, policy has to be informed on among other things '*who prefers what kind of variety attributes most?*' and '*how much are farmers willing to trade-off one variety attribute for another?*' In this study, we try to give answer to these and related questions by analyzing farmers' adoption behaviors towards the two major crops in the country – sorghum and *teff*. Informing policy on these factors contextually will enable decision-markers to understand mechanisms of influencing farmers' variety management behavior and harmonize on-farm conservation with modern technology adoption.

Why and how are farmers' preferences for crop variety traits relevant for on-farm conservation and modern technology adoption? According to the *characteristic model* developed by Lancaster (1966), consumers derive utility not from goods themselves but from the attributes they provide. Accordingly, this implies that farmers are maximizing their household utility by consuming their preferred variety attributes not by directly consuming the varieties embedding those preferred attributes. Hence, what farmers are looking for at the end of the day is variety attribute, and the demand for varieties can be considered as a *derived demand* revealed from farmers' preferences for variety attributes. For on-farm conservation, therefore, understanding farmers' variety attribute preferences will be useful to predict the likelihood of survival of varieties embedding those attributes. This enables policy makers to identify varieties for which policy incentives are required

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and the chance it gives to link crop diversity conservation with its utilization are all the desirable features of on-farm conservation ventures (Emerton, 2000).

and those that can be maintained *de facto*[2]. In agricultural research priority setting too, understanding farmers' variety attribute preferences will serve as an input for developing varietal technologies with more chance to be adopted and be successful (Edilegnaw, 2004).

The subsequent part of this introductory chapter is structured as follows. In the next section, national and global stakeholders involved in sustainable utilization of crop genetic resources are briefly discussed. Section 1.3 briefly presents the contributions of sorghum and teff crops in Ethiopian agriculture. Section 1.4 outlines the objectives of the thesis and the research methodology implemented to address the objectives. Subsequently, the scope of the thesis and its organization are presented in Section 1.5 and Section 1.6 respectively.

1.2. National and global stakeholders in sustainable utilization of crop genetic resources

According to a study by Worede *et al*., (2000), Ethiopia's genetic resources are subject to serious erosion and irreversible losses. Natural resources *i.e.* land, water, forests and other forms of biodiversity have now deteriorated in the country (FDRE, 1997; 1998). Despite the resource degradation that has been occurring over the course of time, the country has still a diverse wealth of plant genetic resources (FDRE, 1996). It has also well established crop improvement program to make use of its crop diversity (Edilegnaw, 2004).

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[2] *De facto* conservation is the decision of farmers to continue cultivating local varieties (Meng, 1997). It is the inadvertent result of farmers' derived demand for crop diversity while trying to achieve their livelihood objectives (Edilegnaw, 2004).

Various government organizations are, therefore, involved in the conservation and sustainable utilization of crop genetic resources in Ethiopia including IBC (Institute of Biodiversity Conservation), EPA (Environmental Protection Authority), EIAR (Ethiopian Institute of Agricultural Research), and MoARD (Ministry of Agriculture and Rural Development). In addition, many NGOs (for instance, Ethio-Organic Seed Action – EOSA[3]) and grass-root organizations dealing with the local community are working in the areas of resource conservation and rural development.

On the global scale, 155 parties at the Earth Summit held in Rio de Janeiro signed the United Nations' Convention on Biological Diversity (CBD) in 1992. This signaled the intention of the world community at large to forming a global alliance to protect habitats, species, and genes, shift to sustainable modes of resource use, and make the necessary policy, economic and managerial adjustments to guarantee that the benefits to be gained from the use of components of biological diversity is equitably shared across local, regional, and global societies. Ethiopia signed the CBD in 1993 and ratified it in May 1994, which then appeared in Proc. 98/1994 (FDRE, 1995). The number of parties that have ratified the convention had reached 187 in the year 2005 (FDRE, 2005)[4].

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[3] This NGO can be considered as a pioneer in linking crop diversity conservation on-farm with improving rural livelihoods (Edilegnaw, 2004).

[4] Among international research institutions contributing to the sustainable utilization of crop genetic resources include the member organizations of the Consultative Group on International Agricultural Research (CGIAR) including the International Food Policy Research Institute (IFPRI) and the International Plant Genetic Resources Institute (IPGRI) that are committed to identifying and informing policies (both national and international), on strategies that will lead to the sound management of the natural resource base that supports agriculture (Smale, 2006).

Article 6 of CBD demands the preparation of National Biodiversity Strategy and Action Plan (NBSAP) by each signatory country. As a party to the Convention and in fulfillment of its obligation, Ethiopia has prepared its NBSAP in 2005.

The NBSAP report of Ethiopia recognizes that agricultural intensification is potentially the major cause of loss of agricultural biodiversity worldwide in general and Ethiopia in particular (FDRE, 2005). The report argues that through the replacement of traditional crop varieties with high-yielding varieties that are dependent on high levels of agricultural inputs, it results in genetic erosion of resilient native varieties.

In view of this, the conservation of the rich agro-biodiversity of Ethiopia through a mix of *in situ* and *ex situ* programs[5] is carved as one of the four strategic priorities of Ethiopia's Biodiversity Strategy and Action Plan.

Despite these commitments and progresses towards the sustainable utilization of crop genetic resources in the world, the dwindling stock of crop biodiversity worldwide in general and Ethiopia in particular shows that a lot still needs to be done and more commitments need to turn into actions in a timely manner. It is, thus, both a challenge and an opportunity for Ethiopia and the world at large to design conservation policies that enable agricultural innovations to make the best use of their crop diversity.

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[5] *In situ* conservation involves conserving crop diversity using traditional agriculture and nature as a media (Haywood, 1995). On-farm conservation is the domain of *in situ* conservation of crop diversity (UNEP, 1992). *Ex situ* is a conservation strategy that involves keeping components of crop diversity alive outside their natural habitats or natural environment, for instance, by using zoos, botanical gardens, and gene banks (Heywood, 1995).

1.3. Sorghum and *teff* in Ethiopian agriculture and their diversity

Farmers' variety attribute preferences towards sorghum and *teff* crops were selected for detailed analysis in this thesis, due to the crops' importance to food security, to the conservation of crop genetic diversity, and to contextual variety development (through technology) and diffusion in Ethiopia. Apart from understanding farmers' preferences for these crops' variety traits[6], one also has to understand the potentials (attributes) of these crops (for example, their adaptability to different agro-ecologies), and the current diversity status of the crops in order to harmonize on-farm conservation with modern technology adoption. In this sub-section, these latter points are briefly discussed in context to Ethiopia.

Sorghum was named because of its height from the Latin word 'surgo' which means 'arise' (Karper and Quinby, 1947). The crop, first domesticated in Africa, is the major cereal that has a wide range of utilization not only in Ethiopia but also in many other African nations (Gebrekidan, 1979; Gebrekidan and Kebede, 1979).

In Ethiopia, sorghum is the major crop next to *teff* grown all over the country across high, intermediate and low altitude areas. The crop occupies 0.7 to 1.1 million hectares with 1 to 1.6 million tons of production annually. It contributes about 15-20% of total cereals production in the country (Edilegnaw, 2004). According to figures from the Central Statistical Agency (CSA), the crop covers 20.07% of all cultivable land in North Wello zone where our research sites are found. Sorghum is used for many purposes including, food, cash, animal feed, fuel, house construction and fence.

[6] This makes up the main theme of the study and hence also the latter chapters of this thesis.

Sorghum consists of over 20 different species of which some come from the East African and some from the West, Central and Southern African region. The primary center of origin and diversity of sorghum is assumed to be the Sudan and Ethiopia (Doggett, 1991) and breeders have found useful attributes from the Ethiopian germplasm stock (Kebede, 1991). Four of the five major races of sorghum in Africa are found in Ethiopia (Edilegnaw, 2004). Ethiopia holds *ex situ* 4% of the world's sorghum genetic stock (FAO, 1998 and Hawkes *et al*., 2000). The crop exists in tremendous variability throughout the areas of sorghum production in Ethiopia (Gebrekidan, 1979; de Wet and Harlan, 1971).

The threat of genetic erosion in sorghum in Africa as a result of expansion of new uniform cultivars and hybrids has not been as great as in other major cereals such as maize. Cyclical drought and crop failures have probably been the major causes of sorghum diversity loss in Africa (Gebrekidan, 1979).

The second crop under investigation in this study is *teff* (Eragrostis abyssinica). According to figures from MoARD, in Ethiopia, cereals, pulses, oil crops, vegetables, and root crops are grown annually on about 10 million hectares of land; of these, 7.6 million (76%) is allocated for cereals, and *teff* is the single dominant cereal crop in Ethiopia occupying 2,212,501 hectares (22.15% of all cultivable land) and the production is about 22,887,828 quintals annually. According to figures from the national agricultural sample enumeration conducted in 2001/2002, *teff* covers 24.29% of all cultivable land in

North Wello zone making the crop the most dominant cereal crop where we conducted our research.

Ethiopia is not only the origin of *teff*, but it is also the center of diversity where the crop is the most adaptable cereal in the diverse agro-ecologies of the country. As a source of staple food for many parts of the country, *teff* is primarily grown to prepare injera (Ethiopian bread), porridge and some native alcoholic drinks. The straw is mainly used for animal feed.

1.4. Overview of research objectives and methodology

1.4.1. Research objectives

On-farm conservation does not mean using traditional crop varieties[7] on all farmers' fields throughout the country. Given the vulnerability of millions of people to food insecurity, Ethiopia can not afford to cover all fields with traditional varieties for the sake of conserving these resources[8]. *In situ* conservation is not a sector-wide strategy for a nation's agriculture but one targeted to a few locations (Brush, 2000). It, therefore, requires targeting farmers who can maintain selected varieties for on-farm conservation (Edilegnaw, 2004). The issue at stake is, therefore, to find a way of balancing on-farm conservation with agricultural productivity objectives of the government.

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[7] Traditional varieties, or land races or local varieties, are variants, varieties, or populations of crops, with plants that are often highly variable in appearance, whose genetic structure is shaped by farmers' seed selection practices and management, as well as natural selection processes, over generations of cultivation (Smale *et al.*, 2001).

[8] This is because while traditional varieties are generally adaptable to different agro-ecological environments and marginal lands, they are less productive compared with modern varieties in the absence of environmental stress (Seyfu, 1997).

Despite a lot of disclosure in favor of on-farm genetic resource conservation, there is no adequate contextual research done as to how it can be harmonized with agricultural productivity objectives and made feasible complement to *ex situ* (Edilegnaw, 2004). To the best of our knowledge, no previous study attempted to link *stated preference* methods[9] with farmers' preferences for crop variety traits in Ethiopia except the work by Edilegnaw (2004) in which case farmers were asked to choose their most preferred variety from a bundle of coffee varieties each described to respondents by only a single attribute (for example, a variety that is high yielding vs. a variety that has more stable yield)[10]. Such research gaps in Ethiopia have, among others, motivated this thesis. The overall objective of the thesis is, therefore, to estimate the private economic values farmers attach to crop variety traits and identify the most important farm household contextual factors that condition their variety attribute preferences.

Specifically, the thesis addresses the following objectives:

- Examine the farm household related contextual factors affecting farmers' variety attribute preferences;
- Estimate the crop specific economic value that farmers attach to each variety attribute;

[9] This method is explained with examples in the next sub-section.

[10] Apart from the fact that coffee is a perennial cash crop as opposed to the seasonal food crops – teff and sorghum – under investigation in this study, the current study uses four attributes (with specific values) to describe a sorghum (or *teff*) variety to respondents. Thus, due to this latter approach, the current study provides a more complete picture regarding the relative importance of the different variety attributes and a fuller extent of opportunity costs forgone (the trade-offs or marginal rate of substitution between attributes) during a change in variety use, when compared with the previous work by Edilegnaw (2004). Further comparisons and hence, the current study's contributions in relation to the work by Edilegnaw (2004) are further discussed in Section 2.3 of chapter two.

- Investigate whether the above economic values that represent preferences vary between sorghum and *teff* crops.

While the first objective is meant to address the research question: *'who prefers what kind of variety attributes most?'* the second objective is about: *'how much are farmers willing to trade-off one variety attribute for another?'*

The third specific objective addresses the research question: *'which attribute of which crop should receive priority in breeding priority setting programs?'* Answering this question is important to prescribe cost-effective and crop specific breeding priority setting strategies that are most likely to be welcomed by farmers. To elaborate on this, as mentioned above, sorghum and teff crops fulfill different purposes in the household – a result of their different phenotypic characteristics[11] – and farmers' preferences towards components (attributes) of the two crops are likely to be different. This difference may be manifested by farmers' varying preferences towards the same attribute in different crops. Thus, in such a setup, a unit increase in an attribute like productivity of a certain crop (for example, sorghum) may not generate the same private economic value to a farmer as a unit increase in the productivity of another crop (for example, *teff*), creating a taste difference. For example, in our empirical analysis, we found that farmers are slightly more risk averse towards a non-adaptable variety of teff than towards a sorghum variety with a similar trait. Thus, if there is a limited budget to improve the environmental adaptability (resistance to drought and pest occurrences) trait of only one of the two crops

[11] Phenotype is defined as the morphological, physiological, biochemical, behavioral, and other properties of an organism that develop through the interaction of genes and the environment (World Resources Institute, 1992).

in this study, farmers in Wollo would be better off if this budget is geared towards the improvement of the attribute in *teff* varieties than towards the same attempt in sorghum varieties. This study, therefore, compares farmers' willingness to accept (WTA)[12] values for each attribute across the two crops and the result is expected to inform plant breeders and researchers engaged in developing improved varieties, in a more actionable way, to prioritize the improvement of a certain crop's attribute (for example, the adaptability trait in *teff*) over the same attempt in another crop (for example, the adaptability trait in sorghum). This is, however, relevant if for practical reasons, breeding can not address this improvement in both crops simultaneously.

1.4.2. Research methodology

To address the objectives of the thesis mentioned above, a choice experiment survey was conducted on 131 farmers who were randomly selected from two Peasant associations (PAs) in North Wollo zone[13]. A choice experiment is a highly 'structured method of data generation' (Hanley *et al*., 1998), relying on carefully designed tasks or "experiments" to reveal the factors that influence choice. In a choice experiment, individuals are given a hypothetical setting and asked to choose their preferred alternative among several alternatives in a choice set, and they are usually asked to perform a sequence of such choices. Each alternative is described by a number of attributes or characteristics. A monetary value is included as one of the attributes, along with other attributes of importance, when describing the profile of the alternative presented. This enables one,

[12] WTA values measure farmers' private economic values that they attach to each variety attribute.
[13] The farm household and choice survey data were collected in two phases where the first phase (collection of data on farm household characteristics) was conducted 6 months prior to the choice experiment survey, which was the second phase.

among other things, to do non-market valuation: value attributes for which it is practically hard to attach monetary figures. Experimental design theory is used to construct profiles of the two crops under study in this thesis in terms of their attributes and levels each attribute takes. Profiles of the crop varieties are then assembled in choice sets, which are in turn presented to the respondents, who are asked to state their preferences (Louviere *et al.*, 2000). Lancaster's attribute theory of consumer choice is the theoretical basis in this study (Lancaster, 1966), and the random utility model is the empirical/econometric basis of the study (Luce, 1959; McFadden, 1974).

After conducting a preliminary research to identify the attributes to be valued[14], we selected four attributes including marketability, productivity, environmental adaptability, and yield stability traits of both crops intended to describe and differentiate one crop variety from another based on the levels each of these attributes take. The profile of a crop variety, therefore, utilizes all four attributes in unison to describe a certain crop variety on offer in a choice set. Apart from their importance to farmers, these attributes are also policy relevant for designing an incentive mechanism to undertake on-farm conservation ventures at least cost or for successful rural interventions like contextual crop variety development and diffusion. The levels for producers' price (marketability) are set based on what has been observed in the past (maximum, minimum, and the most frequent levels observed) in North Wollo zone. The productivity levels are set based on farmers' working conditions under extension and non-extension services. The binary

[14] The preliminary research involved identifying the most important crop variety attributes and their levels by consulting with experts in this area (crop breeders and researchers who have previous experience and knowledge on the subject), by reviewing previous studies and historical data from CSA and EIAR, and by identifying the most important seed selection criteria put forward by the surveyed households during the first phase of the data collection process.

levels for environmental adaptability and yield stability traits represent the existence or absence of the traits in sorghum or *teff* varieties.

The sample population in each Kebele was randomly divided into two, each sub-sample receiving one of the two versions of the choice experiment: sorghum or teff variety choice sets. Farmers were then presented with 9 choice sets each containing three profiles of either teff or sorghum varieties to choose from, thus, a total of 9 choices were elicited from each respondent.

We selected the choice experiment method, among other *stated preference* environmental valuation methods like contingent valuation method (CVM)[15], to address our research objectives due to a number of reasons, the most important being:

- The choice experiment method allows for estimation not only of the value of the environmental good as a whole, but also of the implicit values of its attributes;
- The strategic bias, that is stating an extremely high/low value to get a point across, is minimised in choice experiment method since the prices of the goods are already defined in the choice sets;
- Willingness to accept (WTA) questions can be asked in choice experiments without the risk of facing huge discrepancies between WTA and willingness to accept (WTP) values as they are reasonable and predetermined (Kahneman, Knetsch and Thaler, 1990). It has been found that in CVM studies individuals

[15] CVM is the most commonly employed environmental valuation method where it involves asking respondents about their willingness to pay (WTP) or willingness to accept (WTA) to a proposed change in the level of provision of an environmental good (Perman *et al*., 2003).

seem to attach much more value to losses than they do to gains hence WTA values exceed WTP values considerably (Georgiou *et al.*, 1997).

However, choice experiment, like CVM, is a *stated preference* method and is seen by many economists as suffering from the problem that it asks hypothetical questions, whereas indirect methods like travel cost and hedonic pricing methods exploit data on observed, actual, behavior. On the other hand, choice experiment has two advantages over indirect methods[16]. First, it can deal with both *direct* and *indirect use values*, whereas the indirect methods cover mainly the former, and involve weak complementarity assumptions (Perman *et al*., 2003). *Indirect use values* of crop genetic resources include resistance to biotic and abiotic stress (represented partly by the two attributes in our choice experiment study namely, environmental adaptability and yield stability traits, see Table 4.1. and Table 4.2. in chapter 4 for the definition of these attributes), which can only be valued by *stated preference methods*. The impure private/public good[17] nature of the crops vis-à-vis their attributes and functions are also contributing factors for market failure in poorly developed rural markets like in Ethiopia, where it is even more necessary to employ hypothetical markets like in *stated preference* methods to value the public good nature of the crops[18]. Secondly, in principle, and unlike the indirect methods, choice experiment answers to WTP or WTA questions go directly to the theoretically correct monetary measures of utility changes (Perman *et al*., 2003).

[16] These advantages also hold for other *stated preference* methods.

[17] The in-between points along the pure private and pure public goods continuum are occupied by the so-called *impure public goods*. Their benefits are partly rival and/or partly excludable (Varian, 1992).

[18] The public good nature of crop genetic resources includes reduced probability of disease outbreak, increases in productivity that benefits consumers, and ecological *resilience*, which are all *non-excludable* (Edilegnaw, 2004). Crops are also produced as private consumption goods the benefit of which is excludable.

Thus, due to these reasons, one has to apply *stated preference* methods like choice experiment to get a more complete picture of the relative importance of the different crop variety attributes and measure the trade-offs farmers are prepared to face as far as variety attributes are concerned.

Furthermore, most studies dealing with the impact of rural development programs and agricultural technology adoption by farmers in developing countries are based on *ex-post* analysis of intervention programs (Wegayehu, 2006) relying on *revealed preference* data on observed, actual, behavior. Farmers are rarely consulted on their preference for type of intervention before the intervention is implemented. This study however, could also serve as key *a priori* information for variety improvement endeavors – a type of development intervention – by systematically eliciting farmers' crop variety attribute preferences and setting the focus on attributes most relevant to farmers. More specifically, the seeds of the crop varieties presented to farmers in our choice experiment study are currently not necessarily in the production lines for subsequent improved variety diffusion, but are hypothetical in nature meant to inform rural development polices on *a priori* basis towards the adoption behaviour of farmers if extension packages, in the form of improved seeds, provide these varieties or their close substitutes.

1.5. Scope and limitations of the study

In this thesis, no genetic information, as recognized by geneticists, is used to differentiate one crop variety from another during the survey or in the thesis manuscript. The survey data used, therefore, do not involve real measurements but mainly reflect farmers' variety choice criteria based on their preferences, constraints and endowments. To address the primary research questions, using farmers' variety choice criteria is found to serve the purpose envisaged.

The fact that our analysis is based on farmers' preferences for only four traits (marketability, productivity, environmental adaptability, and yield stability) of sorghum and teff crops should not be translated into saying that these are the only attributes in farmers' variety choice criteria. In almost all choice experiment studies, the researcher has to make a trade-off between being comprehensive (inclusion of all relevant attributes) and the complexity of the choice experiment (Alpizar *et al.*, 2001). That is, as one tries to include too many attributes in a choice experiment, the associated cognitive demand from respondents in making choices would be too much and respondents may simply answer carelessly or employ some strategic behaviour, which is not a true reflection of their attribute preferences. Thus, the four attributes under study in this thesis reflect the balance between including the most important attributes in our choice experiment with the complexity of the task involved in making choices[19]. Therefore, our stated preference analysis of farmers' preferences for crop variety traits covers only the four attributes mentioned above.

Moreover, the small size of our sample has prevented us from testing for regional differences in preferences *i.e.* between the surveyed farm households in the two PAs.

[19] The number of attributes in a choice experiment is studied by Mazotta and Opaluch (1995) and they find that including more than 4 to 5 attributes in a choice set may lead to a severe detriment to the quality of the data collected (e.g. respondents may simply answer carelessly or employ some strategic behaviour) due to the complexity of the task.

This is because our sample population of size 131 farmers drawn from two PAs is already divided into two sub-samples for our analysis each receiving one of the two versions of the choice experiment: sorghum or *teff* variety choice sets[20], and testing for regional differences in preferences would, therefore, have required us to further divide our sub-samples into two making the average size of each about 32 households, which would have been a small sample size to draw any important conclusions from. However, it should be noted that the analysis done in this thesis and all the conclusions and policy implications drawn afterwards do not suffer from this small sample size problem.

1.6. Organization of the thesis

The following chapter presents the literature review where a range of *revealed* and *stated preference* studies are discussed in relation to agro-diversity. Studies that merge *revealed* and *stated preference* methods along with studies that inform Ethiopia's rural development policy on *a priori* basis are also discussed.

Chapter 3 describes the farm household survey data employed in the empirical chapter of the thesis. The sampling design implemented along with the description of the research sites is also included in this chapter.

[20] Therefore, the current analysis is based on the pooled data from the two PAs receiving either version of the choice experiment questions. The analysis is then done separately for each version of the choice experiment.

Chapter 4 deals with the conceptual framework where the relationship between farm household characteristics and farmers' crop variety choice decisions is outlined. This chapter also presents the design and administration of the choice experiment survey.

Chapter 5 empirically looks at contextual farm household characteristics and their role in determining farmers' variety attribute preferences. The estimated crop specific economic value that farmers attach to each variety attribute are reported and discussed in this chapter.

Drawing on the previous empirical chapter, chapter 6 presents the conclusions and policy implications along with some future research directions.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

In this chapter, we present an array of *revealed* and *stated preference* studies mostly committed to valuing attributes of crop varieties, and hence share similar features to this study. The value of crop variety attributes can be measured with *stated* or *revealed preference* approaches. The former approach involves asking farmers (assuming the unit of analysis is the farmer) to make a hypothetical choice between different crop varieties offered in a choice set and differentiated by their attributes. *Revealed preference* approach involves utilizing data on farmers' actual and observed behaviour, which reflects their observed seed selection criteria. However, in terms of methodology, both *stated* and *revealed preference* methods have advantages and drawbacks. *Stated preference* methods are criticized because of their hypothetical nature and the fact that actual behavior is not observed; *revealed preference* methods suffer from collinearity among attributes and other modelling shortcomings (Smale, 2006). Therefore, combining the two is expected to increase the statistical efficiency of results and lend greater validity by taking advantage of the relative strengths of the two types of data. Consequently, studies that try to merge *stated* and *revealed* preference approaches – due to their attractive external validity feature[21] – have also been reviewed in subsequent sections.

[21] See section 2.3 for a discussion of external validity with examples.

One of the advantages of *stated preference* methods is their ability to serve as *a priori* information for any proposed change in environmental goods. Studies that can potentially serve as *a priori* information for Ethiopian rural development goals have also been briefly included in section 2.5 under the premise that the current study contributes to the existing literature dealing with informing and prescribing agricultural policies that are most likely to be welcomed by farmers. Section 2.6 concludes the literature review chapter.

2.2. Valuing crop variety attributes through *revealed preferences*

Revealed preference methods like the work by Edmeades (2007) applied the *hedonic price method* to estimate the supply functions of variety attributes of a subsistence crop in a developing economy. The hedonic price was derived within the framework of utility maximizing agricultural households who make consumption and production decisions simultaneously. This was reflected in the specification of the hedonic function to account for both consumption and production attributes jointly. By using spatially segmented information from three regions in Uganda, the author identified and estimated supply functions for three attributes: quality (taste, softness, and color), bunch size, and fruit size. The supply functions for these attributes were estimated as a second stage where the first stage involved the estimation of hedonic price function for each region in which the unit of observation was the farm-gate price[22] of the household-variety of banana. The marginal implicit prices of both consumption and production attributes were drawn from the first stage and included as independent variables in the supply functions and a two-

[22] Farm-gate prices trace the behavior of sellers and buyers at the first link in the market chain and provide an indication of attribute trade-offs made by farmers at the farm-gate (Edmeades, 2007).

stage least squares estimation (2SLS) approach was used to correct for potential bias in the estimation of the functions brought about by the endogeneity of the marginal implicit prices, and study the attribute trade-offs involved. A number of substitutability and complementarity cases were found between attributes. For example, an attribute like quality of banana associated with its taste, softness and color (consumption attribute) appeared to be a complement to its bunch size (production attribute) at the farm gate. On the other hand, the results for banana fruit size (production attribute) suggested substitutability with both bunch size and quality. Therefore, the paper concluded that if variety improvement endeavors are to succeed, they should not focus only on agronomic traits, but also on consumption attributes embodied in varieties.

However, as argued in chapter 1, *revealed preference methods* are confined to value attributes of crop varieties that cover mainly *direct use values* (*e.g.,* the consumption and production attributes mentioned in the above study), and one has to employ *stated preference methods* like *choice experiment* to estimate the demand for attributes, which have *indirect use values* (e.g., the environmental adaptability and yield stability traits in this study).

The following section reviews works that employ *stated preference method*s to value components of crop varieties. This method was necessary due to the public good nature of the attributes studied and hence no formal market exists for trading these attributes.

2.3. Valuing crop variety attributes through *stated preferences*

A Stated preference method, in particular *choice experiment* (CE) approach was applied by Birol *et al*. (2006a) to study farmers' demand for agricultural biodiversity in the home gardens of Hungary's transition economy. Hungary was described as a country in economic transition after joining the EU in May 2004, and the purpose of the study was to test the effects of economic development and transition on farmer demand for agricultural biodiversity in home gardens and food self-sufficiency in the country. In their study, each farmer was presented with five or six choice sets according to the blocking method used, and each choice set contained three alternatives- two of which were described by five relevant attributes and an opt-out option was included as a third alternative for farmers not interested in home garden cultivation. In the model estimation, social and economic characteristics entered the utility function as interaction terms with the choice attributes since they were constant across choice occasions for any given farmer, hence, the presence of alternative-varying regressors make conditional logit model a valid method of analysis. However, including all interactions of the settlement level characteristics with five home garden attributes in the conditional logit estimation resulted in multicollinearity problems. To overcome this constraint, the authors constructed four indices from 14 settlement level characteristics comprised of variables such as number of primary and secondary schools, number of food markets, population, and number of shops and enterprises to name a few. The four indices include, settlement development index (SDI), urbanization index (UI), food market index (FMI), population density index (PDI), all constructed using factor analysis except SDI. Factor analysis collapses the number of variables, classifying them according to their correlations and structure. The SDI, which is similar to the human development index (HDI) of the United

Nations (UNDP, 2003) was constructed by assigning each settlement a score for each characteristic in the first stage. That is, the settlement with the highest value or the characteristic was awarded a score of 100 and others were ranked proportionately in descending order. In the second and final stage, the SDI was calculated for each settlement by averaging over the characteristics indices. These four indices are then interacted with farmers' demand for home garden attributes and included in the conditional logit model that is now free from multicollinearity.

The authors found that as the settlement in which farmers reside develop and the physical infrastructure of their markets becomes denser, they rely less on their home-produced goods for food and the agricultural biodiversity they seek to maintain on their farms diminishes. On the other hand, farmers residing in the most isolated and economically marginalized settlements value the agricultural biodiversity and food produced in their home gardens most. As long as this is the case, the opportunity costs of these farmers of sustaining current levels of agricultural biodiversity are nil. However, as major changes in markets and incomes are expected to occur in Hungary as a consequence of economic transition and EU membership, the opportunity cost may not always remain nil. Therefore, the study recommends that economic growth should go hand-in-hand with public programs that identify farming communities for least cost options and apply any incentive mechanism aimed at sustaining current levels of agricultural biodiversity in Hungary.

Another similar investigation was made by Birol *et al.*, (forthcoming) on Mexican farmers' valuation of *milpa*[23] diversity and genetically modified (GM) maize using choice experiment. Data were collected across three states of Mexico, and analyzed using random parameter logit (RPL) model with interactions, which can detect for unobserved, as well as observed sources of heterogeneity in the sample. Besides accounting for unobserved unconditional heterogeneity, RPL is superior to other multinomial models like conditional logit (CL) since it does not require the independence of irrelevant alternatives (IIA) property to be satisfied but the violation of which renders CL and Multinomial Logit (ML) models inappropriate. Accordingly, the authors tested for the IIA property and were able to find that the data doesn't violate the IIA property, which makes the CL an appropriate model for estimation. However, CL assumes homogenous preferences across farmers within each site and the authors tested the assumption by estimating an RPL model and comparing the parameters with a CL model using Swait-Louviere log likelihood ratio tests. They found that they were able to reject the null hypothesis that the regression parameters for the CL and RPL are equal at 0.5% significance level for two of their three sites. Hence improvement in the model fit can be achieved with the use of the RPL model instead of CL for these two sites but CL is appropriate for the third site. The results reveal that there is considerable heterogeneity in farmers' preferences for *milpa* diversity and GM maize across and within the three states. For instance, the inter crop diversity attribute (i.e., crop species diversity in the *milpa*, which consists of intercropping of maize, beans and squash) is valued most highly by the farm households that are located in the most economically and geographically

[23] A milpa is a traditional intercropping system of maize, bean, and squash cultivated by Mexican farmers and considered as repositories of agrobiodiversity in Mexico (Birol *et al*., forthcoming).

marginalized region, whereas, intra crop diversity (i.e., maize variety diversity) attribute is valued most highly by farmers who also value maize genetic diversity embodied in maize landraces[24], regardless of the market integration level of the households.

The locations and characteristics of those farm households who value the option to cultivate GM maize the most are also identified to be fully integrated into output and labor markets. Therefore, the major policy implication drawn in the study based on these findings is that farmers that derive the highest private economic values from the agrobiodiversity components of the *milpas* would constitute the least-cost targets for *in situ* conservation on-farm programmes. The findings could also aid in assessing the potential diffusion and impact of liberation of GM maize to the environment, as well as to farmers' welfare.

A choice experiment was implemented on another study to understand household preference for consumption characteristics of millet varieties (Ndjeunga and Nelson, 2005). This case study, undertaken in western Niger, is different from the above choice experiment studies in that it tries to identify variety preferences solely from the consumers' side instead of at least also from the producers' side (farmers involved in both producing and consuming their output) as in the literatures reviewed above. This, of course, can partly explain why farmers (suppliers of the variety attributes to consumers; they being members of both) keep the varieties that attract markets. The study systematically evaluates preferences of consumers for *tuwo*[25] and *couscous*[26] cooking

[24] See sub-section 1.4.1 in the introductory chapter for a definition of landraces.

[25] *Tuwo* in the study is described as a stiff porridge made from sorghum, pearl millet, maize, rice, or finger millet flour; it's usually eaten with fingers accompanied by some types of sauce made from many ingredients. It is also known in different countries by different names.

quality characteristics. Interestingly enough, the survey instrument was developed in such a way that after the most important cooking quality characteristics were identified from focus group discussions, respondents were asked to eat and evaluate (using the identified attributes) five fermented and nonfermented *tuwo*, the overnight keeping quality of the *tuwo*[27], and five *couscous* products, all made from the same five pearl millet varieties and by the same cook. Respondents were asked to taste these *couscous* and *tuwo* products and rank them by assigning the highest value (5) for the most liked product and the lowest value (1) for the least liked product. In doing so, the authors used an appropriately specified ordered probit model and a relatively new method of analysis called tree-based partitioning to measure the value of the cooking characteristics. Findings from this study indicate that taste, chewiness, color, and cohesiveness are the most important attributes preferred by *couscous* consumers, whereas, color, cohesiveness, taste, and consistency were the most important traits for nonfermented tuwo consumers. Finally, stickiness, taste, chewiness, consistency, and mouth feel were found to be the most important fermented *tuwo* traits. These taste preferences have important implications in providing some direction for millet breeding programs and food processing of millet, which is also partly the aim of this thesis though the setting is different.

Perhaps the most relevant works to this thesis, which also contributed to its inception, dealt with the analysis of farmers' preferences for coffee variety traits (Edilegnaw, 2004; Edilegnaw and Mburu, undated)[28]. To elucidate their variety attribute preference

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[26] *Couscous* in the study is described as a steamed granulated product made from sorghum, pearl millet, maize, fonio, or wheat.
[27] Respondents were asked to evaluate the overnight keeping quality of the *tuwo* the next day.
[28] Both studies draw from the same data collected in 2001/2002.

structure, 266 randomly selected coffee growing farmers in South Western Ethiopia were asked to reflect their preferences among coffee variety attributes: yield, yield stability, environmental adaptability, marketability and disease resistance. The most preferred attribute for each farm household was selected and subsequently used as a response variable in both studies. Information on farmers' endowments, constraints and concerns were on the other hand employed as explanatory variables. One interesting such variable was used as a proxy for risk faced by each farm household, which drew from the integration of Roy's *safety first model* with the utility-based derivation of farmers' preference for variety attributes. The studies describe farmers' safety first strategy as making a *lexicographic optimizer i.e.* a farm household who aims at meeting the target minimum survival level (with a subsistent level of income obtained from the sum of the value of livestock, non-farm, off-farm and unearned income sources) as first priority objective and maximizes expected returns as second priority. This variable was found to have a highly significant and intuitive explanatory power in elucidating farmers' preference for the above coffee variety attributes.

A Multinomial Logit Model was fitted to the dataset and was found to be highly significant in explain farmers' variety attribute preference. The findings indicate that factors inducing higher demand for yield (marketability) are different from those factors leading to higher demand for yield stability (environmental adaptability). The results suggest that farmers in more accessible areas and those who are less concerned with satisfying subsistence income (risk proxy) prefer yield and marketability attributes of the coffee varieties. On the contrary, farmers in less accessible areas and those more concerned with potential future income shocks (or survival) have more propensities for adaptability and yield stability.

Moreover, farmers who are less concerned with natural problems (disease, drought, and pests) have been found to have higher demand for yield. Farmers who expect good prospect for availability of rural development services (input supply, farm implements, markets and extension services) have higher demand for yield and marketability, which are all in line with the *a priori* expected sign. These results, complemented by the results of this thesis, have implications not only for on-farm conservation but also for improved variety adoption and breeding priority setting. The policy recommendations in the paper suggest that the above results contribute to the optimization of on-farm conservation costs by identifying varieties that are most likely to be conserved *de facto* and those that need external incentives; basing the decision on the types of varieties preferred by different farm household types as described in the result. The other important policy implication is in breeding priority setting, where breeding should target to satisfy demands of different farm household types classified by their resource endowments, preferences and constraints not just their environment.

The above studies have both striking similarities and differences to this thesis. For instance, the attributes considered most important by respondents to both studies are quite similar. This similarity may be because both groups of respondents come from the same country and face similar concerns. The other major similarity arises in the fact that both studies employ *stated preference methods,* where hypothetical varieties of crops were presented in a choice set, to elicit farmers' variety attribute preferences. Their policy implications are also similar.

However, coffee is a perennial cash crop as opposed to the seasonal food crops – teff and sorghum – under investigation in this study. Thus, one of the major implications of this is that different interpretations of the attributes between the two sets of respondents for the current and previous studies can be warranted. Moreover, though both types of questionnaires employ *stated preference methods*, a coffee variety in the previous study was explained to respondents by only a single attribute (for example, a variety that is high yielding; or a variety that has more stable yield) as opposed to a sorghum (or teff) variety illustrated by four attributes (with specific values) in the current study[29]. By doing so, the latter tries to estimate the economic value (monetary value) of the non-traded attributes to farmers, which would not have been possible for the previous study, and hence the current study provides a more complete picture regarding the relative importance of the different variety attributes and a fuller extent of opportunity costs forgone (the trade-offs or marginal rate of substitution between attributes) during a change in variety use.

2.4. Valuing agro-diversity through both revealed and stated preferences

In the above studies, we see how important CE is in estimating the values of attributes of an environmental good (s), especially when the attributes in question are not traded in the market. But, how well does a hypothetical and non-market valuation method like CE perform when compared to a more conventional method of analysis (e.g. hedonic

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[29] See an example of a choice set in Figure 4.2 of chapter 4 where the description of three sorghum varieties with the levels of four attributes is included.

approach) where money has actually changed hands? Answering this question was one of the aims of a study by Scarpa *et al*. (2003a), where *revealed* and *stated preference* value estimates were compared in attempting to value indigenous cattle breeds in Kenya. In their study, the authors selected those cattle characteristics that are relevant in market transactions for the CE implementation and compared their marginal values with their counter-part (results from the linearly specified hedonic analysis) by simply identifying the determinants of market price in real transactions; both sets of data were collected from the same population of traders, in particular from seven cattle markets in Kenya. This allowed the study to conduct an external test of preference consistency between actual and hypothetical choices. The authors found that value estimates for cattle traits like slaughter weight (kgs), sex and body condition[30] from the hedonic function compare well in magnitude with those implied by the different multinomial models used to analyze the CE data. Only one attribute namely, Maasai Zebu breed[31], was found to be not significantly different from zero in the *revealed preference* analysis, but it is significantly negative in the *stated preference* approach. One possible explanation offered by the authors for this discrepancy was that during the data collection, respondents were dealing with severe drought conditions and a majority of the recorded sales would be desperate attempts to sell animals for slaughter before they died of starvation and the particular breed of animal would not play a major role in either buyer or seller preferences. Despite this discrepancy however, the authors contend that CE estimates

[30] Body condition of the cattle took ordinal values like poor, good and excellent illustrated to respondents by laminated photographs or by pointing to an animal within view that corresponds to a particular body condition (Scarpa et al., 2003a).

[31] The traditional cattle herds kept by the pastoralist Maasai of East Africa belong to a broad sub-group of cattle referred to as 'Maasai Zebu'. These animals have a high degree of tolerance to drought and endemic disease not present in exotic breeds but produce less meat and milk per animal than the latter if both are subject to high level of management and nutrition (Scarpa *et al*., 2003a).

pass the external test and appear to be adequately precise in estimating values for cattle traits that are relevant in market transactions for Maasai traders. These findings, therefore, suggest that CEs may be a promising tool for valuing phenotypic traits[32] (e.g. higher resilience) and complement other research results, including the results from this thesis, that tackle such issues more directly.

Drawing on the above conclusions, a subset of the authors who wrote the above paper (along with different authors) did a related work in attempting to value breed traits of local[33] pig breeds in peasant economies of Yucatan, Mexico (Scrapa *et al.*, 2003b). The genetic purity of these local pig breeds (they are referred in the study as 'creole' pigs) is reported to be under serious threat by the indiscriminate adoption of exotic pig breeds. The study reports that the latter breeds are claimed to be superior in terms of highly digestible feed-meat conversion but, for this potential to be fully delivered the traditionally extensive management systems must be intensified, which is often beyond the scope of existing human and capital resources available to a typical peasant economy. On the other hand, some genetically determined traits of the creole pig, such as higher tolerance to environmental extremes and parasite resistance, seem to ensure a higher rate of survival in the traditional management system, which relies on very low input and technology. However, the recent trend of importation and promotion of pigs of 'improved' breeds in Mexico is reported in the study to contribute to: a drastic reduction in the number of creole pigs (breed substitution), and the loss of the creole pig characteristics through cross-breeding (genetic erosion). Therefore, the authors used

[32] See section 1.4.1 of chapter 1 for a definition of phenotype.
[33] The term 'local' refers to livestock that have become adapted to the specific environments of low external input rearing systems (Scrapa *et al.*, 2003b).

choice modelling to estimate producers' preferences for genetically determined pig attributes in the backyard economy of Yucatan. Attributes selected for the CE were distinct between exotic and local pig breeds; these included, piglet costs, weight of the pig at 6 months, bathing frequency for heat relief, and disease resistance. The random utility parameter estimates conditional on respondents' characteristics suggest that attributes of indigenous piglets[34] are relatively more valuable for the predominantly younger, less educated, and lower income households in the sample. The estimated magnitudes for these breed traits of considerable relevance for the household production function were also found to be comparable with shadow cost computations obtained through historical accounts, agricultural censuses and scientific articles, providing the CE results with external validity. Therefore, such information is valuable for conservation programmes thereby identifying those households that most value the local creole breed and for designing cost-effective policies that counter the trend towards marginalization of the indigenous breed. Furthermore, breeding programmes meant to address producers' preferences/concerns, for which pigs often provide a means for saving, smooth consumption patterns, and used as cyclical buffering, can also benefit in terms of priority setting that takes into account the above attributes without negatively affecting the conservation programmes. Local varieties of crops, which are of interest for this thesis, share similar traits with creole pigs regarding disease resistance and productivity when compared with improved/exotic varieties/breeds and face similar threats as creole pigs. This is despite the fact that their biological make-up is totally different. Therefore, *stated preference* researches, as in the above study, need to inform policy on the conservation of

[34] Indigenous piglets do not require feed purchase, show high disease resistance and need only one bath a week.

indigenous flora and fauna in relation to agriculture and this thesis contributes to the former. This thesis also shares similar features to the above study in that the current study contributes to understanding farmers' crop variety attribute preferences, which can later be used by crop breeding programs to develop improved varieties that address the concerns of farmers in Ethiopia.

Another external validity investigation was also made in a developed country context. This investigation was conducted on undergraduate students from two universities in Sweden, by eliciting their willingness to pay (WTP) for donations to environmental projects (Carlsson and Martinsson, 2001). The authors' test of external validity was a test based on marginal WTP, where respondents were presented with hypothetical and actual experiments each choice set containing two alternatives with two different environmental projects and donations per person needed for each project. The result indicated that the authors were unable to reject the hypothesis that the preferences are the same in the two experiments. This is therefore, a further indication that choice experiments seem to be an alternative method of eliciting individuals' preferences for public goods. Applying choice modeling to impure public goods like the crops considered in this thesis[35], is also an interesting area that should receive a certain degree of validity from the previous conclusion.

After calculating willingness to accept (WTA) values for each variety attribute of the crops studied in this thesis, we attempted to compare farmers' valuation of the

[35] For a discussion on the impure public good nature of the crops under study in this thesis, see sub-section 1.4.2 in the previous chapter.

productivity attribute in our hypothetical *stated preference* data with Producers' price (farmers' sale price) data from Central Statistical Agency (CSA) for this attribute, where actual behavior is revealed, and we found them to be similar (See section 5.3. in chapter 5 for a detailed discussion of this finding). Thus, this important finding provides our study with external validity, like the works reviewed under this section, by minimizing the disadvantages associated with the hypothetical nature of our *stated preference* study.

2.5. Stated preferences as *a priori* information for Ethiopian rural development goals

Wegayehu (2006) investigated farmers' perception of the relevance of different development intervention programs in the eastern Ethiopian highlands and found that farmers' specific socio-economic circumstances and subjective ranking of agricultural problems play a major role in their preference ranking of interventions in the areas of market, irrigation, resettlement, and soil and water conservation. The study underscores the importance of *a priori* information if development efforts are to bring about the desired outcome, which the author argues is lacking and is partly responsible for the failure of rural development programs in most developing countries. The results of the study also suggest that the menu for intervention programs needs to take into consideration socio-economic differences that might exist within the same agro-ecological settings for micro level implementation of development programs. Thus, the paper concludes that if a well-stated and best-articulated national or regional policy and/or strategy is to succeed, one also has to pay due attention at the grassroots level execution of the policies and strategies.

As stated in the introduction chapter of this thesis, the results from the current study could also serve as a key *a priori* information for variety improvement endeavors – a type of development intervention – by systematically eliciting farmers' crop variety attribute preferences and setting the focus on attributes most relevant to farmers.

On the Ethiopian rural development programs menu, agricultural extension packages are currently on top of the list, assuming that the list is populated in order of prevalence. However, the dichotomy between extension driven adoption of modern inputs, on the one hand, and community driven local public goods, on the other hand, is particularly evident in the highlands of Ethiopia (Carlsson et al., 2005). In spite of these trade-offs, the study by Carlsson *et al.* (2005) argues that the target populations of these policies seldom have the possibility to express their preference between the two. Therefore, the authors employed a *stated preference* survey in particular, choice experiment, to investigate Ethiopian farmers' preferences between an agricultural extension package and a local public good – health care or protected spring. As described in the study, the current extension approach in Ethiopia includes predominantly the provision of improved seeds of food and commercial crops, and artificial fertilizers, and is currently provided to farmers with credit under local government collateral arrangements. The repayment requirements of these short-term credits hold even under occurrence of crop loss sustained by peasant borrowers.

A standard random effects binary Probit model was fitted for the analysis, where the dependent variable is equal to one if the respondent opted for the extension package and zero otherwise. The study found that a majority of people prefers the public good. However, when the extension package is combined with insurance in terms of no payback of the credit in case of crop loss, then the authors found a significant increase in the choice of the extension package. The study thus sheds light on why Ethiopia's major development strategy has had limited success and gives evidence of how *stated preference* methodologies can be utilized for development policy design. The latter can be achieved by informing policy, on *a priori* basis, about the preferences of the targeted population towards the proposed policies.

In this thesis, we try to relate crops' responses to the major underlying environmental pressures leading to the crop loss mentioned in the above study (e.g. drought and disease), with farmers' preferences to these crops. This is in contrast to the approach employed in the above study – through the inclusion of an insurance component in the extension package that directly reduces the risk from adoption[36]. Furthermore, the seeds of the crop varieties presented to farmers for this study are currently not necessarily in the production lines for subsequent improved variety diffusion, but are hypothetical in nature meant to inform rural development polices towards the adoption behaviour of farmers if extension packages, in the form of improved seeds, include these varieties or their close substitutes. Therefore, if agricultural technologies are conceived without considering farmers' contextual conditions on *a priori* basis, they carry the twin risks of being

[36] For a detailed discussion of this approach see Carlsson *et al.* (2005).

released without farmers taking them or being rejected while farmers would have found them valuable (Edilegnaw and Asmare, 2007).

2.6. Concluding remarks

This chapter presents how this thesis contributes to the existing literature dealing with the application of *stated preference* methods in general, and stated choice methods in particular, in a developing country setup. At the household level, the study also contributes to a promising research direction, in terms of methodology, that would involve merging of *stated* and *revealed preference* approaches, where the latter approach lends external validity to the former. Finally, as the studies reviewed above, the current study can potentially serve as *a priori* information for one of Ethiopia's rural development interventions: contextual crop variety development and dissemination.

CHAPTER THREE

DATA COLLECTION METHODOLOGY AND DATA DESCRIPTION

3.1. The data generation process: survey design and implementation

This research was dependent on both primary and secondary data with the field work undertaken in the North Eastern part of the country (North Wollo zone of Amhara Regional State). Two phases of data collection procedures were implemented for this study within the framework of IPGRI's (International Plant Genetic Resources Institute) Genetic Resources Policy Initiative (GRPI) - Ethiopia project, with an aim to support the development of policy options for sustainable conservation and utilization of crop genetic resources in Ethiopia. The first phase of data collection, which was administered from October 2006 till January 2007, was mainly concerned with collection of data on farm household characteristics and asset ownerships, and factors related to their seed choice decisions, agricultural extension and markets, shocks, and their risk coping strategies. All the socio-economic variables employed in chapter 5 to explain farmers' variety attribute preferences are drawn from this phase *i.e.* data from the first and second phases were merged in our empirical analysis. The second phase of data collection, which was conducted during June and July of 2007, was by and large, the choice experiment survey. A detailed discussion of the design and administration of this second phase or the choice experiment survey is included in the next chapter. In this section, however, we will discuss the sampling and data collection procedures followed during the first phase. This was necessary because the second phase, which made up the main theme of the study, has built upon the sampling structure already constructed during the first phase *i.e.* respondents who were sampled and interviewed for the first phase (the farm household survey) were also re-interviewed for the second phase (the choice experiment survey).

During the first phase, a base-line survey was undertaken to identify sources of heterogeneity of farm households before the *stratified multi-stage sampling* was adopted to identify Zones, Districts, Peasant Associations (PAs), villages, and farm households. Moreover, a total of 24 key informants (12 per PA per session) were interviewed (during the 2006/2007 cropping season) to undertake wealth ranking, understand farmers' decision behaviour related to variety use, and identify the most important crop varieties in use in the PAs surveyed in both phases.

The First phase of the data collection procedures has considered two Zones (South Gondar and North Wollo) in Amhara Regional State. In each zone, two districts were considered based on agro-ecological representation. In each district, two peasant associations (PAs) were selected based on the same criterion. However, due to logistical and time constraints, the choice experiment survey (phase 2) was conducted on farm households residing only in North Wollo zone. Consequently, in terms of distribution, 131 farm households (33.4 % of all farm households surveyed for the first phase) were interviewed for both the first and second phases of data collection. Our econometric analysis in chapter 5 is based on these farm families who have been interviewed for both phases. These farm households were also drawn from two PAs namely Woinye, and Ala Weha from Guba Lafto district of North Wollo zone.

Finding the most important sources of heterogeneity of peasant households was the most important step after selection of the PAs. By and large, poverty status / wealth indicators were the most important variables found to be the sources of heterogeneity among farm households. Using the variable as a stratification mechanism, households were sampled to ensure proportionality. Accordingly, in terms of distribution of the sampled households, 68 and 63 farm households have been sampled and interviewed (for both phases) from Ala Weha and Woinye PAs respectively.

In consultation with Agricultural Bureaus and development agents working with farmers, the survey sample was structured to cover a representative sample of villages and farmers with respect to a wide range of agro-ecological and economic variables. The variables included in the selection process include prevalence of drought, distance from markets, distance from extension and input supply services, relative importance of different income sources, and prevalence of poverty. In consultation with the respective development agents working in the PAs sampled, the most important sources of heterogeneity among households which were identified for selecting farm households proportionately include land size, poverty status, sex of the household head, and income source outside agriculture.

Households were stratified by groups according to rosters kept in each PA, and individual farm households were sampled in proportion to stratum representation. The data for both phases were collected through personal interviews with a structured questionnaire. Two versions of the choice experiment survey were designed each containing either of the hypothetical sorghum or *teff* variety choice sets. The sample population in each PA was then randomly divided into two, each sub-sample receiving one of the two versions of the choice experiment (see chapter 4).

In sampling farmers, sites close to markets (input, output and credit) and those far away from markets and other public services were considered *i.e.* an effort was also made to get representative sample in terms of access to market and public services. In consultation with the zonal agricultural bureaus, the survey sample was structured to cover a representative sample of villages in the study area. Thus, the villages were chosen to incorporate a wide range of agro-ecological, market, road and cultural diversity. This way, 10 villages (4 from Woinye PA and 6 from Ala Weha PA) were sampled before selecting peasant households for interview.

In total, 11 enumerators from North Wollo zone who knew the local language and culture were hired and trained for effective collection of data during the first phase. All of these enumerators, who were also employees of MoARD as development agents, were diploma holders. Six of the eleven enumerators were rehired and trained for the choice experiment survey (phase 2). In addition, these enumerators were also involved in the questionnaire pre-test and interview with the close supervision of the principal investigators for each of the two respective phases of data collection procedures[37].

[37] The principal investigator of the farm household survey (phase 1) is Dr. Edilegnaw Wale; whereas, the principal investigator for the choice experiment survey (phase 2) is the author of this thesis.

The draft questionnaire employed in the first phase had modules on demography and farm household contextual characteristics, household asset ownership and poverty, farmers' land use decisions, farmers' variety attribute preferences, seed sources and seed turn-over, farmers' ranking of the different types of shocks they frequently face, farmers' survival and coping strategies during shocks, and farmers' access to services (markets, extension, irrigation *etc*.). This draft questionnaire was then pre-tested to examine its feasibility in line with farmers' expectations, responses, outcomes, and level of understanding. About 18 farmers were involved during the pre-test. Following the pre-test, the test results were incorporated in revising the questionnaire in line with farmers' response to the previous version. The survey data collected this way is later employed in our empirical analysis in chapter 5 to explain farmers' preferences for crop variety traits conditional on the farm household contextual characteristics and other factors mentioned above.

Following sampling of farmers, training of enumerators, questionnaire pre-test, and revision of the questionnaire, 131 farmers drawn from two PAs in North Wollo zone were interviewed. All of these farmers were interviewed twice where each interview was conducted for either phase of the data collection procedure mentioned above. Each enumerator did an average of three interviews a day accompanied by the respective principal investigator for each phase. The principal investigators were also involved in interviewing some farm household heads to better understand their decision making behaviour regarding variety selection and management.

The next section discusses the characteristics of the two PAs covered by this study. The relevant information provided by key informants along with secondary data collected from the agricultural bureaus in each PA is reorganized and presented in the next section.

3.2. Study site description

The villages surveyed in Woinye PA include Shall, Mamuarecha, Kokeba, and Kolegenda. The PA has a human population of 11,210 and size of 3,215 hectares. Woinye PA is located 23 kms West of Woldeya town, the capital of North Wollo zone. Agro-ecologically, the PA is 'Woina dega' – 83%, 'Dega' – 10%, and 'Kola' – 7%. There are more than 15 types of crops under cultivation in the PA. The most important crops[38] (along with their land cover) include *teff* – 205 hectares (ha), sorghum – 156 ha, 'dagusa' – 196 ha, maize – 146 ha, wheat – 125 ha, and barley – 105 ha. The most important local varieties of sorghum in the PA include *degabit*, *jamiye*, *zengada*, *tehulederie*, and *maritu*. Among the most important local varieties of *teff* are *nech teff*, *key teff*, and *sergegna*. According to key informants, the productivity of the local varieties of sorghum and teff crops under farmers' conditions in the PA are 19 quintals/ha, and 9 quintals/ha respectively. *Yeju mashila* is the most common improved variety of sorghum that stays productive (at around 20 quintals/ha) for 3 years.

Concerning the cropping seasons in Woinye PA, about 25 percent of the farmers produce during 'meher' and 'belg' seasons. The rest are engaged in crop farming primarily during the main raining season, which is in winter ('kiremt'). Moreover, farmers who have

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[38] Crops' importance, in this study, reflects the crops' (or their varieties') contribution to food security and economic benefits (*e.g.*, income generated from crop sale) in the farm household.

access to irrigation in this PA can produce 2 – 3 times per year from the irrigable crops like onions, potatoes, pepper, cabbage, and sugar cane. About 30 % of the cultivated land (1052 ha) is irrigable with a total land size of 314 ha. About half of the farm households in the PA use irrigation for growing their crops. The most important agricultural problems in the PA in relation to crop production include shortage of rain fall, soil degradation, soil erosion, and shortage of land (land fragmentation and landlessness). These problems are also common in many parts of the country with varying levels of intensity. Pest problems are also reported to be among the most common problems affecting sorghum and *teff* crops in both PAs studied in this thesis.

Concerning farmers' livestock assets in Woinye PA[39], on average, a farm household owns one ox, a cow, two calves, three sheep, and three goats. From among all households, 40% of them own donkey (s), and 3% own mule (s). Livestock diseases are the most critical problems in the PAs covered in our survey.

The second PA surveyed for this choice experiment study is Ala Weha PA. The villages surveyed in Ala Weha PA include, Doro Gibir, Hayqote, Ambalat, Gwasate, Kulu Bayne, and Weyneba. The PA is located 10 kms North of Woldeya town. Agro-ecologically, Ala Weha PA is 'Woina dega' – 5%, and Kola – 95%. The most important food crops in the PA are *teff*, sorghum, maize, and cow beans that cover respectively 360, 380, 170, and 35 hectares of the area under the PA. The most important local varieties of sorghum in the PA include *degalet*, *jemiye*, and z*engada*. The average productivity of these varieties

[39] Livestock assets are usually employed in agricultural journals (especially those that focus on developing countries), as a proxy for the total value of wealth in a farm household; this is also true in this study.

under farmers' conditions is reported to be 12 quintals/ha. The most important local varieties of *teff* in the PA are *Bunign* and *Ayiro* with an average yield of 10 quintals per hectare on farmers' fields. *Yeju*, which yields 16quintals/ha and *DZ196,* which yields 15 quintals/ha, are the most important improved varieties of sorghum and *teff* crops respectively in the PA. The proportion of land allocated to improved varieties of sorghum grew from 2 to 10 percent in the PA during the period between 2003 and 2005. However, the high price of improved seeds (and fertilizers), the associated high moisture requirement, and the overall mistrust associated with improved varieties[40] are described as the reasons why farmers in the PA keep improved and local varieties of crops side by side on their fields. In this case, farmers' preferences towards local varieties are a reflection of their risk-averse behaviours. According to key informants pests and diseases, shortage of pesticide, backward system of planting crop seeds, growing poor crop varieties (in terms of their productivity), and the prevalence of dangerous weed on farmers' fields are the most important problems of agriculture in the PA in relation to crop production.

Based on our survey data, on average, a farm household in the PA owns two oxen, two cows, two calves, and four goats[41]. From among all households, 50% of them own donkey(s).

[40] For example, according to key informants, farmers in the PA do not trust the improved varieties to stay productive year after year.
[41] The descriptive statistics reported here are rounded to the nearest whole numbers.

Table 3.1 Summary of main study site characteristics

Study site characteristics	Woinye PA	Ala Weha PA
Agro-ecological coverage	‘Woina dega’ – 83%, ‘Dega’ – 10%, and ‘Kola’ – 7%.	‘Woina dega’ – 5%, and Kola – 95%
Most important food crops	*Teff*, sorghum, *dagusa*, maize, wheat, and barley	*Teff*, sorghum, maize, and cow beans.
Livestock assets owned by an average household in the PA	1 ox, 1 cow, 2 calves, 3 sheep, and 3 goats.	2 oxen, 2 cows, 2 calves, and 4 goats.

Source: Agricultural bureaus in Woinye and Ala Weha PAs.

Therefore, based on our study site descriptions summarized above, we can conclude that the two PAs surveyed for this choice experiment study share both similar and different features concerning each PA’s characteristic indicators identified above. For instance, *teff*, sorghum, and maize are among the most important food crops in both PAs. Agro-ecologically, however, ‘Woina dega’ is the dominant agro-ecology in Woinye PA covering 83%; whereas, ‘Kola’ is the major agro-ecology in Ala Weha PA covering 95%. This should, however, increase the representative-ness of our surveyed farm households since our sample is comprised of farmers who came from the three major agro-ecologies in Ethiopia and who are actively growing the two major crops (sorghum and *teff*) in the country.

3.3. Farm household characteristics in North Wollo

The average characteristics of the surveyed households and farm decision makers in North Wollo zone are reported in Table 3.1 below by type of choice experiment (CE) questions asked: sorghum or *teff* choice sets. The descriptive statistics for binary variables (e.g. Gender) is reported in percentage terms (see Table 3.1). Similar average values for most of the household characteristics can be observed between respondents presented with either version of the choice experiment questions. This reflects the simple random sampling design employed to determine who should be presented with which version of the choice experiment questions[42]. The reason for our reporting the descriptive statistics separately for the two sets of respondents in Table 3.1 (as opposed to reporting the pooled data between the two categories) is because our empirical analysis in chapter 5 is done separately for each version of the choice experiment questions. Thus, we were able to investigate in chapter 5 how the farm household contextual factors (the variables reported in Table 3.1) affect farmers' preferences for sorghum and *teff* variety traits separately. Most of the discussions under Table 3.1 are, however, based on the pooled data where there is no significant difference in average characteristics between respondents presented with either version of the choice experiment questions.

The survey instrument employed in the first phase to collect farm household characteristics reported in Table 3.1 is reported in Appendix III.

[42] Before this sampling design is employed, development agents were consulted to ensure if all the surveyed farm households are familiar with the crops under study. They disclosed that the farmers surveyed (during the first phase) have at least previous experience with the crops. This is also supported by our data from the first phase.

Table 3.2. Farm household characteristics by type of questions asked

Variable name	Definition	Sorghum-CE respondents (N=66)	Teff-CE respondents (N=65)
		Mean (S.D)	
Age	Age of the household head	46.09 (11.60)	47.49 (12.67)
Experience	Farming experience of the household head	25.06 (10.31)	25.71 (12.84)
Household size	Number of household members	5.32 (2.11)	5.45 (1.95)
Education	The highest level of schooling attained by the household head	1.84 (2.55)	2.10 (2.75)
No. dependents	The number of dependents (with no labor or money contribution) in the household	1.18 (1.63)	1.12 (1.24)
Land size	Total land size cultivated by the household, in hectares	0.78 (0.55)	0.72 (0.50)
Livestock value	Total value of livestock, in birr, in the household	4904.28 (4494.87)	5126.95 (4978.70)
Access services	Average walking distance to services, in minutes[43]	47.26 (24.32)	49.24 (29.58)
Access2	The average of walking time	52.75	50.81

[43] Services include electricity, piped water, telephone, primary school, secondary school, all weather roads, and irrigation. Respondents were asked to specify the walking distance (in minutes) for each type of service and an average walking distance to services was calculated for each respondent (see question 2.10 in the survey instrument included in Appendix III).

	needed to reach the agricultural extension center, the nearest weather road and market (average sum to the three in minutes)	(42.29)	(38.16)
Drought frequency	The number of times the household faced drought problems during the last ten years	2.70 (1.92)	2.20 (1.42)
Pest_ disease frequency	The number of times the household faced pest and/or disease problems during the last ten years	3.12 (2.61)	3.00 (1.99)
		Percent	
Gender	The household head is a male	87.9	92.3
Land shortage	Land shortage is considered by the household head as the most important problem currently facing the household	69.0	60.9
Poor quality land	Poor quality of land is considered by the household head as the most important problem currently facing the household	22.4	31.3
Poverty status	The household considers itself at least self sufficient in relation to other households in the area	84.8	86.2
Off farm employed	At least one member of the	29.2	35.5

	household works off farm		
Agri ext participation	The household has been participating in the agricultural extension program	75.8	64.6

Source: Genetic Resources Policy Initiative (GRPI) - Ethiopia project, 2006/2007.

The average age of the surveyed household heads in Guba Lafto Woreda is about 47 years, out of which, 54 % (25.4 years) is spent on developing farming experience along with other responsibilities. The average size of a household in our sample is 5.39; and there are on average 1.15 number of dependents (with no labor or money contribution) living in each household. The average highest level of schooling attained by a household head in our sample is grade 2; however, 45% of our surveyed household heads are illiterate.

The average values of wealth indicators in farm households like total land size (in hectares) and total livestock value (in birr) managed by our surveyed households are also reported in Table 3.1. Farm household heads were asked to state the total land operated by the household in local units (e.g. *Timad*) and their responses were converted to hectares before organizing our data for analysis (see question 3.0 in the survey instrument included in Appendix III). The average total land size operated by a household in our sample is, therefore, 0.72 hectares. Farm households in our sample also manage lands that are of size as small as 0.13 hectares and as big as 3 hectares of land. However, 65% of the surveyed households consider land shortage as the most important problem currently facing their respective households[44]. This figure shows that the majority of farmers are more likely to find even the average land size (0.72 hectares), to be an insufficient source of input for agricultural productions that satisfy the household food consumption needs of farm families. Poor quality of land is also the most important problem for about 27% of the surveyed households.

Household heads were asked to state how much, in birr, they value each of their livestock and their responses were recorded by type of livestock (see question 2.7 in the survey instrument included in Appendix III). Accordingly, the average aggregated value of livestock owned by a farm household in our sample is worth about 5,000 birr. This average value, however, suffers from outliers since the percentage of farmers whose livestock value is worth less than or equal to 700 birr and those who own livestock worth more than 15,000 birr are, 8.1% and 5.7% of the surveyed households, respectively[45]. This significant disparity that exists between livestock owners in terms of the values of their livestock is also a reflection of the significant wealth gap that exists between farm families residing in the PAs surveyed. In order to circumvent the problem associated with the inclusion of outliers in our calculation of average livestock value[46], we have recalculated the average after dropping the above outliers from our sample. Accordingly, the average total livestock value was found to be 4,477 birr, which is less than the

[44] There is, however, a slight discrepancy concerning this variable between households presented with sorghum and *teff* variety choice sets where respondents in the former category reported higher rate of land shortage problems (by 9 percentage point difference) than households presented with *teff* variety choice sets (see Table 3.1). Similar discrepancies are observed in *Poor quality land* and *Agri ext participation* variables between the two sets of respondents as reported in Table 3.1.

[45] The extreme minimum and maximum total values of livestock in our sample are 80 birr and 23,900 birr respectively.

[46] This is because average values tend to be biased towards extreme values and hence may not be representative of the samples they were derived from.

previous average by 523 birr. Similarly, the average total livestock values (without the outliers) for respondents presented with sorghum and *teff* variety choice sets are 4,578 birr and 4,367 birr respectively.

Other farm household characteristics that can potentially explain farmers' variety attribute preferences are off-farm employment and poverty status of farm households (see Table 3.1 above). If a member(s) of a household works either on someone else's land or in some other employment position (against payment in cash or in kind), then, the household is considered in this study to have income generated from off-farm employment opportunities (see question 2.2 in the survey instrument included in Appendix III). Accordingly, about 32.4% of the surveyed households have reported that they have at least one member of their household working off-farm.

Another important variable in explaining farmers' crop variety attribute preferences is the poverty status of our sample households. Each farm household head was asked to judge the poverty status (the level of well-being) of his/her household in relation to other households in the area and in doing so, each household head was asked to place his/her household in one of the five response categories: very poor, poor, self-sufficient, rich, or very rich (see question 2.1 in the survey instrument included in Appendix III). To test the reliability of this variable before including it in our model *i.e.,* to test whether or not farmers are biased to classify themselves in categories that they do not belong, we cross-checked farmers' responses to this question by calculating the average total livestock value (as a proxy for well-being) for respondents in each response category mentioned above. Accordingly, we found significant differences in the average total livestock values between these five response categories, which confirmed our *a priori* expectations if farmers were not biased in their judgement of the poverty status of their households. Therefore, we can conclude that even though all farmers may not employ the same standard to judge the poverty status of their farm households, their judgement is closely comparable. Before including this variable in our model estimation, however, farm households who consider themselves self-sufficient, rich or very rich in relation to other households were merged into one category (known by *at least self-sufficient* farmers) and were coded as 1 and those who consider themselves either poor or very poor were set to 0 in our *poverty status* variable, which is essentially reduced to a dummy variable (See the descriptive statistics for this variable in Table 3.1 above). This data transformation was necessary to make our interpretation of the variable in the econometric models simple and tractable. Consequently, farmers who consider themselves at least self-sufficient in relation to other households in the area cover 85.5% of the surveyed households.

Variables that measure a farm household's level of integration into different rural development infrastructures, local markets, and agricultural extension programs are *Access services*, *Access2*, and *Agri ext participation* variables as defined in Table 3.1 above. These variables are chosen to investigate how the rural development endeavours of governmental and non-governmental organizations are affecting farmers' crop variety attribute preferences. Accordingly, the average walking distance (in minutes) to infrastructures like electricity, piped water, telephone, primary school, secondary school, all weather roads, and irrigation in the PAs surveyed is about 48.25 minutes. Similarly, the average of walking time (in minutes) needed to reach the agricultural extension center, the nearest weather road and market in these PAs is 51.8 minutes. This variable (*Access2* in Table 3.1*)* was, however, dropped from our econometric models reported in chapter 5 due to the multicollinearity problem that arose with its inclusion[47]. Farm households currently participating in the agricultural extension program also cover about 70% of the surveyed households.

The last two variables included in Table 3.1 but not discussed so far are *Drought frequency,* and *Pest_ disease frequency* variables (see Table 3.1 for the definition of these variables). The descriptive statistics for these two variables shade light on why farmers attach the highest private value, as revealed in chapter 5, to environmental adaptability and yield stability traits of both sorghum and *teff* crops. More than 92% of the surveyed households stated that they have faced drought problems at least once during the last ten years with a mean frequency occurrence of 2.45 times per household since the last ten years[48]. The variation in drought frequency problems from one household to another may be explained by the varying agro-ecologies represented by the PAs studied.

Drought frequency figures are similar to the frequency of occurrence of pest and disease problems (causes of yield instability in our attribute definition). About 90% of our respondents reported that they have faced pest and disease problems at least once during

[47] Variables named *Access services* and *Access2* in Table 3.1 were found to be highly correlated.

[48] Often each drought encounter by a farm household results in a crop failure that has devastating consequences on farmers' livelihood. Thus, it is not unexpected that in our analysis in chapter 5, we found the majority of farmers attaching the highest private value to environmentally adaptable *teff* and sorghum varieties, which are, according to our attribute definition, better resistant to drought and frost encounters.

the last ten years and the mean frequency of occurrence is about 3.06 times per farm household since the last ten years.

In this chapter, an explanation of the survey design implemented, an account of the study site descriptions, and a discussion of the descriptive statistics on the farm household characteristics in North Wollo zone have been made. Overall, the procedures undertaken during the first phase of the data collection suggest that the surveyed farm households (and the PAs they came from) are highly representative of the most important sources of heterogeneity among farm households and peasant associations in the North Eastern part of Ethiopia. For instance, our descriptive analysis of the total value of livestock assets in the surveyed farm households suggests that both relatively rich and poor households have been represented in our sample. The PAs surveyed also represent, among other things, the three major agro-ecologies in Ethiopia. Ultimately, the representative-ness of our sampled farm households and PAs should increase the scope of the policy implications drawn in this thesis beyond, for example, just the one district covered in our survey.

CHAPTER FOUR

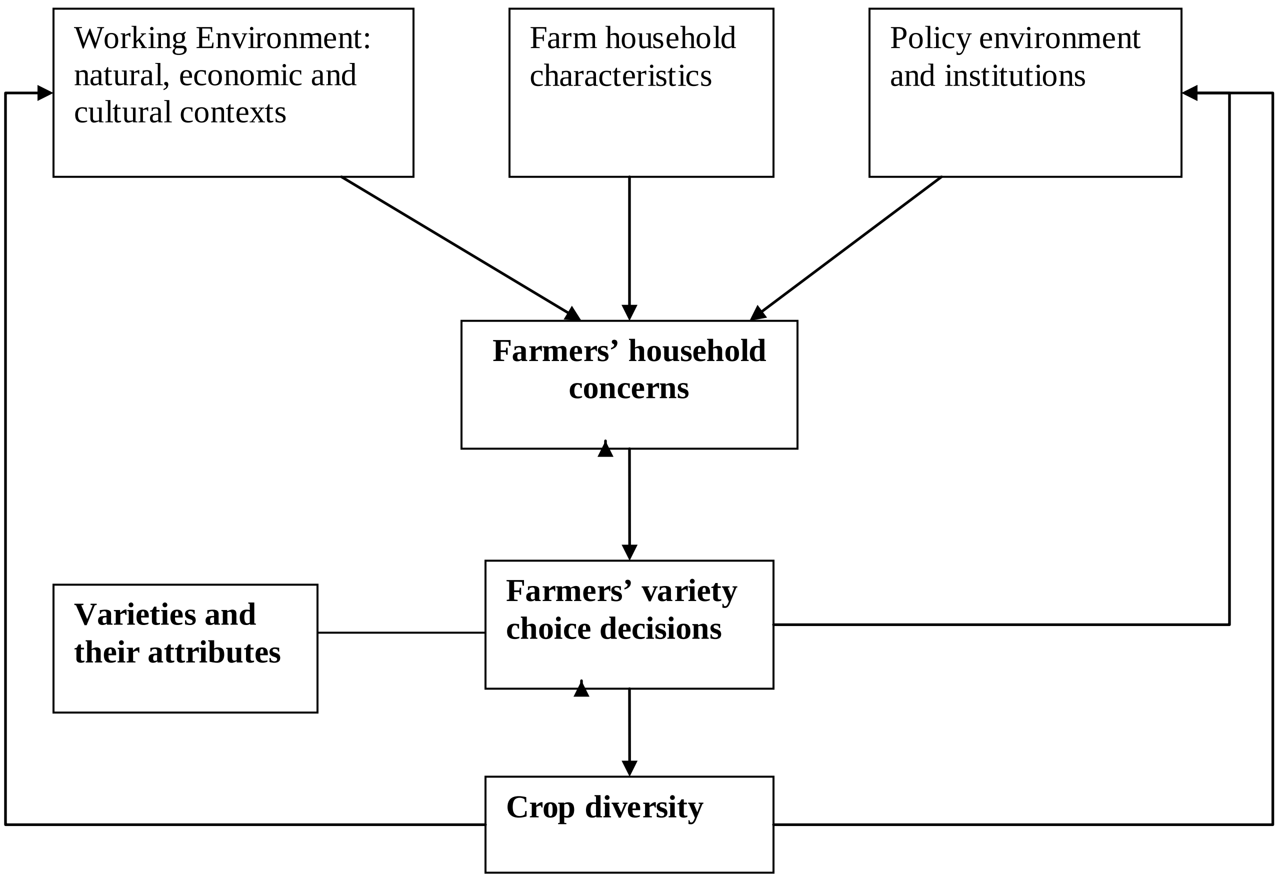
CONCEPTUAL FRAMEWORK AND DESIGN OF THE CHOICE EXPERIMENT

4.1. Farmers' concerns and variety attribute preferences

Undertaking on-farm conservation ventures requires understanding farmers' variety choice and variety attribute preferences. Such an understanding will also help in the areas of research priority setting and targeted adoption of crop varieties. Variety attribute preferences and the varieties that embed these attributes are, in turn, shaped by farmers' economic (resource constraints, markets and risk) and non-economic (religion, culture and norms) concerns. For example, when local variety attributes satisfy farmers' concerns, their *de facto* conservation is the outcome of the harmony of variety attributes and farmers' concerns. In essence, farm household characteristics translate to variety attribute preferences and land allocation decisions (Edilegnaw, 2004).

Farmers' variety attribute preferences are, therefore, the reflections of their concerns and hence studying variety attribute preferences implies studying their concerns indirectly. Figure 4-1 below sketches the relationships among farmers concerns, their contextual characteristics, environmental characteristics, and crop diversity. As presented in the scheme, farmers' concerns are the outcomes of their socio-economic, the policy environment, and environmental characteristics in which they are operating. Farm household characteristics account for preference heterogeneity across individuals by identifying segments of farmers that are characterized by common demographic traits while living under the same policy and environmental characteristics. Addressing those concerns therefore, requires matching variety attributes with farmers' concerns. The farmers' variety choice and management decisions will then determine the outcome variable: crop diversity. Crop diversity is, therefore, the outcome of farmers' multiple concerns and the fact that no single variety satisfies all their concerns (Brush, 2000). Having this constraint, most farmers are managing diverse set of crops to get as many desirable attributes as possible (Edilegnaw, 2004), and hence indirectly contribute to the crop diversity in their region.

Fig 4.1: A simplified conceptual characteristic model (Adapted from Edilegnaw (2004))



The probability of existence of a variety on farmers' fields is a function of the extent to which it embeds the important attributes playing a key role to the household. Thus, the question boils down to the fitness of the variety attributes with household concerns. Each farmer, however, derives different utility from consuming different variety attributes based on the concerns facing him/her (Edilegnaw, 2004). This is because concerns, resource endowments, constraints, and the socio-economic setup of a farm household are likely to be different for different households, hence inducing farmers to rank the importance of variety attributes differently. The survival of a variety on-farm or the successful adoption of newly introduced improved variety is, therefore, dependent on its capacity to supply the variety attributes that receive more weight by the farm household.

We may also think in terms of a loop where farmers' variety choice decisions and the crop diversity in their region, in turn, shape farmers' working (natural, economic and cultural contexts) and policy environment (see Figure 4-1). In order for an agricultural policy to succeed in the designing of variety development that matches farmers' concerns with the attributes of improved varieties, it has to be informed on farmers' variety use decisions, which is, in turn, a reflection of their variety attribute preferences and concerns. Local variety conservation interventions, which are part of the agricultural policy environment, can also learn from the information gathered on farmers' variety attribute preferences and predict the likelihood of survival of local varieties embedding those attributes. This enables policy makers to identify varieties for which policy incentives are required and those that can be maintained *de facto*.

Farmers can be grouped by the concern profiles they share. Categorizing farmers into different segments according to their farm household characteristics where each segment is comprised of farmers that share similar characteristics and then identifying the most important variety attributes to each segment is, therefore, advantageous for identifying and targeting farmers for on-farm conservation of local varieties or for developing improved varieties that take the concerns of each segment of farm households into account. In section 5.7 of chapter 5, we selected three profiles of farmers that are meant to represent stereotype farm families in rural Wollo and we have calculated how much each of our selected variety attributes is valued by each of these profiles so that the results serve as an input for developing varietal technologies as well as for on-farm conservation ventures with more chance to be successful in Wollo.

4.2. Theoretical underpinnings and the basic model

Birol (2004) states that among the environmental valuation methods[49], the choice experiment method is considered to be the most appropriate one for valuing the multiple benefits of, in our case, food crops to producers. The author further argues by citing Hanley *et al.*, (1998a) and Bateman *et al.*, (2003) that this is because the choice experiment method allows for estimation not only of the value of the environmental good as a whole, but also of the implicit values of its attributes. This approach has a theoretical grounding in Lancaster's attribute theory of consumer choice (Lancaster, 1966), and an econometric basis in models of random utility (Luce, 1959; McFadden, 1974).

[49] Among *stated preference* methods, the most commonly employed environmental valuation method is the Contingent Valuation Method (CVM). Apart from its ability to measure the value of an environmental good and its attributes, the choice experiment method has several other advantages over CVM. These include i) The respondents are more familiar with the choice approach compared to the payment approach used in CVM. ii) Choice experiment method can solve for a few of the biases that are present in the CVM. These include a) The strategic bias, that is stating an extremely high/low value to get a point across, is minimised in choice experiment method since the prices of the goods are already defined in the choice sets. b)Yea-saying bias is eliminated as in a choice experiment respondents have to choose between sets; hence, they can not state that they value a good even if they do not. c) Insensitivity to scope is eliminated, since the choice sets that are offered to the respondents are complete and carefully designed respondents might not mistake the scale of the good or its attributes for something else that it could be embedded in (Perman *et al.*, 2003). iii) Willingness to accept (WTA) questions can be asked in choice experiments without the risk of facing huge discrepancies between WTA and willingness to pay (WTP) values as they are reasonable and predetermined (Kahneman, Knetsch and Thaler, 1990). It has been found that in CVM studies individuals seem to attach much more value to losses than they do to gains hence WTA values exceed WTP values considerably (Georgiou *et al.*, 1997).

Due to the complexity of farmers' variety use decisions, the micro-economic model should be utility-based since a profit maximization framework is unable to explain farmers' variety attribute preferences and their land allocation decisions (Edilegnaw, 2004). Lancaster developed the *characteristic theory of consumer behaviour* asserting that consumers derive utility not from goods themselves but from the attributes they provide. For illustration of the basic model behind choice experiment, consider a farm household's choice of a crop variety, and assume that utility depends on choices made from a set C, which includes all the possible options of different crop varieties. This list of all options that are available to the farm household is referred to as the choice set. The farm household is assumed to have a utility function of the form

$$U_{ij} = U(Z_{ij}, S_i) \qquad (4.1)$$

Where for any farm household *i,* a given level of utility will be associated with any alternative crop variety *j*. Utility derived from any of the crop variety alternatives depends on the attributes of the crop variety, Z_{ij}, and the social and economic characteristics of the farm household, S_i, since different households may receive different levels of utility from these attributes. Thus, their ordering as well as their choice of specific set of variety attributes will be conditional on the fitness of their contextual household characteristics with the nature of the crop variety embedding those attributes.

The random utility model is the theoretical basis for integrating choice behaviour with economic valuation in the choice experiment method. In this model, the utility of a choice is comprised of a systematic (explainable or deterministic) component, V_{ij}, and an error (unexplainable or random) component, e_{ij}, which is independent of the deterministic part and follows a predetermined distribution.

$$U_{ij} = V_{ij} + e_{ij} \tag{4.2}$$

The systematic component can be explained as a function of characteristics of the crop variety and of the social and economic characteristics of the farm household as explained above, in (4.1). That is

$$U_{ij} = V(Z_{ij}, S_i) + e_i \tag{4.3}$$

Given that there is an error part in the utility function, predictions cannot be made with certainty and analysis becomes probabilistic choice. Consequently, choices made between alternative crop varieties will be a function of the probability that the utility associated with a particular crop variety option (*j*) is higher than that for other alternative crop varieties. That is to say, the probability that farm household *i* will choose crop variety j over all other combinations *h* is given by

$$P_{ij} = \Pr ob\{V_{ij} + e_{ij} > V_{ih} + e_{ih}; \forall h \neq j, \forall h \in C\} \tag{4.4}$$

The parameters for the relationship can be introduced by assuming that the relationship between utility and attributes and characteristics follows a linear path in the parameters and variables function, and by assuming that the error terms are identically and independently distributed with a Weibull distribution (Greene, 2000). These assumptions ensure that the probability of any particular alternative *j* being chosen can be expressed in terms of logistic distribution. This specification is known as the conditional logit model (McFadden, 1974; Greene, 2000), and it takes the general form

$$P_{ij} = \frac{e^{V_{ij}}}{\sum_{h \in C} e^{V_{ih}}} \quad (4.5)$$

The conditional indirect utility function generally is given by:

$$V_{ij} = \beta + \beta_1 Z_1 + \beta_2 Z_2 + ... + \beta_n Z_n + \beta_a S_1 + \beta_b S_2 + ... + \beta_m S_k \quad (4.6)$$

Where β is the alternative specific constant (ASC), that captures the effects in utility from any attributes not included in choice specific attributes. This constant term, referred to as ASC in the literature, is however dropped from our model estimations in chapter 5 because our choice sets do not include a status quo or an opt-out option (Bateman *et al.*, 2003 pp 7.5)[50]. That is, ASCs are primarily included to reflect the differences in utilities for each alternative relative to the base (status quo) when all attributes are equal. The number of crop variety attributes considered is *n* and the number of social and economic

[50] The reason for the exclusion of status quo in our choice sets is explained in subsection 4.3.2.

characteristics of the farm household employed to explain the choice of the crop variety is *k*. The vectors of coefficients β_1 to β_n and β_a to β_m are attached to the vector of attributes (Z) and to vector of interaction terms (S) that influence utility, respectively. Since, at a point in time, social and economic characteristics are constant across choice occasions for any given farm household, they can only enter as interaction terms with the crop variety attributes.

The choice experiment method is consistent with utility maximization and demand theory (Bateman *et al.*, 2003). When parameter estimates are obtained, welfare measures can be estimated from the conditional logit model using the following formula:

$$CS = \frac{\ln \sum_i \exp(V_{i1}) - \ln \sum_i \exp(V_{i0})}{\alpha} \qquad (4.7)$$

Where CS is the compensating surplus welfare measure, α is the marginal utility of income (generally represented by the coefficient of the monetary attribute in the choice experiment) and V_{i0} and V_{i1} represent indirect utility functions before and after the change under consideration. For the linear utility index the marginal value of change in a single attribute can be represented as a ratio of coefficients, reducing equation (4.7) to

$$W = -1\left(\frac{\beta_{attribute}}{\beta_{monetary\,variable}}\right) \qquad (4.8)$$

This part-worth (or implicit price) formula represents the marginal rate of substitution between income and the attribute in question, or the marginal welfare measure (willingness to pay or willingness to accept) for a change in any of the attributes.

The assumptions about the distributions of error terms implicit in the use of the conditional logit model impose a particular condition known as the independence of irrelevant alternatives (IIA) property. This property states that the relative probabilities of two options being chosen are unaffected by introduction or removal of other alternatives. In other words, 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). If it is found that the IIA property is violated then conditional logit results would be biased hence a discrete choice model that does not require IIA property, such as random parameter logit model, should be used. After estimating the conditional logit models in chapter 5, we tested whether or not IIA holds for each of these models following the Hausman procedure[51] contained within LIMPDEP 8.0 NLOGIT 3.0 software, and all of our tests provided inconclusive results *i.e*. the models do not fully conform to the underlying IIA conditions. Therefore, we have also estimated the random parameter logit (RPL) models to account for these inconclusive results and the results for our RPL models are reported in chapter 5. Furthermore, inclusion of social and economic characteristics is also beneficial in avoiding IIA violations, since social and economic characteristics relevant to preferences of the respondents can increase the systematic component of utility while decreasing the

[51] This procedure is explained in chapter 5.

random one (Bateman *et al.*, 2003). Accordingly, we have also estimated conditional logit models with interactions (socio-economic variables interacted with variety attributes) and the inclusion of the interaction terms significantly increased the systematic component, and hence, the model fit, in our conditional logit model estimates as reported in section 5.6 of chapter 5.

4.3. Choice experiment design and administration

4.3.1. Setting the scene: attributes and levels for the choice experiment

The choice experiment technique was initially developed by Louviere and Hensher (1982) and Louviere and Woodworth (1983). A choice experiment is a highly 'structured method of data generation' (Hanley *et al*., 1998a), relying on carefully designed tasks or "experiments" to reveal the factors that influence choice. Experimental design theory is used to construct profiles of the environmental good in terms of its attributes and levels of these attributes. Profiles are assembled in choice sets, which are in turn presented to the respondents, who are asked to state their preferences (Louviere *et al.*, 2000).

The first step in choice experiment design is to define the good to be valued in terms of its attributes and the level each attribute takes. In the choice experiment study reported in this thesis, the most important crop variety attributes and their levels were identified in consultation with experts in this area (crop breeders and researchers who have previous experience and knowledge on the subject), by reviewing previous studies and historical data from CSA, and by identifying the most important seed selection criteria put forward by the surveyed households during the first leg of the data collection process. The chosen crop variety attributes and their levels are reported in Table 4.1 and Table 4.2 by crop.

Table 4.1. ***Sorghum Variety attributes and attribute levels used in the choice experiment***

Variety Attributes	**Definition**	**Attribute Levels**
Producers' Price	The amount of money the farmer receives by selling a quintal of the sorghum variety	110 birr, 150 birr, 200 birr
Productivity	The amount of yield/hectare the farmer is able to harvest by planting the sorghum variety on his land.	14 quintals/hectare, 19 quintals/hectare, 25 quintals/hectare
Environmental Adaptability	Whether or not the sorghum variety is resistant/ tolerant to drought and frost occurrences.	The variety is adaptable (resistant) Vs the variety is not adaptable (nonresistant)
Yield Stability	Whether or not the sorghum variety gives stable yield year-after-year, despite occurrences of crop disease and pest problems.	The variety gives stable yield year-after-year Vs the variety gives variable yield year-after-year.

Table 4.2. ***Teff Variety attributes and attribute levels used in the choice experiment***

Variety Attributes	**Definition**	**Attribute Levels**
Producers' Price	The amount of money the farmer receives by selling a quintal of the *teff* variety	210 birr, 270 birr, 330 birr
Productivity	The amount of yield/hectare the farmer is able to harvest by planting the *teff* variety on his land.	8 quintals/hectare, 15 quintals/hectare, 20 quintals/hectare
Environmental Adaptability	Whether or not the *teff* variety is resistant/ tolerant to drought and frost occurrences.	The variety is adaptable (resistant) Vs the variety is not adaptable (nonresistant)
Yield Stability	Whether or not the *teff* variety gives stable yield year-after-year, despite occurrences of crop disease and pest problems.	The variety gives stable yield year-after-year Vs the variety gives variable yield year-after-year.

As can be seen from the above tables, the chosen attributes and their definitions are identical between the two crops – only the attribute levels for producers' price and productivity characteristics are different – indicating that farmers' concerns towards the two crops under study are generally similar. Apart from their importance to farmers, these attributes are also policy relevant for designing an incentive mechanism to undertake on-farm conservation ventures at least cost (by identifying farmers who are demanding attributes embedded in local varieties) or for successful rural interventions like contextual crop variety development and diffusion. However, as mentioned in the introduction chapter, the fact that our analysis is based on farmers' preferences for these four traits of sorghum and *teff* crops should not be translated into saying that these are the only relevant attributes in farmers' variety choice criteria. In almost all choice experiment studies, the researcher has to make a trade-off between being comprehensive (inclusion of all relevant attributes) and the complexity of the choice experiment exercise to respondents (Alpizar *et al.*, 2001). The number of attributes in a choice experiment is studied by Mazotta and Opaluch (1995) and they find that including more than 4 to 5 attributes in a choice set may lead to a severe detriment to the quality of the data collected (e.g. respondents may simply answer carelessly or employ some strategic behaviour) due to the complexity of the task. Thus, the four attributes under study in this thesis reflect the balance between including the most important attributes in our choice experiment with the complexity of the task involved in making choices.

Each of the first two 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[52]. That is, it would be more appropriate to use producers' price as direct monetary attribute for farmers actively participating in the local markets by supplying their *teff* and/or sorghum produce, and productivity trait tends to be more fitting to those farmers whose output is less than or just enough to satisfy the household food consumption needs; hence, prohibiting them to supply part of their output to local markets. In chapter 5 we have attempted to calculate the willingness to accept (WTA) values for environmental adaptability and yield stability traits of both crops based on each of the two monetary attributes (see section 5.3 and section 5.7 in chapter 5)[53].

With more than 92% 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 for our choice modelling exercise is appropriate. The same can be said about yield stability attribute of both crops – about 90% 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 have two levels representing the existence or absence of the traits in each crop (see Table 4.1 and Table 4.2).

[52] Inclusion of monetary attribute in choice surveys is necessary in order to estimate welfare changes associated with a change in non-monetary attribute (s). It also enables us to do non-market valuation: value attributes for which it is practically hard to attach monetary figures.
[53] The monetary attributes represent willingness to accept (WTA) compensation, i.e. benefit rather than a cost measured by willingness to pay (WTP), since the property rights of the crops and of their outputs and functions reside with the farmers (Freeman, 2002).

The levels for producers' price attribute of both crops used in our choice experiment (CE) try to mimic the reality by representing the Zone's minimum[54], average, and maximum prices of a quintal of sorghum or *teff* output during the last ten years (see Table 4.1 and Table 4.2). These levels, whose ingredients were collected from CSA, were calculated by first averaging prices over varieties within each crop for each year since the last ten years, and then by computing the average, and identifying the minimum and maximum of these values since the last ten years on a crop specific basis, which make the final results non-specific in terms of varieties or time but specific in terms of crops considered – sorghum or *teff*. Note that we had to go through these calculations because the price information at CSA is available only in variety and time specific format for all major crops including the crops under study.

The attribute levels for productivity attribute of both crops are selected to reflect the Zone's yield potential under agricultural extension and non-extension services (see Table 4.1 and Table 4.2). More than 70% of the surveyed households participate in the agricultural extension service and both participants and non participants are likely to find these levels realistic. In order to arrive at the actual values for these levels, we have reviewed the Zone's productivity register for the two crops at CSA and Ethiopian Institute of Agricultural Research (EIAR) under extension and non-extension services.

[54] For example, about 22% of the surveyed households complained of large (unacceptable) decrease in output prices at least once during the last ten years.

4.3.2. Choice experiment design

The number of attributes and attribute levels selected for this choice experiment reflect a balance between efficiency, resemblance to reality and enhancement of variability of each attribute (Kontoleon, 2003). Of the four attributes that were selected, two of them took three levels and the remaining two were binary (see Table 4.1 and Table 4.2). Out of these attributes and attribute levels, one can construct up to 36 ($3^2 \times 2^2$) unique crop descriptions (combinations of attributes) for each crop. However, in this study, orthogonalisation procedure[55] was used to recover only the main effects, yielding 9 alternatives representing a fractional factorial design or main effects[56] each allocated to different choice sets as explained in the next paragraph. Notwithstanding the statistical advantages possessed by complete factorials, recovering only the main effects was necessary because as the number of possible combinations (36 in our case) become large and not tractable, one is motivated to reduce these combinations into manageable number so that the researcher can undertake a practical work in the field without compromising on the capacity of the reduced combination to capture the most important sources of variation in preferences (Louviere *et al.,* 2000) [57].

The choice sets were created using a cyclical design principle (Bunch, Louviere, and Andersson, 1996). A cyclical design is a straightforward extension of the orthogonal

[55] This procedure makes the variations of the attributes of the crop descriptions (profiles) uncorrelated in all choice sets (Alpizar *et al*., 2001).
[56] 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).
[57] Although exclusion of interaction effects may introduce bias into main effects estimations, it has been shown that main effects usually account for more than 80% of the explained variance in a model (Louviere, 1988; Louviere *et al.,* 2000).

approach. First, each of the alternatives from a fractional factorial design is allocated to different choice sets. Attributes of the additional alternatives are then constructed by cyclically adding alternatives into the choice set based on the attribute levels. That is, the attribute level in the new alternative is the next higher attribute level to the one applied in the previous alternative. If the highest level is attained, the attribute level is set to its lowest level (Carlsson *et al.,* 2007). We, therefore, assigned the 9 alternatives from our fractional factorial design to 9 choice sets and constructed two other alternatives per choice set following the procedure mentioned above. We followed these procedures twice, each used to construct either sorghum or *teff* profiles (See Table 4.A.1 and Table 4.A.2 in the appendix). Given that the choice experiment questions succeeded rather very limited basic household-related questions[58], the nine choice sets were considered not to create respondent burden and fatigue[59].

In order to promote easy and common understanding among our sampled households, all attributes (and their levels) were explained to respondents using both written and visual aids prior to and during the choice experiment exercise (see Figure 4.A.1 in the appendix for an example of a choice set (in Amharic) accompanied by visual aids as presented to farmers). These illustrations were especially useful to elicit reliable answers from illiterate respondents that cover about 45% of our sample.

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[58] As mentioned in chapter 3, data on all farm household characteristics (Table 3.1) were collected 6 months prior to the choice experiment survey.

[59] Any number of choice sets between 4 and 16 is generally considered to be efficient (Louviere *et al.,* 2000).

The survey instrument was carefully translated to Amharic and pre-tests of the choice experiment were conducted on 16 randomly selected farmers, eight from each of the two research sites (PAs), who have not been selected and interviewed for the first phase of the farm household survey. The survey approach and design of the choice experiment were further modified following the pre-tests. An example of a choice set is presented in Figure 4.2 below and all of the 9 choice sets per crop used in the choice experiment are reported in Table 4.A.1 and Table 4.A.2 in the appendix.

As can be seen from the Tables in the appendix and the sample choice set in Figure 4.2, a status quo or an opt-out option has not been included in our choice experiment design. This is due to the several potential disadvantages to incorporating an opt-out option into our experimental design. For example, respondents may select the opt-out option not because it provides the highest utility among the alternatives but to avoid making difficult decision (Huber and Pinnell, 1994) or may be used as a simple choice heuristic (Carlsson *et al.*, 2007). Additionally, allowing respondents to select an opt-out option provides less information on respondents' relative preferences for the attributes in the hypothetical alternatives. Also, opt-out options can create econometric challenges when researchers do not know what attribute levels are associated with the opt-out option (Bennett and Blamey, 2001)[60].

[60] It is, however, noteworthy that there are also important advantages to including an opt-out option, the most important being that an opt-out option prevents a forced choice in the experiment (Bennett and Blamey, 2001). Opt-out options become even more valuable in cases when participation levels are in themselves of policy interest (see for example Birol *et al*., 2006b). However, in our study, almost all of the surveyed farm households (and the population they represent) have been and are likely to continue growing at least one of the two crops under study and therefore participation levels are expected to be very high.

Figure 4.2. ***Sample choice set***

Assuming that the following sorghum varieties were the ONLY choices you have, which one would you prefer to plant?

Sorghum Variety Characteristics	**Sorghum Variety 1**	**Sorghum Variety 2**	**Sorghum Variety 3**
Producers' price	150	200	110
Productivity	14	19	25
Environmentally Adaptable	Yes	No	Yes
Stable-in-yield	No	Yes	No

I prefer to plant ***Sorghum variety 1****….. **Sorghum variety 2**…. **Sorghum variety 3** ……*
(Please check (√) one option)

In order to test the effects of including or not including an opt-out on the marginal trade-off between attribute levels, Carlsson *et al*. (2007) using cyclical design principle – the same design employed in this study – created two survey versions with and without an opt out and found that there are no differences in marginal WTPs among the specific attributes in the study between the two versions. This recent study shows that the effects of including (or excluding) an opt-out option in choice experiment designs can be empirically tested and therefore future researches in crop variety attribute preferences may contribute to that effect.

4.3.3. Administration of the choice experiment

As mentioned in chapter 3, the choice experiment survey was conducted during June and July of 2007, with face-to-face interviews following the farm household survey, conducted from October 2006 to January 2007 and whose descriptive statistics are presented in chapter 3 (Table 3.1). The sample population in each peasant association (PA) was randomly divided into two, each sub-sample receiving one of the two versions of the choice experiment: sorghum or *teff* variety choice sets.

Even though all the respondents have grown the crops under study at least in the past and hence are all familiar with the goods that are being valued in the choice experiment, it was crucial that respondents had a uniform understanding of each of the attributes, as defined above. Consequently, in an introductory section, the context in which choices were to be made was explained to all respondents, and each attribute was explained using illustrations like in Figure 4.A.1 in the appendix. Furthermore, it was also explained to the respondents that the key attributes of the crops had been selected as a result of prior research and combined artificially in the choice sets. Respondents were informed that completion of the exercise would help agricultural policy makers in the design of variety development and local variety conservation interventions. They were told the purpose of the exercise and the anonymity of the information to be generated so that they feel free in their choice and responses. And finally, the respondents were reminded that there were no right or wrong answers and that we were only interested in their opinions.

The sample design for the choice experiment and farm household survey is already presented in chapter 3. Of the 68, and 63 households that were interviewed for the farm household survey in Ala Weha, and Woinye PAs of North Wello zone respectively, all agreed to take part in the choice experiment. There was not any item non-response (all choice sets were answered), which is one of the advantages of face-to-face interviews as opposed to the frequently applied mail surveys in developed countries, in which case, incomplete responses to choice experiment questions is common. A total of 1179 choices were elicited from a total of 131 farm households.

4.4. Recapping the core elements of the choice experiment approach

In a choice experiment, individuals are given a hypothetical setting and asked to choose their preferred alternative among several alternatives in a choice set, and they are usually asked to perform a sequence of such choices. Each alternative is described by a number of attributes or characteristics. A monetary value is included as one of the attributes, along with other attributes of importance, when describing the profile of the alternative presented (see Figure 4.2). This enables one, among other things, to do non-market valuation: value attributes for which it is practically hard to attach monetary figures. For instance, the environmental adaptability and yield stability traits of the crops in our choice experiment study. Experimental design theories, like the cyclical design principle employed here, are used to construct choice sets and determine the optimal number of choice sets to be presented to respondents (Alpizar *et al.*, 2001). Thus, this approach ensures that when individuals make their choice, they implicitly make trade-offs between the levels of the attributes in the different alternatives presented in a choice set.

CHAPTER FIVE

MODEL SPECIFICATION AND DISCUSSION OF ECONOMETRIC RESULTS

5.1. Data organization

The data were coded according to the levels of the attributes used in the choice experiment. Attributes with two levels entered the utility function as binary variables that were effects coded (Louviere *et al.*, 2000). For environmental adaptability variable, resistance to drought and frost occurrences was entered as 1 and nonresistance to these environmental pressures was entered as -1. For yield stability attribute, crop varieties that gave stable yield despite occurrences of disease and pest problems were entered as 1 and those crop varieties that were unable to give stable yield when encountering the above problems were effects coded as -1. The levels used for producers' price and productivity were entered in a cardinal-linear form. Consequently, the producers' price attribute took levels 110, 150, and 200 in the choice experiment data entry for sorghum; and levels, 210, 270, and 330 for its *teff* counterpart. Similarly, the productivity attribute took levels 14, 19, and 25 for sorghum CE data entry and levels 8, 15, and 20 for its *teff* counterpart. As mentioned in chapter 4, the levels for producers' price are based on what has been observed in the past (maximum, minimum, and the most frequent levels observed). The productivity levels are set based on farmers' working conditions under extension and non-extension services.

5.2. Conditional logit model estimates for Sorghum and *teff* attribute preferences

The choice experiment was designed with the assumption that the observable utility function would follow a strictly additive form (Birol, 2004). 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

$$V_{ij} = \beta_1 Z_{pprice} + \beta_2 Z_{productivity} + \beta_3 Z_{adaptability} + \beta_4 Z_{yield-stability} \qquad 5.1$$

Where β_{1-4} refer to the vector of coefficients associated with the vector of attributes describing crop variety attributes. In the above specification the constant term, referred to as "alternative specific constant", or ASC in the literature, is dropped from the indirect utility function because our choice sets do not include a status quo or an opt-out option (Bateman *et al*., 2003 pp. 7.5). The results of the conditional logit estimates for the randomly selected sub-sample of 66 farm households presented with the "sorghum" version of the choice experiment are reported in Table 5.1 below.

Table 5.1. *Conditional logit estimates of crop attributes for sorghum variety choices*

Attribute	Coefficient. (s.e.)
Producers' price	0.014*** (0.160×10^{-2})
Productivity	0.169***

	(0.014)
Environmental adaptability	1.064*** (0.102)
Yield stability	0.779*** (0.042)
Sample size	594
ρ^2	0.414
Log likelihood	-376.23

Source: Own survey in collaboration with Genetic Resources Policy Initiative (GRPI) - Ethiopia project, 2006/2007.
*** 1% significance level, ** 5% significance level and *10% significance level with two-tailed tests.

All of the sorghum variety attributes are highly statistically significant factors in the choice of sorghum varieties, and have the expected signs in that any single attribute increases the probability that a sorghum variety is selected, other attributes remaining equal. When the producers' price attribute is used as the normalizing variable, the most important sorghum variety attribute for farm households is environmental adaptability (resistance to drought and frost occurrences). This is followed by yield stability (resulting from resistance to disease and pest problems) and productivity variables, the magnitude of the former about four and half times more than the latter[61]. The overall fit of the model as measured by McFadden's ρ^2 is very high. According to Hensher *et al*. (2005, pp. 338), values of ρ^2 between 0.2 and 0.4 are considered to be extremely good fits. Furthermore, the high ρ^2 and significance of each regressor suggest that the attributes selected for the

[61] Note that the coefficients and standard errors for producers' price and productivity appear lower than the other coefficients and their standard errors because actual values (110 birr, 150 birr, 200 birr) and (14Q/ha, 19 Q/ha, 25Q/ha) were used respectively. For a similar result see Birol (2004).

choice experiment survey are, by and large, what farmers considered to be among the most important factors in sorghum variety selection.

The IIA property of this model is tested using a procedure suggested by Hausman and McFadden (1984). This test involves constructing a likelihood ratio test around different versions of the model where choice alternatives are excluded. If IIA holds then the model estimated on all choices (the full choice set) should be the same as that estimated for a sub-set of alternatives (Bateman *et al.*, 2003). Whether or not the property of IIA is violated in this model is tested by following the Hausman procedure available in LIMPDEP, Version 8.0, NLOGIT 3.0 statistical analysis software. The Hausman test for violation of the IIA assumption provided inconclusive results 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. Therefore, the IIA tests performed indicate that the model does not fully conform to the underlying IIA conditions. Hence the model needs to be augmented either by including social and economic characteristics as interaction terms, or by employing other models that relax the IIA assumptions, such as random parameter logit model or both (Morey and Rossmann, 2003). Consequently, in this chapter, we separately estimated random parameter model and conditional logit model with interaction terms, and the results are reported in Section 5.5 and 5.6, respectively.

The results of the basic conditional logit model estimates for the randomly selected sub-sample of 65 farm households presented with the "*teff*" version of the choice experiment survey questions are reported in Table 5.2.

Table 5.2. *Conditional logit estimates of crop attributes for teff variety choices*

Attribute	Coefficient. (s.e.)
Producers' price	0.746×10^{-2}*** (0.114×10^{-2})
Productivity	0.152*** (0.013)
Environmental adaptability	1.021*** (0.091)
Yield stability	0.572*** (0.087)
Sample size	585
ρ^2	0.378
Log likelihood	-391.23

Source: Own survey in collaboration with Genetic Resources Policy Initiative (GRPI) - Ethiopia project, 2006/2007.
*** 1% significance level, ** 5% significance level and *10% significance level with two-tailed tests.

Again, all of the *teff* variety attributes are highly statistically significant factors in the choice of *teff* varieties, and have the expected signs. Similar to the above findings for the preference of sorghum variety attributes, when the producers' price attribute for *teff* is used as the normalizing variable, the most important *teff* variety attribute for farm households is environmental adaptability (resistance to drought and frost occurrences). This is followed by yield stability (resulting from resistance to diseases and pest problems) and productivity variables, the magnitude of the former about four and half times more than the latter[62]. The overall fit of the model as measured by McFadden's ρ^2 is 0.378, which lies between 0.2 and 0.4 suggesting that this model also qualifies for Hensher and his coworkers' characterization of an extremely good fit.

The Hausman and McFadden test conducted for violation of the IIA assumptions (using LIMPDEP 8.0 NLOGIT 3.0) provided the same inconclusive results by failing to find a positive definite difference matrix for any two alternatives. This was the case for all three tests conducted by dropping a different alternative each time. Therefore, the IIA tests performed indicate that neither model fully conforms to the underlying IIA conditions. Hence, both of these models need to be augmented either by including social and economic characteristics as interaction terms, or by employing other models like random parameter logit model or both, as explained above.

5.3. Willingness to Accept (WTA) values for each variety attribute by crop

Comparison of attribute preferences across the two crops using the standard Swait-Louviere log likelihood ratio test on estimates reported in Table 5.1 and Table 5.2 can not be made because this test requires that the two sub-samples are presented with choice experiment survey questions drawn from the same orthogonal design[63]. Therefore, the

[62] The same explanation applies for the appearance of lower coefficients of producers' price and productivity for teff as for their sorghum counterparts (see the previous footnote).

[63] The test statistic for Swait-Louviere log likelihood ratio test is much like the usual log likelihood ratio test distributed as x^2 and is expressed as $x^2 = -2(LL_1 - LL_2)$,where LL_x refers to the log likelihood statistics of different conditional logit models. It's usually computed to test whether the sum of the log-likelihoods for two different data sets differs significantly from the log-likelihood for a model estimated from the pooled data sets (Bennett and Blamey, 2001). It is, for example, frequently used to test for regional differences of respondents' attribute preferences, and hence requires the presentation of an identical good (described by the same attributes) to respondents from each region (see for example, Birol, 2004; Birol and Rayn, forthcoming). In this thesis, however, the crops to be valued are not identical and

only way to compare attribute preferences for the two crops is by comparing their WTA values for each crop variety attribute, taking into account the inherent differences of the normalizing variable (producers' price for each crop). Using Wald Procedure (Delta method) in LIMDEP farm households' valuation of crop attributes is calculated by finding the part-worth as described in equation (4.8) of the previous chapter. The results are reported in Table 5.3 below.

Table 5.3. WTA (in birr per quintal of the respective crop) values for each variety attribute by crop (99.5%* C.I *.)

Attribute	**Sorghum**	***Teff***
Productivity	**-12.07** **(-13.47, -10.67)**	**-20.44** **(-23.67, -17.21)**
Environmental adaptability	**-76.21** **(-85.83, -66.59)**	**-136.94** **(-159.01, -114.87)**
Yield stability	**-55.79** **(-64.83, -46.75)**	**-76.73** **(-93.64, -59.82)**

Source: Own survey in collaboration with Genetic Resources Policy Initiative (GRPI) - Ethiopia project, 2006/2007.
Note: values computed using Wald procedure (Delta method) in LIMDEP 8.0 NLOGIT 3.0.

The negative WTA values for all of the attributes considered in this study across the two crops suggest that farmers are willing to accept less, in terms of income generated from crop sale, for more productive, environmentally adaptable, or stable yielding varieties of both *teff* and sorghum crops. The range reported in Table 5.3 under the WTA value for

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thus, the Swait-Louviere log likelihood ratio test is not a valid test for comparing attribute preferences across the two crops.

each attribute is the 99.5% confidence interval, where a farmer's WTA value for each attribute is expected to be found in this range 99.5% of the time.

Farm households in Northern Wello zone attach the highest private values to environmental adaptability and yield stability traits of both sorghum and *teff* crops. This shows that farmers are not only looking for a single attribute like productivity of the variety when making their seed selection decisions but also other more important but non-tradable attributes like environmental adaptability (drought and frost resistance) and yield stability (disease and pest resistance) forcing them to make complicated trade-offs. Farm households are willing to give up on average 12.07 and 20.44 birr per each quintal of sorghum and *teff* crops supplied to the market respectively, for a unit increase (1 quintal) in the productivity of the same crops per hectare. Therefore, if farmers are supplying each year to the market 12 and 10 quintals of sorghum and *teff* crops respectively[64], according to the above figures they are willing to give up each year a total income of about 144 and 204 birr from the sale of sorghum and *teff* crops respectively, and get in return a unit increase in the productivity of these crops. However, farmers can also sell the excess from this increase in productivity of both crops for about a similar price in the market and cover for the above total income loss incurred when looking for a more productive variety[65]. These findings, therefore, provide an external validity to our choice experiment study in that we are essentially comparing the private economic values

[64] Note that the supply variation is due to the apparent yield potential difference between the two crops on farmers' fields, and that farmers are assumed to make these supplies based on the levels of productivity for both crops in our choice sets.

[65] According to figures from CSA, the zone's average price of a quintal of *teff* and sorghum over a time interval of a decade equals 219 birr and 150 birr respectively; the derivation of these figures is discussed in the pages to follow.

farmers place on a quintal of *teff* (or sorghum) in our hypothetical *stated preference* data with a *revealed preference* data from CSA where money has actually changed hands, and found them to be similar. This external validity also increases the reliability of our findings for the private values of those attributes not traded in the market like environmental adaptability and yield stability[66].

Productivity attribute can also be used as a proxy for monetary attribute, and may even be more appropriate in some cases where only a small portion, if any, of the production output of a farm family makes it to the market after satisfying the household food consumption needs of this farm family[67]. Using the same procedures to compute the implicit prices of crop attributes as in Table 5.3, the implicit prices of environmental adaptability and yield stability of both crops in terms of yield per hectare are reported in Table 5.4 below.

[66] See section 2.3 in chapter 2 of this thesis for a review other studies that accompany their *stated preference* results with external validity.
[67] For a previous application of yield used as a proxy for monetary attribute, see Birol and Rayn (forthcoming), whose findings are summarized in the literature review of this thesis.

Table 5.4. WTA (in quintals of output per hectare) values for each variety attribute by crop (99.5% C.I .)

Attribute	Sorghum	*Teff*
Environmental adaptability	**-6.31** **(-6.97, -5.65)**	**-6.70** **(-7.41, -5.99)**
Yield stability	**-4.62** **(-5.28, -3.96)**	**-3.75** **(-4.41, -3.09)**

Source: Own survey in collaboration with Genetic Resources Policy Initiative (GRPI) - Ethiopia project, 2006/2007.
Note: values computed using Wald procedure (Delta method) in LIMDEP 8.0 NLOGIT 3.0.

Results in Table 5.4 show, as the results in Table 5.3, that farm households attach the highest private value to environmental adaptability (resistance to drought and frost pressures) followed by yield stability (resistance to disease and pest occurrences) when compared to each other for both crops. Farmers assign an equivalent of 6.31 and 6.70 quintals per hectare worth of output for an environmentally adaptable trait contained within a variety of sorghum and *teff* crops respectively. This shows that farmers assign slightly higher value to an adaptable variety of *teff* than sorghum despite the inherently higher yield potential of sorghum per hectare of a farmer's field (compare the levels of productivity for the two crops in Tables 4.1 and 4.2, for a reflection of this potential difference in yield). Hence, farmers are slightly more risk averse towards a non-adaptable variety of *teff* than towards a sorghum variety with a similar trait[68]. This may be because

[68] As mentioned in the introduction chapter, one rationale for comparing farmers' WTA for these two crops' traits is to prescribe cost-effective and crop specific policies, and priority setting strategies in crop breeding programs intended to bring the most optimal results. For example, based on our results, it can be argued that if there is a limited budget to improve the environmental adaptability trait of only one of the two crops in this study, farmers in Wollo would be better off if this budget is geared towards the improvement of the attribute in *teff* varieties than towards the same attempt in sorghum varieties.

teff is the most important crop - among the bundle of crops being cultivated - for about 61% of the farm households surveyed. The opposite is true for yield stability though this may be offset by higher yield potential associated with sorghum allowing farmers to pay more (or accept less) in terms of yield per hectare for a stable yielding sorghum variety than *teff* with a similar trait.

The trade-offs between productivity and adaptability, and between productivity and yield stability *i.e.* the values in Table 5.4, can also be converted into monetary values by multiplying each trade-off value with the Zone's respective average price for a quintal of sorghum or *teff* crop since the last ten years. Accordingly, in North Wello Zone, the average price of a quintal of *teff* and sorghum over a time interval of a decade equals 219 birr and 150 birr respectively[69]. Multiplying these values with the corresponding figures in Table 5.4, the results are reported in Table 5.5 below.

[69] These zonal average prices, whose ingredients were collected from CSA, were calculated by first averaging prices over varieties within each crop for each year since the last ten years, and then by computing the average of these values since the last ten years on a crop specific basis, essentially making the final results non-specific in terms of varieties or time but specific in terms of crops considered - sorghum and *teff*. Note that we had to go through these calculations because the price information at CSA is available only in variety and time specific format for all major crops including sorghum and *teff*. The same procedures were also followed to set the levels for producers' price attribute of sorghum and *teff* crops (for a further discussion of this levels see chapter 4).

Table 5.5. WTA values for each variety attribute by crop (in birr equivalent of quintals of output per hectare)

Attribute	Sorghum	Teff
Environmental adaptability	**-946.5**	**-1467.3**
Yield stability	**-693**	**-821.25**

Source: Own survey in collaboration with Genetic Resources Policy Initiative (GRPI) - Ethiopia project, 2006/2007.

Findings reported in Tables 5.1 - 5.5 all suggest that farm households value environmental adaptability trait of both sorghum and *teff* crops most, followed by the yield stability attribute. These values, however, are not at all unexpected since more than 92% of the surveyed households stated that they have faced drought problems at least once during the last ten years with a mean frequency occurrence of 2.45 times, often each resulting in devastating consequences on farmers' livelihood. These figures are similar to the frequency of occurrence of pest and disease problems with about 90% of our respondents reporting that they have faced these problems at least once during the last ten years with a mean frequency occurrence of 3.06 times; perhaps, showing that the consequences of these latter problems (causes of yield instability in our attribute definition) are not as devastating as drought problems.

Overall, our regression and descriptive analysis results suggest that farmers in the two Kebeles are extremely risk averse by opting for more environmentally adaptable and stable yielding varieties at a significant cost to yield and/or income generated from crop sale. These findings are similar to the results from Carlsson *et al*. (2005), where the study found that Ethiopian farmers exhibit an extremely risk averse behaviour in their farm technology adoption decisions by seeking for insurance against crop failure in their credit repayment requirements. The current study's findings are also closely associated with results from Edilegnaw (2004), where coffee farmers' survival first strategy plays a major role in their coffee variety attribute selection criteria[70].

5.4. Accounting for preference heterogeneity

Basic conditional logit model assumes homogeneous preferences across farm households presented with each version of the choice experiment questions (Birol, 2004). However, preferences across households are in fact heterogeneous and accounting for this heterogeneity enables estimation of unbiased estimates of individual preferences and enhances the accuracy and reliability of estimates of demand, participation, marginal and total welfare (Greene, 2000). Furthermore, accounting for heterogeneity enables prescription of policies that take equity concerns into account. An understanding of who will be affected by a policy change in addition to understanding the aggregate economic value associated with such changes is necessary (Adamowicz and Boxall, 2001). Determination of individual heterogeneity is also of particular relevance when knowledge of population segments is crucial for assessment of existence and nature of niche consumers or producers (Kontoleon, 2003).

[70] For a more detailed overview of the two cited studies in this paragraph, one can refer to the literature review chapter of this thesis.

One way of accounting for preference heterogeneity is by separating the respondents into various groups (segments) and by estimating the demand function for each group separately (Kontoleon, 2003). A second way of accounting for preference heterogeneity is by using household and decision-maker level contextual characteristics directly as interaction terms (Birol, 2004). Interaction of individual-specific social and economic characteristics with choice specific attributes or with ASC (alternative specific constant) of the indirect utility function is a common solution to dealing with the heterogeneity problem as well as with violations of the IIA (see for example Rolfe *et al*., 2000; Birol, 2004; Birol and Rayn, forthcoming). The main problem with this method is multicollinearity, which occurs when too many interactions are included in the estimation; hence, the model needs to be tested down, using the higher log-likelihood criteria (Breffle and Morey, 2000).

An alternative method to accounting for preference heterogeneity is the use of random parameter logit model. Next section explains this model in greater detail and reports the random parameter logit estimates for each version of the choice experiment questions. Section 5.6 investigates the effects of household and decision-maker level characteristics on farm households' demand for variety attributes for each crop.

5.5. Random parameter logit model

Even though segment analysis and use of social and economic characteristics help to recognise conditional heterogeneity, these methods do not detect for unobserved heterogeneity. It has been demonstrated that heterogeneity can be present in significant residual form even when conditional heterogeneity is accounted for (Garrod *et al.*, 2002). Unobserved heterogeneity in preferences across respondents can be accounted for by using the random parameter logit model, which, unlike conditional logit is not based on the IIA assumption.

The random utility function in the random parameter logit model is given by

$$U_{ij} = V_{ij} + \varepsilon_{ij} \equiv Z_j(\beta + \eta_i) + e_{ij} \qquad \textbf{(5.2)}$$

where respondent *i* receives utility *U* from choosing alternative *j* from choice set C. Like the case of conditional logit model, utility is decomposed into a non-random component (*V*) and a stochastic term (*e*). Indirect utility is assumed to be a function of the choice attributes Z (as well as of social and economic characteristics S, if included in the model) with parameters β, which due to preference heterogeneity may vary across respondents by a random component η_i. By specifying the distribution of the error terms *e* and η, the probability of choosing *j* in each of the choice sets can be derived (Cameron and Trivedi, 2005). Accounting for unobserved heterogeneity, equation (4.5) in chapter 4 now becomes

$$P_{ij} = \frac{e^{Z_{ij}(\beta+\eta_i)}}{\sum_{h\in C} e^{Z_{ih}(\beta+\eta_i)}} \qquad \textbf{(5.3)}$$

The introduction of random parameters has the attractive property of inducing correlation across alternatives (Cameron and Trivedi, 2005). That is, since this model does not require IIA assumption, the stochastic part of utility may be correlated among alternatives and across the sequence of choices via the common influence of η_i (Birol, 2004). Treating preference parameters as random variables requires estimation by simulated maximum likelihood. Procedurally, the maximum likelihood algorithm searches for a solution by simulating '*m*' draws from distributions with given means and standard deviations. Probabilities are calculated by integrating the joint simulated distribution (Cameron and Trivedi, 2005).

Recent applications of random parameter logit model have shown that this model is superior to conditional logit model in terms of overall fit and welfare estimates (Birol, 2004; Birol and Rayn, forthcoming; Kontoleon, 2003). However, it should also be noted that even if unobserved heterogeneity can be accounted for with the use of the random parameter logit model, the model fails to explain the sources of heterogeneity (Boxall and Adamowicz, 1999). One solution to detecting the sources of heterogeneity while accounting for unobserved heterogeneity would be by inclusion of respondent characteristics in the utility function as interaction terms. This would enable random parameter logit model to pick up preference variation in

terms of both unconditional taste heterogeneity (random heterogeneity) and individual characteristics (conditional heterogeneity), and hence improve model fit (see for example, Birol and Rayn, forthcoming).

In this chapter the random parameter logit models for both crops were estimated using LIMDEP 8.0 NLOGIT 3.0. All the parameters except for producers' price and productivity attributes were specified to be independently normally distributed and distribution simulations were based on 500 draws. The results of the random parameter logit estimations for sorghum variety choices are reported in Table 5.6 below.

Table 5.6. Random parameter logit estimates for sorghum variety choices

Variable	Coeff. (s.e)	Coeff. S.d. (s.e.)
Producers' price	0.027***(0.0031)	-
Productivity	0.347***(0.033)	-
Environmental adaptability	5.10***(1.29)	4.67***(1.10)
Yield stability	4.55***(1.18)	1.47(0.96)
Sample size	1782	
ρ^2	0.526	
Log likelihood	-309.65	
Replications for simulated probability	500	

Source: Own survey in collaboration with Genetic
Resources Policy Initiative (GRPI) - Ethiopia project, 2006/2007.
*** 1% significance level, ** 5% significance level and *10%

significance level with two-tailed tests.

Random parameter logit model estimates of sorghum variety choices resulted in highly significant derived standard deviation for environmental adaptability choices but do not support any choice specific unconditional, unobserved heterogeneity concerning the demand for yield stability showing that every farmer demands yield stability. However, even though there is significant heterogeneity in the demand for environmental adaptability, the deviation from the mean (+ or -4.67) does not change the sign on the mean (5.10), hence, it can be concluded that all of the farmers in our sample derive positive utility from higher levels of this attribute.

Comparing the two models estimated for sorghum variety choices, namely conditional logit (CL) and random parameter logit (RPL) models, the Swait-Louviere log likelihood ratio test rejects the null hypothesis that regression parameters for the CL and RPL models are equal at 0.5% significance level. Hence, improvement in the model fit can be achieved with the use of RPL model for sorghum variety choices. The result is also supported by the increase in the ρ^2.

Similarly for *teff* variety choices reported in Table 5.7 below, the RPL model resulted in a better fit than its CL counterpart as can be seen in the higher ρ^2 and confirmed by the Swait-Louviere log likelihood ratio test. The results also show that the demand for both environmental adaptability and yield stability has highly significant choice specific unconditional and unobserved heterogeneity. However, the deviations from the mean for both attributes is less than the respective means, showing that these deviations are not strong enough to influence even some farmers to opt for non adaptable and/or non stable *teff* varieties. Hence, by looking at these two models, it can be concluded that all of the farmers in the sample derive positive utility from higher levels of environmental adaptability and yield stability for both crops under study.

The willingness to accept values (WTA) based on the two superior models discussed above for both crops are reported in Table 5.8 below. These WTA values for each crop attribute are calculated by finding the part-worth as described in equation (4.8) of the previous chapter. The values are similar for productivity attribute calculations reported in Table 5.3 (based on basic CL model), hence providing an additional external validity to our choice experiment survey results as argued above.

Table 5.7. Random parameter logit estimates for Teff variety choices

Variable	Coeff. (s.e)	Coeff. S.d. (s.e.)
Producers' price	0.013***(0.0019)	-
Productivity	0.278***(0.025)	-
Environmental adaptability	5.02***(1.43)	3.50***(1.25)
Yield stability	3.72***(1.12)	3.16***(1.00)
Sample size	1755	
ρ^2	0.477	
Log likelihood	-335.98	
Replications for simulated probability	500	

Source: Own survey in collaboration with Genetic

Resources Policy Initiative (GRPI) - Ethiopia project, 2006/2007.
*** 1% significance level, ** 5% significance level and *10% significance level with two-tailed tests.

Table 5.8. WTA (in birr per quintal of the respective crop) values for each variety attribute by crop

Attribute	Sorghum	Teff
Productivity	**-13**	**-21**
Environmental adaptability	**-189**	**-386**
Yield stability	**-169**	**-286**

Source: Own survey in collaboration with Genetic Resources Policy Initiative (GRPI) - Ethiopia project, 2006/2007.

The WTA values for environmental adaptability and yield stability attributes are however, significantly higher than their counterparts reported in Table 5.3. This shows that farm households in North Wello zone are extremely risk averse by opting for more adaptable and/or stable varieties of crops at a much greater cost to income generated from sorghum and *teff* sale. Notwithstanding the differences in these results, farm households still prefer environmental adaptability (resistance to drought and frost pressures) trait over both yield stability (resistance to disease and pest occurrences) and productivity traits for both crops. Therefore, if crop varieties were to have only one attribute (environmental adaptability), the probability that farmers will select these varieties is greater than the probability of them selecting either stable yielding or more productive varieties of either sorghum or *teff*.

The WTA values based on the above two superior models for both crops and with productivity attribute taken as a proxy for monetary attribute is reported in Table 5.A.1 of the appendix. These results also show that farmers are more risk averse towards a non-adaptable variety of *teff* than towards a sorghum variety with a similar trait supporting our results in Table 5.4. The results are also similar for yield stability trait of both crops, where farmers are willing to accept almost equal values, in terms of quintals of output per hectare, sacrificed to get stable- in-yield varieties of both crops.

5.6. Conditional logit model accounting for preference heterogeneity

To account for heterogeneity of preferences across farm households the effects of farm household, household head, farm level, and development integration characteristics on farm households' demand for crop varieties and crop variety attributes must be investigated. As already mentioned in chapter 4 (equation 4.6), in random utility models the effects of social and economic characteristics on choice cannot be examined in isolation but as interaction terms with choice attributes. Due to possible multicollinearity problems, it is not possible to include all the interactions between the explanatory variables collected in our survey (See Table 3.1 in chapter 3) and the four crop variety attributes when estimating the conditional logit models (Breffle and Morey, 2000).

To address this limitation, independent variables were eliminated based on Variance Inflation Factors (VIF), which were calculated by running "artificial" ordinary least squares regressions between each independent variable (i.e. farm household, household head, farm level, and development integration characteristics) as the "dependent" variable and the remaining independent variables[71]. Those independent variables for which $VIF_j > 5$ indicate clear evidence that the estimation of the characteristic is being affected by multicollinearity (Maddala, 2000). Our VIF values suggest that our data is not suffering from multicollinearity problems for all potential explanatory variables reported in chapter 3 except age, and Access2 (the average of walking time needed (in minutes) to reach the agricultural extension center, the nearest dry weather road and market) variables, which were subsequently removed from our model estimations.

The next step we took before reporting our CL with interactions results in Table 5.10 and Table 5.11 was to "test down" our interaction terms by eliminating those interactions that are insignificant starting from the most insignificant one (as revealed by the P-values) and then removing them one by one until we are left with significant interactions only[72]. Eleven independent variables remained:

1) gender of the household head (denoted as *Sex*, where a value of 1 is for male)
2) the number of household members who share the same food stock (denoted as *Household size*)

[71] Variance Inflation Factors (VIF_j) for each such regression are calculated as: $VIF_j = \frac{1}{1-R_j^2}$, where R_j^2 is the R^2 of the artificial regression with the jth independent variable as a "dependent" variable.
[72] Note that the CL model was re-estimated each time an interaction term was eliminated and that only those interactions that are significant at 10% level or less are reported in Table 5.10 and 5.11.

3) 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*)

5) whether or not the farm household has been participating in the agricultural extension package program (denoted as *Agri. Ext Participation*)

6) average of 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*)[73]

7) whether or not the household head considers land shortage as the primary problem the household faces (denoted as *Land shortage*)

8) total land size operated by the household in hectares (denoted as *Total land size*)

9) total value of livestock, in birr, that is currently owned by the household (denoted as *Livestock value*)

10) whether or not the household head considers his/her household to be at least self-sufficient in relation to other households in the area (denoted as *Poverty status*, where a value of 0 means the household considers itself poor or very poor), and

11) number of dependents with no labor or money contribution in the household (denoted as *No. dependents*).

[73] 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.

The above explanatory variables used in the analysis of the survey data are divided into three sets: household characteristics, farm and livestock characteristics, and development integration characteristics. The descriptive statistics for these three sets of variables are reported in Table 3.1. Assuming that these characteristics have the same direction of influence regardless of the crop considered[74], their hypothesized effects on the demand for attributes of crop varieties based on findings from other studies are reported in Table 5.9.

Table 5.9. Explanatory variables and their hypothesized effects on demand for attributes of crop varieties

Characteristics	**Producers' Price**	**Productivity**	**Environmental adaptability**	**Yield stability**
Household characteristics				
Sex	+, -	+,-	+,-	+,-
Household size	+	+	+	+
Experience	+	+	+	+
Off-farm work	+	+	-	-
No. dependents	+	+	+	+
Poverty status	+	+	-	-
Farm and livestock characteristics				
Land Shortage	+	+	+	+
Total land size	+,-	+,-	+,-	+,-
Livestock value	+	+	-	-
Development integration characteristics				
Access Services	-	-	+	+
Agri. Ext participation	+	+	-	-

[74] This assumption is later tested based on the results in Tables 5.10 and 5.11.

To test the above hypothesized effects and enable the determination of observed preference heterogeneity, the indirect utility function in equation (5.1) was then extended to include the interaction terms between the four crop variety attributes and the eleven farm household, household head, farm level, and development integration characteristics enumerated above. The final conditional logit function that was estimated is:

$$V_{ij} = \beta_1(Z_{\Pr oducers-price}) + \beta_2(Z_{\Pr oductivity}) + \beta_3(Z_{Env-adaptability}) + \beta_4(Z_{yield-stability})$$

$$\begin{aligned} &+\delta_1(Z_{\Pr oducers-price} \times S_{Sex}) + \delta_2(Z_{\Pr oductivity} \times S_{Sex}) + ... + \delta_4(Z_{Yield-stability} \times S_{Sex}) \\ &+\delta_5(Z_{\Pr oducers-price} \times S_{households-size}) + ... + \delta_8(Z_{yield-stability} \times S_{household-size}) + ... \\ &+\delta_{41}(Z_{producers-price} \times S_{no.dependents}) + ... + \delta_{44}(Z_{Yield-stability} \times S_{no.dependents}) \end{aligned} \quad (5.1')$$

Out of the 44 possible interactions employed in equation (5.1') to explain farm households' demand for crop variety attributes, only those interactions that are significant at 10% level or less are reported in Table 5.10 and 5.11 below.

Table 5.10. Effects of farmer specific household, farm level, and development integration characteristics on demand for sorghum variety attributes

Attributes and interactions	Coefficient (s.e.)
Producers' price	0.001** (0.005)
Productivity	-0.09 (0.08)
Environmental adaptability	-1.47*** (0.47)
Yield stability	0.282 (0.301)
Producers' price * Sex	0.008* (0.005)
Productivity * Sex	0.128*** (0.044)
Productivity * Experience	0.004** (0.002)
Productivity * Off-farm work	0.100** (0.042)
Productivity * Agri. Ext Participation	0.09** (0.042)
Env. Adaptability * Sex	0.754*** (0.269)
Env. Adaptability * Experience	0.053*** (0.012)
Env. Adaptability * Access services	0.014*** (0.004)
Env. Adaptability * Land shortage	0.772*** (0.219)
Env. Adaptability * Off-farm work	-0.498** (0.234)
Yield stability * Total land size	1.23*** (0.398)
Yield stability * Livestock value	0.0002*** $(.51 \times 10^{-4})$
Yield stability * Poverty status	-1.02*** (0.281)
Sample size	468
ρ^2	0.567

Log likelihood	-219.85

Source: Own survey and data from Genetic
Resources Policy Initiative (GRPI) - Ethiopia project, 2006/2007.
*** 1% significance level, ** 5% significance level and *10%
significance level with two-tailed tests.

Comparing McFadden's ρ^2 between the conditional logit model results reported in Tables 5.10 - 5.11 and Tables 5.1- 5.2 shows a significant improvement in the model fit due to the inclusion of interaction terms in our analysis of the demand for both crops' variety attributes. This was also verified by the Swait-Louviere log likelihood ratio tests conducted between these results and we found that CL with interaction terms (results in Tables 5.10 - 5.11) is superior to the basic CLM (results in Tables 5.1 - 5.2) for both crops at 0.5% significance level.

Inclusion of interaction terms in our analysis of the demand for sorghum variety attributes also resulted in insignificant coefficients for productivity and yield stability traits while there is a highly significant and positive utility derived from higher levels of producers' price and a negative disutility derived from environmental adaptability traits of sorghum crop varieties (Table 5.10). This shows that most of the positive utility derived from environmental adaptability, productivity, and yield stability traits of sorghum varieties, as we have reported in previous results, is explained by the interaction terms between these attributes and the socio-economic characteristics (see Table 5.10 above)[75].

[75] In order to prove this, we have estimated the model without, for example, the five interaction terms between environmental adaptability and the socio-economic variables reported in Table 5.10, and found that the coefficient for environmental adaptability trait regained its positive and highly significant value. The same was also true of the demand for productivity and yield stability attributes.

The interaction between the demand for higher levels of producers' price (or productivity) and sex of the household head is positive. This shows that male headed households demand higher prices for their output and more productive sorghum varieties than female headed households. This may be because male headed households are more integrated into the market than their female counterparts and hence demanding more marketable varieties with good output potentials. More experienced farm households also demand more productive and environmentally adaptable sorghum varieties. As farm household heads get more experienced in farming, they are likely to have larger family sizes that they have to support from their produce either through direct household food consumption or through the income generated from selling their produce, both prompting higher demand for productivity. More experience also forces many farmers to go through recurrent drought encounters in the past, which are common in the area and often result in acute food shortages to those farm households located in the area, inducing more experienced farmers to look for varieties that are better resistant to such environmental pressures.

Farm households with at least one member working off-farm tend to gamble with nature by demanding more productive varieties even if this sorghum variety is not environmentally adaptable. This is because farm families with off farm income have a better potential to insure themselves against crop failure that might arise as a result of drought and frost problems by supplementing their output with items purchased at the local markets in the two Kebeles. Hence, this allows them to look for more productive sorghum varieties than those farm households without off farm income and thus more concerned with the environmental adaptability trait of the varieties on offer. Participation in the agricultural extension package program may also be motivated by the demand farmers have for more productive varieties as can be seen by the positive and significant coefficient for the interaction term included in Table 5.10.

Farmers residing far away from basic infrastructures like irrigation and piped water among other things, look for more environmentally adaptable sorghum varieties. The fact that environmentally adaptable varieties require relatively less moisture to grow is appealing to such farmers who do not have easy access to irrigation and piped water and hence mainly depend on the weather condition to keep their crops grow.

Farm household heads who stated that land shortage is the primary problem the household faces also have a high demand for environmentally adaptable sorghum varieties. Land shortage problems can be translated into small total output for these farm households, and farmers are particularly risk averse towards non-adaptable varieties planted in these small plots of land since otherwise, they risk the much needed output that these plots provide to the vagaries of nature. Demand for yield stability also increases with total land size and the value of livestock owned by the farm household. As the total land size operated by the farm household increases, farmers will have a better potential to participate in the market and sell their produce and hence require yield stability to keep the supply steady. More stable yield also means more stable supply of fodder for the livestock the household rears, which induces the household head to demand sorghum varieties that are stable in yield.

Farm households who consider themselves poor or very poor in relation to other households in the area have a higher demand for yield stability than farmers who consider themselves at least self-sufficient. This finding implies that poorer households demand sorghum varieties that can secure the food safety of the household while evening out the risk element associated with disease and pest occurrences.

The results of the conditional logit model with significant interaction terms estimated to study the demand for teff variety attributes is reported in Table 5.11 below. The coefficients for producers' price, productivity and yield stability attributes when not interacted with the socio-economic variables resulted in positive and significant demand for these attributes, similar to our findings in Table 5.2. However, similar to our findings in Table 5.10 for sorghum variety attributes, the demand for environmental adaptability trait of teff varieties, when seen individually, is found to be negative and highly significant. This is because as in the above case, all of the positive demand for environmentally adaptable trait of teff varieties, which is reported in Table 5.2, is explained by the interaction terms between this particular trait and the socio-economic characteristics that significantly determine the demand for this attribute (see Table 5.11 below). Following the same procedure mentioned in the above footnote, we proved this by estimating the model without the variables where environmental adaptability is interacted and found that the attribute regained its positive and highly significant coefficient.

Table 5.11. Effects of farmer specific household, farm level, and development integration characteristics on demand for teff variety attributes

Attributes and interactions	Coefficient (s.e.)
Producers' price	0.004** (0.002)
Productivity	0.119*** (0.027)
Environmental adaptability	-2.83*** (0.543)
Yield stability	0.637* (0.338)
Producers' price * Livestock value	0.685×10^{-6}*** (0.256×10^{-6})
Productivity * Access services	0.0001* (0.0005)
Env. Adaptability * Sex	0.895** (0.401)
Env. Adaptability * Experience	0.0233*** (0.007)
Env. Adaptability * Access services	0.015*** (0.004)
Env. Adaptability * Livestock value	-0.0001*** (0.00003)
Env. Adaptability * Poverty status	1.60*** (0.326)
Env. Adaptability * Household size	0.262** (0.107)
Yield stability * Livestock value	-0.0001*** (0.00003)
Yield stability * Land shortage	-0.372** (0.171)
Yield stability * No. dependents	0.178** (0.073)
Yield stability * Household size	0.203* (0.108)
Sample size	549
ρ^2	0.469

Log likelihood	-314.59

Source: Own survey and data from Genetic
Resources Policy Initiative (GRPI) - Ethiopia project, 2006/2007.
*** 1% significance level, ** 5% significance level and *10% significance level with two-tailed tests.
.

Results in Table 5.11 also show that farmers with accumulated wealth in the form of higher total livestock value tend to gamble with nature by looking for more marketable *teff* varieties even though such varieties do not provide stable yield or are not environmentally adaptable. This is because wealthy farmers can insure themselves against crop failure that might arise as a result of drought, frost, disease, or pest problems by supplementing their output with livestock that is either directly consumed or sold to buy food items from the local markets.

Farmers residing far away from basic infrastructures and services also require more productive and environmentally adaptable *teff* varieties than farmers living closer to these services. As already explained for sorghum variety choices above, environmentally adaptable *teff* varieties also require relatively less moisture in the soil to grow, which makes them more likely to be adopted by farmers living far away from irrigation and piped water infrastructures among others. The fact that farmers living in remote areas also demand higher productivity from their *teff* variety options is perhaps an indication that the government can incorporate such farmers in the agricultural extension program and provide them with more productive improved varieties.

The interaction between the demand for environmentally adaptable *teff* varieties and the poverty status of the household is positive. This is unexpected because it implies that richer households demand more environmentally adaptable *teff* varieties than poorer households. One possible explanation for this is that farmers who consider themselves poor or very poor may already be receiving food assistance from relief organizations for many years and is likely to continue, if not increase, during drought and frost seasons, which are then left to affect most noticeably those farm households who have managed to stay at least self-sufficient and hence prompting them to demand for environmentally adaptable *teff* varieties since they have much to lose than poorer households. Another unexpected finding is that the demand for yield stability trait of *teff* varieties decreases with the household head mentioning land shortage as the primary problem for the household. This may be because some farmers who are primarily concerned with land shortage problems have interpreted a stable-in-yield variety as a type that provides constant yield year after year, and this may not be a desirable attribute since these farmers may like to see an upward trend in the quantity of output for their small land.

Results in Table 5.11 also show that the demand for both environmental adaptability and yield stability characteristics of *teff* varieties increases with the household size. The shock to output associated with growing non-adaptable and/or non-stable varieties has a much larger negative effect on larger households than smaller ones, inducing bigger households to be more risk averse towards such crops. This is also true as the number of dependents in the household with no labor or money contribution increases; we found that the demand for yield stability – as a way of averting the shock associated with disease and pest occurrences – increases.

Most of the findings above in our analysis of the demand for both sorghum and *teff* crop variety attributes are also shared by the work of Edilegnaw (2004), where he found that farmers in more accessible areas and those who are less concerned with satisfying subsistence income prefer more productive and marketable coffee varieties; and on the contrary, farmers in less accessible areas and those more concerned with potential future income shocks (or survival) have more propensities for adaptability and yield stability traits of coffee varieties.

A summary of all the econometric models used in this chapter with their definitions, why they were applied to the data and their suitability to the data at hand are reported in Table 5.12 below.

Table 5.12. Summary of econometric models employed in this chapter

Econometric Model	Definition	Results
Conditional Logit	The choice of a crop variety is a function of the attributes of the crop variety and of the characteristics of the respondent. The error terms are assumed to have a Weibull distribution and hence the model is estimated with a logit model (McFadden, 1974; Greene, 2000; Cameron and Trivedi, 2005).	Basic conditional logit model are reported in Tables 5.1 and 5.2. The model however does not conform to the underlying IIA conditions. Hence the model needs to be augmented either by including social and economic characteristics as interaction terms or by employing the random parameter logit model (Cameron and Trivedi, 2005).
Random Parameter Logit Model	Mixed logit model which can account for unobserved heterogeneity and does not require IIA assumptions (Cameron and Trivedi, 2005).	Random parameter logit model estimates, as reported in Table 5.6 and 5.7, result in mostly significant derived standard deviations or choice specific unconditional unobserved

		heterogeneity but they are not strong enough to significantly influence choice. Therefore conditional logit model with interactions is used.
Conditional Logit with Interactions	Interactions with social and economic characteristics of the farm households are included in order to deal with the heterogeneity problem and with violations of the IIA (Cameron and Trivedi, 2005)	This model presents an improvement over the conditional logit model and enables determination of observed preference heterogeneity as reported in Tables 5.10 and 5.11. The main conclusions and policy implications in the next chapter are drawn from this model.

5.7. WTA values for selected farm household profiles for each crop

The results of the conditional demand functions with interactions reported in Tables 5.10 and 5.11 can be used to calculate the value assigned by the farm families to crop variety attributes (Scarpa, *et al.*, 2003a), by modifying equation (4.8) in chapter 4 to

$$W = -1\left(\frac{\hat{\beta}_{attribute} + \delta_{atribute} \times S_1 ... + \delta_{attribute} \times S_{11}}{\hat{\beta}_{monetaryattribute} + \delta_{monetaryatribute} \times S_1 + ... + \delta_{monetaryattribute} \times S_{11}} \right) \qquad (4.8')$$

Where variables S_{1-11} are the social and economic factors under consideration. The compensation payments that households are willing to accept for giving up their crop variety attributes are shown in Table 5.13, according to three social and economic "profiles", which are chosen to represent stereotype farm households in rural Wello.

Profile 1 represents an elderly male headed relatively large household with 11 members, 6 of which are dependents and the experience of the primary decision maker is 50 years.

The household has no member working off-farm, resides in less accessible area with an average of 120 minutes walking distance away from basic infrastructures, and is not participating in the agricultural extension program. The total land size operated by this household is only 1 *Timad* (0.25 ha) and hence considers scarcity of land as a primary problem. This farm family has only 800 birr worth of livestock and judges itself to be poor or very poor in relation to other households in the area.

Profile 2 pertains to a male headed medium sized farm household with 6 members, 3 of which are economically dependent and the experience of the primary decision maker is 25 years. The household has no member working off-farm, resides in relatively more accessible area with an average of 50 minutes walking distance away from basic infrastructures, and participates in the agricultural extension program. The total land size operated by this household is 3 *Timads* (0.75 ha) and considers scarcity of land as a primary problem. This farm family has 5,000 birr worth of livestock and judges itself to be at least self-sufficient in relation to other households in the area.

Profile 3 describes a female headed and small sized farm household with only 3 members, and only 1 member is economically dependent and the experience of the primary decision maker is 10 years. The household has at least one member working off-farm, resides in more readily accessible area with an average of only 10 minutes walking distance away from basic infrastructures, and participates in the agricultural extension program. The total land size operated by this household reaches 11 *Timads* (2.75 ha) and hence does not consider land shortage as a primary problem. The farm family has as much as 15,000 birr worth of livestock and judges itself to be at least self-sufficient in relation to other households in the area.

The results of the derivation of WTA estimates conditional on the social and economic variables of these farm household profiles are reported in Table 5.13 below.

Table 5.13. WTA values by farm household profiles and crops (in birr per quintal of the respective crop)

Crop and Attribute	Profile 1	Profile 2	Profile 3
Sorghum			
Productivity	-14	-13	-15
Environmental Adaptability	-242	-115	+136
Yield Stability	-43	-71	-617
Teff			
Productivity	-51	-22	--*
Environmental Adaptability	-818	-268	--
Yield Stability	-750	-195	--

Source: Own survey and data from Genetic Resources Policy Initiative (GRPI) - Ethiopia project, 2006/2007.
*-- indicates that the demand for the attribute is insignificant at 10% significance level.
Note: values computed using Wald procedure (Delta method) in LIMDEP 8.0 NLOGIT 3.0.

WTA value estimates for the three household profiles and the two crops under study in this thesis disclose three main results. First, productivity of both crops has a positive use value for all the three household profiles except probably for those richer households (profile 3) presented with hypothetical *teff* varieties, in which case productivity attribute is found to be insignificant. They, however, derive the highest positive utility from more productive sorghum varieties. Larger and poorer households (profile 1) also derive higher positive utility from productive sorghum and *teff* varieties than medium sized and relatively richer households (profile 2).

Second, the environmental adaptability attribute of both crops is valued most highly by large, relatively secluded and poorer households followed by medium sized, more readily accessible, and at least self-sufficient households (profile 2). The results in Table 5.13 also show that environmental adaptability attribute of sorghum varieties has actually negative use value for smaller and richer households with a female head and the demand for this attribute in *teff* varieties is insignificant for the same farm household. This result shows that farm families with the likes of the descriptors in profile 3 are rather willing to pay (WTP) to get this attribute than to derive it themselves from crop varieties already found on their plots.

Third, the demand for yield stability attribute is mixed between the two crops. Our results demonstrate that the demand for yield stability trait in sorghum varieties is most noticeable in richer households living in easily accessible areas, whereas larger and poorer households derive the highest positive utility from stable-in-yield *teff* varieties followed by medium sized, and moderately experienced farm households. The demand for yield stability in *teff* varieties is insignificant for relatively inexperienced but richer farm households headed by a female.

WTA value estimates for our binary attributes with productivity as a proxy for monetary attribute is reported in Table 5.A.2 of the appendix. The results confirm all the above findings except that in this case, there is a significant positive utility associated with environmental adaptability trait of *teff* varieties for those small farm households who are inexperienced but are rich and have income source from off-farm job opportunity.

5.8. Brief summary and concluding remarks

The results of this chapter show that farmers in North Wollo zone attach the highest private values to environmental adaptability (resistance to drought and frost occurrences) followed by yield stability (resistance to disease and pest occurrences) and productivity attributes of both sorghum and *teff* crops.

Because of their effect on farmers' utility, farm household characteristics, farm and livestock ownership, and farmers' integration into rural development interventions in the areas of infrastructure development and agricultural extension have been found to influence farmers' variety attribute preferences. For instance, the environmental adaptability trait in sorghum and *teff* crops is valued most highly by large, relatively secluded and poorer households than medium sized, more readily accessible, and at least self-sufficient households. This has implication on on-farm conservation of varieties embedding this attribute. For example, as rural development interventions (improved access to extension and infrastructures such as irrigation and piped water) are put in place and contribute to the improvement of the livelihoods of the poor farm households by making them at least self-sufficient, these farmers will be less concerned with attributes like drought and frost resistance. Hence, those varieties having these attributes will likely be replaced by new ones. Policy incentives are, therefore, required to maintain environmentally adaptable *teff* and sorghum varieties on-farm by harmonizing rural development with conservation efforts. Besides identifying varieties that need policy incentives for conservation, policy makers can also utilize the findings from our empirical analysis for targeted adoption of varieties. For instance, they can target the more vulnerable farmers for on-farm conservation of stable yielding *teff* varieties and the relatively income-shock tolerant farmers for stable yielding sorghum varieties due to their pro-stability decision behaviour. The details of the conclusions and policy implications of the empirical results are contained in Chapter 6.

CHAPTER SIX

CONCLUSIONS AND POLICY IMPLICATIONS

6.1. Conclusions

The aim of this study was to estimate the private values that farmers attach 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 farm households' demand for crop varieties and their attributes conditional on the characteristics of the households and the main decision-makers.

To the extent that the findings are representative of other PAs in the country, the results of the choice experiment study demonstrate that farmers in Ethiopia make significant trade-offs between crop variety attributes before making their seed selection decisions. Farmers, in general, derive positive utility from more productive, environmentally adaptable, marketable, or stable yielding varieties of both *teff* and sorghum crops. Farmers attach the highest private values to environmental adaptability (resistance to drought and frost occurrences) followed by yield stability (resulting from resistance to disease and pest problems) and productivity attributes of both crops. Farmers' trade-offs between productivity and adaptability traits of the two crops under study have also shed light on the relative importance of the environmental adaptability trait in sorghum and *teff* crops. The results of the empirical analysis demonstrate that farmers are slightly more risk averse towards a non-adaptable variety of *teff* than towards a sorghum variety with a similar trait. This has implication on breeding priority setting as mentioned in the next section. Thus, based on these results, it can be argued that if there is a limited budget to improve the environmental adaptability trait of only one of the two crops in this study, farmers in Wollo would be better off if this budget is geared towards the improvement of the attribute in *teff* varieties than towards the same attempt in sorghum varieties.

To investigate if the multiple private values that are generated by crop varieties are shared across farm households, we examined the farm household contextual factors that influence farmers' preferences for crop variety traits. The results 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 traits. Our results indicate that *teff* and sorghum varieties that are resistant to drought and frost occurrences *i.e.*, environmentally adaptable varieties are valued most highly by larger and poorer farm households residing far away from basic infrastructures and less so by medium sized, and moderately experienced farm households. The demand for yield stability varies by the crop considered. Our results show that the demand for yield stability trait in sorghum varieties is most noticeable in richer households living in easily accessible areas, whereas larger and poorer households derive the highest positive utility from stable yielding *teff* varieties followed by medium sized, and moderately experienced farm households. Richer farm households who have been participating in the agricultural extension package and who have at least one member working off-farm derive the highest positive utility from more productive sorghum varieties. On the other hand, poorer farm households who do not participate in the extension package and reside in less accessible areas derive the highest positive utility from more productive *teff* varieties. Marketable sorghum varieties *i.e.*, those that fetch the highest price for the farm family, are valued most highly by male headed farm households. Farm households with accumulated wealth in the form of higher total livestock value derive the highest private utility from marketable *teff* varieties.

The choice experiment study reveals the most important farm household characteristics and crop variety traits that are worth considering in designing conservation policies in Ethiopia. The study can also serve as an input for contextual variety development, breeding priority setting, and targeted diffusion of improved varieties with more chance to be adopted and be successful in Ethiopia. Economic theory predicts that those farm households who now attach the highest values to attributes already embedded in varieties that the households keep on their farms *i.e.*, those conserving *de facto*, would need the least additional public funds as incentives to continue their management (Meng, 1997). These "least cost" farmers should, therefore, be ranked the highest as candidate farmers for conservation (Brown, 1990).

6.2. Implications for policy

The results of this study have implications not only for on-farm conservation but also for improved variety development and adoption. Since conservation of crop diversity is not an end in itself, this section will pinpoint the relevance of the results to both of these policy concerns. There are four major policy directions that are emphasized in this section.

The first policy implication is in the area of identifying the varieties conserved *de facto* and those that need external incentives. Once policy is informed on the types of varieties preferred by different farm household types, on-farm conservation costs can be optimized. For instance, *de facto* conservation of high yielding sorghum varieties by more accessible and income-shock tolerant farmers implies that there is no need to design external incentives for these varieties to deal with their maintainers. On the contrary, in an area where the demand for a certain variety trait (say, environmental adaptability) is low, the variety (ies) embedding that trait should be targeted for conservation. For instance, for farming systems operated by relatively rich farm households, and for those found in easily accessible areas, conservation should be target to environmentally adaptable varieties of both *teff* and sorghum crops.

The second policy implication is in the area of opportunity cost compensation. One of the issues to be dealt with in on-farm conservation is the opportunity cost that farmers are facing when the policy is in place (Edilegnaw, 2004). To this end, understanding farmers' variety trait preferences will enable policy makers to identify the variety attributes that have to be compensated. For instance, larger and poorer farm households who fail to satisfy their current consumption requirement are most affected when they have to abandon *teff* and/or sorghum varieties (for the purpose of on-farm conservation) with better yield stability and environmental adaptability.

The third policy implication is in the area of variety adoption. For the success of agricultural technologies, their attributes should address farmers' concerns. Thus, understanding farmers' variety trait preferences is an input to this end. For instance, according to our empirical results, to target and address variety demand for income shock vulnerable and segmented farmers, the priority variety attributes are environmental adaptability, yield stability, and to a lesser extent the productivity traits of *teff* and sorghum varieties.

The fourth policy implication is in the area of breeding priority setting. Given that farmers' variety attribute preferences are determining both their propensity to use improved varieties and the chance of using them successfully, breeding should target to satisfy demands of different farm household types classified by their resource endowments, preferences and constraints. To this end, analyzing farmers' variety attribute preferences will help to inculcate farmers' demands in the making of the technology. For instance, we found that farmers attach the highest private value to environmental adaptability (resistance to drought and frost occurrences) trait followed by yield stability (resulting from resistance to disease and pest occurrences) attribute of both sorghum and *teff* crops. Breeding should, therefore, primarily target the improvement of these two attributes in both sorghum and *teff* varieties, where environmental adaptability should come first. Moreover, as breeding attempts to improve the cross-cutting attribute (environmental adaptability) in the crops under study, we found that farmers in Wollo would be better off if this improvement comes first in *teff* varieties than in sorghum varieties. This is because as mentioned above and in the previous chapter, farmers are slightly more risk averse towards a non-adaptable variety of *teff* than towards a sorghum variety with a similar trait (see section 5.3 in chapter 5). Therefore, if, for practical reasons, breeding can not address the improvement of the most important attribute in both crops simultaneously, then priority should be given to the improvement of the environmental adaptability trait in *teff* varieties.

Breeding should also target to satisfy demands of different farm household types classified by their resource endowments, preferences and constraints. The research priority setting should, therefore, also ask '*breeding for whom?*' not just only '*breeding for which environment?*', as it is mostly the case (Edilegnaw, 2004). This way, targeted technology development and dissemination would support efforts to deal with the complicated problems of slow technology adoption, lack of agricultural transformation, and perpetuation of poor agricultural productivity (and poverty) in the country.

6.3. Important issues for future research

Choice Experiment (CE) is an emerging methodology which has not been applied very much in crop diversity studies. While applying CE in this study answers many questions regarding farmers' preferences for crop variety traits, there are still important questions about farmers' variety choice behaviour, which are left unanswered. For example, as already mentioned in chapter 4, the fact that our analysis is based on farmers' preferences for marketability, productivity, yield stability and environmental adaptability traits of sorghum and *teff* crops should not be translated into saying that these are the only relevant attributes in farmers' variety choice criteria. Among attributes of sorghum and *teff* crops that are not covered in this study but nevertheless important to farmers are the amount of fertilizer requirement, food quality (taste, color, milling quality etc.), early maturity, and the quantity of remains for animal feed. Studying farmers' preferences towards these and other attributes is, therefore, an interesting area for future research as it provides a more complete picture regarding the relative importance of the different variety attributes.

In multi-cropping agricultural systems like Ethiopia, one can also relatively easily (since many farmers are familiar with many crops) apply CE and study farmers' preferences for variety attributes embedded in cereals like barley, wheat, maize, beans, and other cereals and cash crops that contribute to the food security of farmers in Ethiopia. The results from such research activities will inform agricultural policy makers in the designing of variety development and local variety conservation interventions targeted towards each of these crops.

Testing whether or not the private values that farm households attach to crop variety attributes differ according to the region in which the farm households are located is also an interesting area for future research. These regions should represent a combination of factors related to market infrastructure, farming system, soils and landscape, agro-ecologies, and cultural references among others. Studies that allow for this test are important to design breeding and on-farm conservation programs that account for differences both in farm household characteristics and physical environments that influence attribute preferences.

Appendix I

Table 4.A.1. Description of the 9 choice sets of the choice experiment for teff variety choices

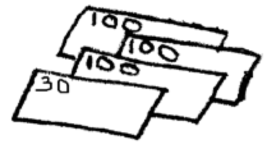
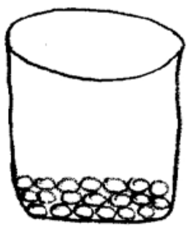
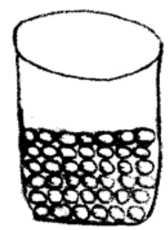
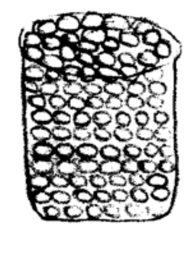
		Teff variety 1				Teff variety 2				Teff variety 3			
Q	CS	Price/Qt	Yield/ha	Environmentally adaptable	Stable-in-yield	Price/Qt	Yield/ha	Environmentally adaptable	Stable-in-yield	Price/Qt	Yield/ha	Environmentally adaptable	Stable-in-yield
1	Q1	330	15	YES	YES	210	20	NO	NO	270	8	YES	YES
2	Q2	330	20	YES	NO	210	8	NO	YES	270	15	YES	NO
3	Q3	270	8	YES	NO	330	15	NO	YES	210	20	YES	NO
4	Q4	270	20	NO	YES	330	8	YES	NO	210	15	NO	YES
5	Q5	270	15	YES	YES	330	20	NO	NO	210	8	YES	YES
6	Q6	210	20	YES	YES	270	8	NO	NO	330	15	YES	YES
7	Q7	210	8	YES	YES	270	15	NO	NO	330	20	YES	YES
8	Q8	330	8	NO	YES	210	15	YES	NO	270	20	NO	YES
9	Q9	210	15	NO	NO	270	20	YES	YES	330	8	NO	NO

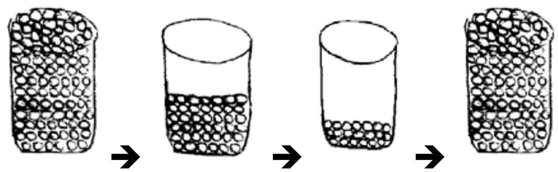
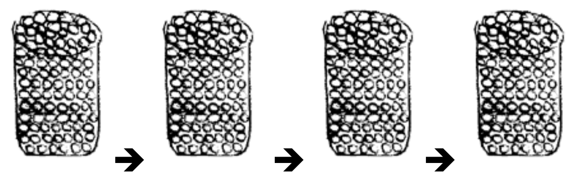
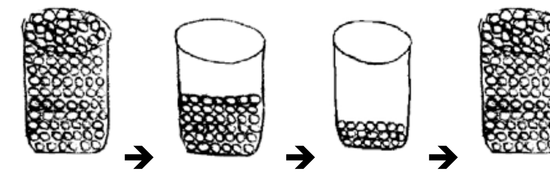
Table 4.A.2. Description of the 9 choice sets of the choice experiment for sorghum variety choices

		Sorghum variety 1				Sorghum variety 2				Sorghum variety 3			
Q	CS	Price/Qt	Yield/ha	Environmentally adaptable	Stable-in-yield	Price/Qt	Yield/ha	Environmentally adaptable	Stable-in-yield	Price/Qt	Yield/ha	Environmentally adaptable	Stable-in-yield
	Q1	200	19	YES	YES	110	25	NO	NO	150	14	YES	YES
2	Q2	200	25	YES	NO	110	14	NO	YES	150	19	YES	NO
3	Q3	150	14	YES	NO	200	19	NO	YES	110	25	YES	NO
4	Q4	150	25	NO	YES	200	14	YES	NO	110	19	NO	YES
5	Q5	150	19	YES	YES	200	25	NO	NO	110	14	YES	YES
6	Q6	110	25	YES	YES	150	14	NO	NO	200	19	YES	YES
7	Q7	110	14	YES	YES	150	19	NO	NO	200	25	YES	YES
8	Q8	200	14	NO	YES	110	19	YES	NO	150	25	NO	YES
9	Q9	110	19	NO	NO	150	25	YES	YES	200	14	NO	NO

Where, Q: Question number, CS: Choice set number

Figure 4.A.1. *A choice set example* **ምርጫ 3**:- እባክዎን ቀጥለው የቀረቡትን ሶስት የጤፍ ዝርያዎች በጥንቃቄ ይመልከቱ፡፡ እነዚህ ሶስት ዝርያዎች ብቻ ቢቀርብልዎ የትኛውን የጤፍ ዘርያ በመሬትዎ ላይ ለመዝራት ፍቃደኛ ይሆናሉ?

የዝርያ ባህርያት	የጤፍ ዝርያ 1	የጤፍ ዝርያ 2	የጤፍ ዝርያ 3
የአምራች ዋጋ በኩንታል	270 ብር 	330 ብር 	210 ብር 
ምርት በሄክታር	8 ኩንታል 	15 ኩንታል 	20 ኩንታል 
የአካባቢ ተላማጅነት	ድርቅና ውርጭ የሚቋቋም 	ድርቅና ውርጭ የማይቋቋም 	ድርቅና ውርጭ የሚቋቋም 

የምርት መረጋጋት (በሽታና ተባይን ከመቋቋም ጋር ይያያዝ)	ከአመት አመት የተረጋጋ ምርት የማይሰጥ 	ከአመት አመት የተረጋጋ ምርት የሚሰጥ 	ከአመት አመት የተረጋጋ ምርት የማይሰ 

Appendix II

Table 5.A.1. WTA (in quintals of output per hectare) values for each variety attribute by crop

Attribute	Sorghum	*Teff*
Environmental adaptability	**-14.70**	**-18.06**
Yield stability	**-13.11**	**-13.38**

Source: Own survey in collaboration with Genetic
Resources Policy Initiative (GRPI) - Ethiopia project, 2006/2007.

Table 5.A.2. WTA values by farm household profiles and crop (in quintals of output per hectare)

Crop and Attribute	Profile 1	Profile 2	Profile 3
Sorghum			
Environmental Adaptability	-18	-9	+9
Yield Stability	-3	-5	-41
Teff			
Environmental Adaptability	-16	-12	-13
Yield Stability	-15	-9	--*

Source: Own survey and data from Genetic
Resources Policy Initiative (GRPI) - Ethiopia project, 2006/2007.
*-- indicates that the demand for the attribute is insignificant at 10% significance level.
Note: values computed using Wald procedure (Delta method) in
LIMDEP 8.0 NLOGIT 3.0.

Appendix III.

Shorter outline of the questionnaire used to access the farm household survey (a subset of the original questionnaire)

October, 2006

Interview No.: ________________________

	Day	Month	Year	Person responsible
Interview				
Supervision				
Data entry				

Respondent ID

Identification	**Name or description**
Zone	
Woreda	
PA	
Village	

Part I. Basic household related information

1.0. Household head characteristics

Characteristics	**Description**
Name of the household head	
Agro-ecology of the village: Dega (1), Weina dega (2), Kola (3), Any other (Please specify)	
Experience[76] in farming (in years)	
Household[77] size	
Religion: Muslim (1), Christian (2), Any other (please specify)	
Marital status of the HH head: Married (1), Single (2), Divorced (3), Widowed (4)	

[76] Experience refers to the number of years that the HH head has been farming since he / she starts to work as an independent HH.

[77] Household is defined as a composition of all members who share the same food stock.

1.1. Was the HH head born in this village? 1. Yes ______ 2. No ______

1.2. If No, How or Why did the HH head come to this village?

____

1.3. HH member characteristics

No	HH member's name (start with the HH head and continue starting with the oldest HH member)	R/nship to the HH head[1]	Sex 1. M 2. F	Age (0 for all infants < 1 year old)	The highest level of schooling completed[2]	The most important activity for members > 6 years old
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						
11.						
12.						
14.						
15.						

[1]**Codes**: Head (1), Wife (2), Son/Daughter (3), Son/Daughter in law (4), Father/Mother (5), Father/Mother in law (6), Grand child (7), Other relative (8), Non-family / Non-relative (9)
[2]0 if illiterate and 1 for reading / writing due to formal or informal education

II. Household poverty status and asset ownership

2.0. How many dependents (household members with no labor or money contribution to the household due to age or permanent sickness) are there in the household?

1. Adult male ______ 2. Adult female ______ 3. Children ______

2.1. Suppose one would like to place all the HHs in this PA based on their level of well-being. How do you judge the poverty status of your HH in relation to other HHs in the area?

1. Very poor ___ 2. Poor ____ 3. Self-sufficient ______ 4. Rich _____ 5. Very rich ______

2.2. Do you or any other members of the HH usually work either on someone else's land or in some other employment, against payment in cash or in kind? 1. Yes _____ 2. No _____

2.3. Could you please rank the income sources of your household?

1. Agriculture - crop production _________ 2. Agriculture - animal production ______

2.6. In most of the years, do you buy more agricultural products than you sell or the *vise verse*?

1. The value of what is bought is more than the value of what is sold ___________

2. The value of what is sold is more than the value of what is bought ___________

3. No opinion _________

2.7. Current livestock ownership by the household:

Livestock	**Quantity (in number)**	**Total value in Birr**
Plowing oxen		
Calves (less than 2 years)		
Steers		
Cows and heifers		
Donkeys		
Sheep		
Goat		
Horses		
Mule (s)		
Modern bee hives		
Traditional bee hives		
Poultry		
Any other livestock (please specify)		

2.10. Access to services

	Item	**Yes = 1; No = 0**	**Walking distance (in minutes)**
1	Electricity		
2	Piped water		
3	Telephone		
4	Primary school		
5.	Secondary school		
6.	All weather road		
7.	Irrigation		
8	Any other (Please specify)		

Part III. Farmers' land use decisions and land ownership

3.0. What is the total land size operated by the household (in any unit)? ______________________

3.1. Local area unit conversion in terms of hectares (if area unit is different from hectares)[78]

____

3.2. What are the most important problems the household faces in relation to land?

a. Shortage ______ b. Poor quality _______ c. Property rights _______

d. Any other (Please specify) ____

Part IV. Farmers' preferences for crop varieties and their seed choice decisions

4.23. What are the most important factors (criteria) you take into account in your seed selection / choice decision for the three most important crops to the household?

Crop	**Seed selection criteria**

Part V. Agricultural extension and markets

5.0. Have you been participating in the agricultural extension package program?

1. Yes_____ 2. No_____

5.1. If Yes, are you still participating? 1. Yes______ 2. No______

5.9. How much time do you need to travel on foot to reach the nearest dry weather road (in minutes)? ____

5.10. How much time do you need to travel on foot to reach the nearest market (in minutes)?

____

5.11. How much time do you need to travel on foot to reach the nearest grinding mill (in minutes)?

____

VI. Shocks, food security, risk and coping strategies

6.0. Would you please rank the following problems in terms of their importance (frequency) to the household?

[78] Please present the conversion factor whenever the unit of the land is outside hectares.

1. Production related problems______ 2. Price or market related problems ________

3. Finance related problems ________ 4. Human or personal problems __________

5. Any other (Please specify) __________

6.1. Please encircle the shocks that you have faced during the last ten years and put the number of times the household has faced the problem,

1. Natural shocks	**2. Market shocks**	**3. Policy shocks**	**4. Social shocks**
1. Drought	1. Lack of access to inputs	1. Land redistribution in the PA	1. Destruction or theft of assets, crops, livestock
2. Too much rain or flood	2. Large (unacceptable) increase in input prices	2. Resettlement / villagization	2. Crime resulting in death or disablement of HH members
3. Frosts or hailstorm	3. Large (unacceptable) decrease in output prices	3. Forced contributions or arbitrary taxation	3. Land or other asset Disputes
4. Pests or diseases for crops and livestock disease	4. Any other (Please specify)	4. Any other (Please specify)	4. Any other (Please specify)
5. Any other (Please specify)			

VII. Optional

7.0. Any other information; please give us any other information not included above that you are interested to talk about in relation to your daily farming activities:

____
____
____
____
____
____
____
____

Thank you very much for sharing your practical experiences with us!

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