ANALYSIS OF FARMER PREFERENCES FOR WHEAT VARIETY TRAITS IN ETHIOPIA: A GENDER-RESPONSIVE STUDY

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ABSTRACT

This study highlights gender differences in the Ethiopian wheat production system and determines trait preferences for different segments of the population. Surveys from 158 men and 147 women farmers were used to evaluate preferences for six traits of bread wheat: *number of productive tillers*; *density of kernels per spike*; *resistance to rust disease*; *size of grain*; *color of grain*; and *price in Ethiopian Birr per 100kg bag of seed*. A conjoint analysis of their responses to 18 trait combinations revealed that the number of tillers was the most important trait in the overall sample. However, cluster analysis revealed seven distinct respondent segments characterized by different trait preferences. Segment membership was weakly correlated with gender, socio-economic status, usage factors, and constraints to production. The methodology and results should be useful to breeders in evaluating trade-offs among various traits.

BIOGRAPHICAL SKETCH

Katherine M. Nelson earned her Bachelor of Arts degree in Sociology in 2002 from the University of Colorado in Boulder. In 2010 she joined the Masters of Science program at Cornell University in Crop and Soil Sciences.

While pursuing her degree, she worked as the teaching assistant for the Master of Professional Studies program in International Agriculture and Rural Development. She interned at the International Rice Research Institute in 2010 and is currently a full time agronomy extension employee.

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Katherine's master's thesis entitled "Analysis of farmer preferences for wheat variety traits in Ethiopia: A gender responsive study," was supervised by Dr. John Duxbury, Dr. Ronnie Coffman, and Dr. Sarah Davidson Evanega.

I hereby dedicate this thesis to my family. They have provided their unconditional love, support, knowledge, and encouragement throughout this journey.

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1. Introduction

Wheat is one of the world's most important staple food crops (Curtis, 2002). Wheat sustains millions of lives and livelihoods, accounting for one-fifth of humanity's food (CIMMYT, 2011). Wheat is under threat from virulent strains of the stem rust disease (Singh et al., 2008). Ethiopia is an ideal place to conduct wheat research because it is one of a few countries where the new strains of stem rust (frequently referred to as Ug99 rust races) have been found (Singh et al., 2006). Ethiopia is also one of the poorest nations and is most at risk of a food crisis if a stem rust epidemic were to occur (World Bank, 2012). Concerted efforts are being made to speed the breeding process so that susceptible wheat varieties can be replaced by resistant varieties in farmers' fields (DRRW, 2010), but adoption of new varieties is slow and sporadic (Bishaw, 2010). Using conjoint analysis methods, I examine farmer preferences for wheat variety traits to understand the factors that drive adoption of new varieties.

Millions of dollars (Gallo et al., 1996) and countless hours are spent each year in developed countries on understanding consumer demand and marketing for agricultural products but relatively fewer funds are funneled into agricultural marketing in a developing country context. Wheat is a highly varied product that is characterized by many stages of development that all have different traits. Breeding programs mainly focus on increasing yield, whereas traits like seed color, end-use quality, and biomass may also be important to farmers (Bishaw, 2010). I use a ratings-based conjoint analysis method (Green and Srinivasan, 1978) to understand and characterize groups of farmers that value different traits in wheat. The results presented in this paper will provide insights into the heterogeneity of wheat trait preferences among small-holder farmers from the Hetossa district in the central highlands of Ethiopia. This research shows the potential for using conjoint analysis to help guide plant breeding priorities in the development of farmer-responsive varieties (Baidu-Forson et al., 1997).

1.1 Global importance of wheat

Wheat (*Triticum spp.)* is one of the world's most important cereal grains. It is grown on 220 million hectares (Singh and Trethowan, 2007) constituting 15.4 percent of the world's arable land (more land area than any other crop) and it is grown in almost all countries and climates (FAOSTAT 2009; Curtis, 2002). It is the staple food for 4.5 billion people in over 94 developing countries worldwide (Braun et al., 2010). Wheat provides nearly 55 percent of carbohydrates and more than 20 percent of the calories and protein consumed globally (Bushuk, 1998). Wheat has the highest content of protein of all the staple foods and contains essential minerals, vitamins, and lipids. It is the primary source of protein in developing countries, with 1.2 billion people dependent on wheat for survival (CIMMYT, 2011). It has been projected that the demand for wheat in the developing world will increase 60 percent by 2050 (CIMMYT, 2011), which is a sobering forecast considering global wheat yields have remained constant for more than a decade. Millions of people's livelihoods in the developing world are, and will continue to be, threatened by insufficient wheat production coupled with climate-change induced yield reduction, global wheat price spikes, increasing costs of inputs, and virulent new strains of diseases and pests. And, while developing countries are at the greatest risk of food shortages, they also have the most potential for increased production.

Food security and wheat dependence

World wheat production increased dramatically from 1951-1990, mainly due to an increase in grain yield per hectare rather than an increase in production area (Curtis, 2002). Consumption worldwide has also increased rapidly since the early 1960's. Wheat consumption in developing countries rose 35 percent during the period 1963-1976 (Curtis, 2002). Due to the increases in wheat production from the high-yielding, disease resistant, semi-dwarf varieties of the Green Revolution, poverty and hunger were dramatically reduced. Gains in wheat production have since leveled off, and many developing countries still produce well below their potential. The world population growth rate from 1993 to 2000 was 1.5 percent, while the growth rate of wheat production from 1985 to 1995 was 0.9 percent (Curtis, 2002). In many countries in South East Asia and Sub-Saharan Africa, the population growth rate is significantly higher, between two to four percent. As population growth continues to surpass the growth of wheat production, there will be serious food shortages for future generations. In addition, where developing countries already lag in wheat production, climate-change scientists estimate increased temperatures that are likely to reduce wheat production by 20-30 percent (CIMMYT, 2011). Developing countries will suffer the greatest impact of climate change and food insecurity with a world population expected to reach 9 billion by the year 2050, or roughly a 35 percent increase. This population increase will mostly come from rapid growth of developing countries in tropical regions that even now cannot produce sufficient food.

1.2 Gender and development

A large majority of smallholder farmers and food producers in Asia and Africa are women (FAO, 1995). Smallholder farmers, especially poor women, will be at greatest risk of food insecurity and are extremely important to the future of food stability in developing nations (McCarney, 1991). Women in developing countries often have less access to resources and education, less decision-making power, and more responsibilities given their dual reproduction and production roles (BMGF, 2008). For these same reasons, it is critical to engage women in research agendas and to design for women when planning agricultural development projects. The importance of men, boys, and girls is not to be diminished by the inclusion of women but, rather, all members of the family unit, especially the most vulnerable, should be considered when designing innovative approaches to development challenges (BMGF, 2008). Improving equity for women must involve the inclusion of men or else development programs have the potential of exacerbating inequity and marginalizing women from their communities. And vice versa, development programs that do not engage women may result in interventions that create more work and burden on female family members (Feldstein, 1994). Designing projects to be gender-responsive and gender-sensitive is a more effective approach to livelihood improvement that extends beyond simply increasing yields to consider improved access to resources, decreased labor demands on women and girls, and better familial nutrition. Here, I use the definition of gender-sensitivity as "recognizing the differences, inequalities, and specific needs of women and men and acting on this awareness" (FMWC, 2002). Defining the term 'gender-responsive' is key to being able to understand and achieve the project design objectives. According to the FAO (1999), gender-responsive agricultural planning responds to the different priorities of diverse groups of farmers where these differences are based on gender and other socio-economic factors. Because women and men farmers have taken an active part in planning agricultural development activities the development planners are aware of these differences and of how best to respond to them. The process involves a commitment from both farmers and planners to carry-out the activities together (FAO, 1999).

The greatest potential for improvement of wheat production is in developing countries where mean yields are well below the global average (CIMMYT, 2011). Increasing production and decreasing losses through the adoption of high-yielding, disease-resistant varieties and improved management practices is key to stabilizing food security in developing countries. In order to design innovations and make recommendations for improved management practices, we must first understand local farming practices and gender roles in farming. These recommendations may then have the potential to increase the efficiency of current production practices while minimizing soil degradation, natural resource depletion, and labor demands (Feldstein & Jiggins, 1994).

Farmers grow varieties that are trusted in their area, perform well under their specific conditions and management, and satisfy their end-use needs (Pena et al., 2002). If a variety does not meet these criteria, a farmer is unlikely to adopt it (Negatu and Parikh, 1999; Dahl et al., 2001). The acceptability of a variety could vary significantly depending on the location of the farmer, socio-economic status, end-use goals, gender, etc. Therefore, it is unlikely that there is one "super" variety that all farmers will adopt (and this would be undesirable for plant breeders as well). The length of time for a variety to become "widely adopted" can take 15 to 20 years and few varieties ever get there (Ceccarelli, 2012). This could be partially attributed to a breeding process that does not account for usage versatility[1] or variety performance under suboptimal soil and management conditions, which are the reality for the vast majority of small-holder farmers.

[1]CIMMYT breeding programs test for quality based on protein levels usig the principle that higher protein results in higher loaf volume (Bushuk 1998). But there are many uses for wheat and large loaf volume is not always a desired characteristic (ie. flat breads, injera, etc).

Wheat breeding programs that target developing countries must consider the multiplicity of constraints and utilization so new varieties will meet the needs of more farmers.

1.3 Constraints to production – wheat rust diseases

Wheat plants are subject to a variety of biotic and abiotic stresses including: diseases (fungal, bacterial, and viral); pests (insects, weeds, nematodes, birds, and mammals); and environmental stresses including drought, flooding, extreme temperature, poor soil fertility (i.e. nutrient availability, pH, toxicity, and salinity). The fungal wheat rust diseases, leaf rust (*Puccinia recondita*), yellow/stripe rust (*Puccinia striiformis)* and stem rust (*Puccinia graminis tritici*), pose a serious and constant threat to wheat production and cause major annual losses around the world (Singh et al., 2006). Fields infected with rust disease produce millions of spores that are carried by wind to infect other fields. Rust diseases are difficult to control and breeding for rust resistant varieties proves to be the most effective measure of control. According to wheat rust expert Ravi Singh (2010), approximately 100 million hectares (almost half of global wheat production) are highly susceptible to leaf rust and yellow/stripe rust causing major annual losses during rust epidemics.

Yellow/stripe rust is the most widespread and common of the rust diseases. Crops infected with yellow rust can suffer yield losses between 10 to 70 percent depending on the susceptibility of the cultivar, earliness of the initial infection, rate of disease development and duration of the disease (Chen, 2005). The most lethal type of rust, however, is stem rust, which often causes 100 percent losses (Park et al., 2007). Even an epidemic of yellow/stripe rust would fail to destroy a crop with the same "killing power" of stem rust (Biffen, 1931). Stem rust was once the most feared disease of wheat because it could decimate a healthy looking crop just weeks before harvest leaving nothing but broken stems and shriveled grains. During the North American epidemic in 1953-54, up to 35 percent of the spring wheat crop and 80 percent of the durum wheat was lost from a stem rust outbreak (Stakman and Harrar, 1957). The near complete annihilation of durum wheat in two consecutive years demonstrated that stem rust could become pandemic in years when environmental conditions favor rust development and cultivars are susceptible (Stakman and Harrar, 1957). Soon after this epidemic, millions of dollars flooded into international wheat research to develop wheat varieties that were resistant to stem rust (Dubin and Brennan, 2009). This thrust of research resulted in the high-yielding, semi-dwarf, rust-resistant varieties of the Green Revolution that helped to increase yields and reduce global poverty and hunger in the 1960's. This stem rust resistance prevailed for 40 years (DRRW, 2010). The disease was thought to be eradicated which resulted in years of scientific complacency on stem rust research and a lack of funding for stem rust research during this time (McIntosh & Pretorius, 2011). But, as Norman Borlaug (2008) commented, stem rust never sleeps. A virulent new strain of stem rust disease appeared in Uganda in 1999 (Pretorius et al., 2000). This strain, aptly named Ug99, was able to infect previously resistant wheat varieties carrying the widely used stem rust resistance gene *Sr31*. By 2004 the fungus had spread to fields in Kenya and Ethiopia and was continuing to spread east, now reaching as far east as Iran and as far south as South Africa (Singh et al., 2011). Up to 90 percent of the world's commercial wheat varieties in production today are susceptible to the Ug99 lineage of stem rust and billions of people could suffer food shortages if another epidemic occurs (Singh et al., 2011).

1.4 Durable Rust Resistance in Wheat project

In 2008, the Bill & Melinda Gates Foundation awarded Cornell University a three year grant for the Durable Rust Resistance in Wheat (DRRW) project, and a five year grant was awarded in 2011. The objectives are to mitigate the threat of virulent stem rust races through pathogen surveillance activities and breeding initiatives so that susceptible varieties will be replaced with durably resistant wheat varieties (DRRW, 2010). The project is an international collaboration between 23 research institutions and scientists and farmers from over 40 countries. Wheat varieties that are developed under the project carry resistance for yellow rust and stem rust using traditional plant breeding techniques.

The goal of replacing susceptible varieties with durably resistant varieties will not be achieved simply through breeding efforts but must also include improvements to the current seed multiplication and dissemination pathways in developing countries. As with any product, it is important to understand the target market because farmer perceptions contribute heavily to the adoption of new varieties (Bishaw, 2010). It is common for farmers from developing countries to save seed and plant the same variety of wheat for more than 20 years because changing to a new variety may seem risky to them (Ceccarelli, 2012). Additionally, farmer management practices and end-uses may differ considerably within a small area or between socio-economic groups in the same area. Furthermore, different varieties will respond better in certain environments and the quality of a product depends heavily upon the characteristics of the variety. The adoption of new varieties of wheat depends on what farmers look for to satisfy their grain yield expectations, their quality needs, and the market demand (Pena, 2002).

There is considerable variation within wheat cultivars and the reason wheat is widely accepted throughout the world across different cultures is because of its agronomic adaptability, variability in end-use products, and storage capability. Given the wide-range of uses and growing conditions, recommendations for varieties should be context specific rather than one-size-fits-all solutions. It is imperative to understand local farming practices, constraints to production, and utilization to create varieties that are appropriate for the agronomic practices, environmental conditions, and end-use purposes of the target group.

1.5 Wheat adaptability and variability

Agronomic adaptability

Wheat has been cultivated for thousands of years and is widely claimed to be one of the key factors that enabled the emergence of city-based societies. People were able to settle due to its wide adaptability and the fact that wheat can be easily and safely stored for long periods of time. In addition, wheat requires minimal processing for consumption and is easily transported. Wheat can grow over a wide range of elevations, climatic conditions, and soil fertility conditions (Nuttonson, 1955). Wheat cultivation is most successful between the latitudes of 30° and 60°N and 27° and 40°S but it can be grown from the Arctic Circle to high elevations near the equator (up to 3000 masl) (Nuttonson, 1955). Even though the optimal growing temperature is 25°C, it can be grown in temperatures ranging from 3°C to 32°C (Briggle, 1980). The optimal rainfall for wheat is between 900-1100 mm throughout the growing season, but wheat can be grown in xerophytic to littoral moisture regimes with average annual rainfall between 250 to 1750 mm (Leonard and Martin, 1963).

Wild types, landraces, improved varieties, and certified seed are all grown in varied conditions and exhibit wide trait variations. Wheat can be classified as either winter wheat or spring wheat. Winter wheat is grown in temperate climates and requires a vernalization period where young plants remain dormant throughout the winter (0°-5°C) before flowering in the spring. Spring wheat is planted in the spring and generally matures by late summer, to early autumn. The length of time to maturity is wide, ranging from three months to possibly more than 8 months.

Variability in end-use quality

Wheat flour can be used to make many different types of products with a range of uses, textures, and flavors. Wheat is unique in its ability to form leavened bread due to the viscoelastic properties of gluten (Bushuk, 1998). The gluten helps to trap carbon dioxide into bubbles that are formed during fermentation, which in turn causes dough to rise. Many different products can be made from wheat flour including leavened breads, flat breads, pasta, cakes, cookies, crackers, and pastries. In addition, the grains can be eaten whole if boiled or roasted or mashed into porridge and they can be fermented to make alcohol. Other parts of the wheat plant are used as animal fodder, fuel for cooking, construction material for roofing thatch, bed stuffing, and other household utilities. Different varieties of wheat grain are characterized by varying levels of kernel hardness, protein content, and visco-elasticity that affect the quality of the end-use product (Pena, 2002). These large differences in grain composition and processing quality among wheat cultivars mean that one cultivar that is suitable to prepare one type of food may not be suitable to prepare a different one. For instance, very hard, light-colored, translucent grains are superior for making noodles, whereas dark, hard, high-protein wheat is best for making leavened bread products, and soft, light-colored, very low protein wheat is preferred for crackers and pastries (Pena, 2002). The type of cultivar has a strong influence on the characteristics, taste, and appearance of wheat products as well as the marketability of the grain (Pena, 2002).

Wheat breeding programs tend to focus on increasing yields, often at the expense of other valued traits (Araus et al., 2008). Smallholder farmers in developing countries use wheat for many purposes and their preferences for traits may differ depending on the end-use. It is common for a smallholder farmer to grow several varieties of wheat for different purposes (Di Falco et al., 2006). They may grow one variety that is low yielding and susceptible to lodging, because the bread quality is excellent and the lengthy stalks are superior for use as roofing material. Another variety may be high-yielding but mediocre quality that they sell as a cash crop and yet another variety that is highly susceptible to disease but has large grains ideal for making a traditional dish. It is important that plant breeders understand the complex trade-offs that farmers make among traits. This will provide insight into traits that may be valued by farmers so these traits can then be promoted to the next generation during the breeding process.

1.6 Ethiopia

Ethiopia is considered one of the world's poorest countries ranking 169th out of 181 countries (World Bank, 2012). Its economy is heavily reliant on agriculture, which results in severe food shortages during crop disease outbreaks and periods of severe drought. The majority of Ethiopian farmers are resource-poor, small-holder farmers that depend on staple crops for subsistence and as a source of income when they have a marketable surplus. Ethiopia ranks second in sub-Saharan Africa in total wheat area and production. The Ethiopian highlands are considered a center of diversity for wheat and it has been cultivated in this region for several millennia with little change in farm implements and farming practices among small-holder farmers. Wheat is mainly cultivated in the southeastern, central, and northwestern highlands at altitudes ranging from 1500-2800masl primarily under rain-fed conditions.

Wheat is one of the most important cereal crops cultivated in the country (Bayeh, 2010). Wheat production ranks fourth in area coverage surpassed only by Teff (*Eragrostis tef*), Maize (*Zea mays*), and Sorghum (*Sorghum bicolor*) and it is the third largest crop in total production (CSA, 2011). The national average of wheat production is 1.74 t/ha (CSA, 2011) which is 24% of the African average and 58% of the global average (FAO, 2009). The relatively low mean yield may be partially attributed to the low level of adoption of improved varieties and improved management techniques (Kotu et al., 2000). Ethiopia imports more wheat than any other crop at 1.74 million tons annually (FAOSTAT, 2009) and consumption is increasing much faster than production with an annual population growth rate of three percent (CIA World Factbook, 2012). Ethiopian farmers have little capacity to rebound from unpredictable events such as the prolonged droughts of 2011, or the yellow rust epidemic of 2010. Increasing wheat production is important to the economic stability and food security of Ethiopia.

There are three broad categories of wheat producers in Ethiopia: 1) small-scale farmers, 2) state farms, and 3) producer cooperatives. Small-scale farmers are responsible for 76 percent of total wheat production (Bayene, 1989). They comprise the largest wheat area, have the lowest yields and have the least capacity to withstand unexpected events.

Constraints to production in Ethiopia

Ethiopian farmers face a number of constraints to production including biotic and abiotic stresses. These constraints differ depending on the area but farmers may face drought, flooding, poor soil conditions, severe weed competition, and the infestation of diseases and pests. In addition to these agro-ecological constraints, small-holder farmers lack access to modern equipment, sources for improved seed, and affordable inputs.

Of the biotic factors, the most detrimental are the wheat rust diseases, particularly yellow/stripe rust and stem rust. Less than ten percent of wheat currently grown in Ethiopia is resistant to yellow/stripe or stem rust, therefore, the adaptation and adoption of new wheat varieties is crucial to the future of food security in Ethiopia (Singh et al., 2006). Average losses to yellow rust amount to approximately 20 percent and, during an epidemic year, such as 2010, losses can amount to 70-80 percent in untreated or late-treated fields (personal communication with Bedada Girma, Principal Scientist for DRRW project in Ethiopia, June 2011). The epidemic in 2010 can be attributed to favorable climatic conditions that allowed for early infection and sustained the disease throughout the growing season. Farmers were not prepared for the infestation and there were limited supplies of fungicide to combat the disease. Farmers experienced significant crop losses and subsequent loss of household food and income (ICARDA, 2011).

In addition to yellow rust, the ability of Ethiopian farmers to meet current and future demands for wheat production is threatened by the virulent Ug99 stem rust lineage. This strain of stem rust was first found in Ethiopia in 2004. The majority of bread wheat varieties grown in Ethiopia are susceptible to the Ug99 strain of stem rust and small-scale farmers do not have the ability to combat a stem rust outbreak with fungicides alone, as proven by the yellow rust epidemic. Fungicide is expensive and there is not enough supply in Ethiopia for farmers to have access to apply in a timely manner. The effect of stem rust is far more destructive than yellow rust. Genetic resistance is the safest and best control strategy for resource-poor farmers in addition to being the most environmentally friendly and profitable option for farmers that can multiply seed (DRRW, 2010). In Ethiopia, the cost to treat one hectare with fungicide ranges from $30-$80 USD annually (personal communication with farmers, June 2011) whereas rust-resistant varieties have little additional cost and may be more profitable for farmers.[2] In addition, the rust-resistant varieties will protect crops from both yellow/stripe rust and stem rust throughout the growing period. Even in the absence of a stem rust outbreak, farmers should see an average yield increase of around 20 percent from protection against typical yellow rust occurrence.

Since the appearance of Ug99, the Ethiopian Crop Variety Register has released approximately 28 resistant varieties but only a few rust-resistant wheat varieties are being planted by a small percentage of farmers (DRRW, 2010). Ethiopia releases more varieties of wheat each year than most other African nations, yet new varieties are seldom adopted (Mekbib, 1997; Bishaw, 2004). Although many varieties of improved seed have been released in Ethiopia, the average use of rust-resistant wheat seed is only about four percent (CSA, 2008). Many more farmers will need to adopt rust-resistant varieties in order to withstand future rust outbreaks in Ethiopia. One variety, Digelu, accounts for about half of the resistant seed that is grown in Ethiopia and another four varieties account for the other 50 percent (DRRW, 2010). Many rust-resistant varieties are released that are never adopted because there is no demand for them, while a few rust-resistant varieties are in high demand but cannot be multiplied and disseminated efficiently by the current seed production system. The low adoption rates can be attributed to many factors including the inefficient seed production and delivery system, a shortage of farmer acceptable varieties, and the lack of a system for raising awareness about the existence and benefits of new varieties.

[2] The initial cost of the seed may be up to $11-$12/100kg higher than the cost of non-resistant seed depending on the market demand. However, this is not an annual expense because farmers can save seed from year to year and make a significant profit by selling rust-resistant seed to other farmers at a higher price (100kg of new seed would yield 30-45 times that amount), however, access to this seed is severely limited by the complex distribution system.

Many studies have looked at seed production issues and seed sources (Bishaw, 2010; Ensermu et al. 1998; Negatu & Parikh, 1999; Kotu et al., 2000; Negatu, Mwangi and Tesemma, 1992; Alemayehu, 1999; Agidie et al., 2000) but relatively little research exists on farmer acceptability of new varieties. In order to be acceptable, the varieties must be agronomically suitable, marketable, and appropriate for quality and usage needs. In the past, wheat breeding programs focused primarily on increasing grain yield, possibly at the expense of other traits that may be important to farmers (i.e. protein amount, grain color, or plant biomass for animal fodder, roofing material, etc.). There is increasing recognition within breeding programs of the importance of gender differences in farmer preference, although relatively little research exists in this area (CIMMYT, 2010). This is the motivation to conduct a study to understand men's and women's preferences for different wheat traits and the inherent trade-offs that farmer's make among individual traits in their decision to grow a new variety.

Influence of gender on adoption

Since 1961, the increased opportunity cost of women's time in sub-Saharan Africa (SSA) has led to a 167 percent increase in consumption of easy-to-prepare staples such as wheat (Kennedy and Reardon, 1994). Yet the much smaller increase in grain production over the same period required imports to meet demand. There is significant potential to increase production on small-scale farms with improved technology such as disease resistant varieties, soil fertility management, and weed control. But, without addressing gender specific constraints and preferences, the full potential may never be reached (Klawitter et al., 2009).

Gender is thought to influence varietal acceptance (Klawitter et al., 2009), and therefore it is critical to analyze men's and women's perceived values of both pre- and post-harvest traits in wheat varieties. Post-harvest and cooking characteristics are rarely evaluated in breeding projects even though they are known to be important to women. A recent study by Sperling (2010) notes that in order to reach women and the poor with plant breeding projects, an emphasis is needed on the performance of cultivars in intercropped systems, the importance of end-use products as food for humans and fodder for animals, the earliness of production, labor demand characteristics, post-harvest processing concerns, and culinary dimensions.

Ethiopian women do not have equal access to land, credit, agricultural resources, technology, or agricultural extension services (Frank 1999). This disparity hinders women's ability to benefit equally from farming activities. Furthermore, although women have an active role in wheat production and processing, they are often not considered "farmers" within cultural perceptions and the social framework in Ethiopia (Frank, 1999). It should be noted that concerted efforts have been made in the past decade to focus policy more on gender within the agricultural system, but access to resources and participation in extension activities still remain a major constraint to gender equity. Despite the large contribution to farming activities by women, many communities still do not consider women to be farmers (Frank 1999). Rural communities define the term "farmer" as someone who can independently perform the activities of plowing and sowing. Although women participate in many physically demanding activities, plowing is considered to be a man's activity that is too difficult and inappropriate for women. The ownership of oxen, for example, is considered essential to farm effectively and women rarely own the oxen and do not have the same access to other agricultural resources. Even in circumstances where they do own oxen (i.e. if their husband died), it is not culturally acceptable for them to engage in plowing activities. Therefore, women are not considered to be farmers or at best are thought of as weak farmers. In rare circumstances, female heads of households have been known to plow their fields so perhaps the perceived inability of women to plow is based more on cultural perception than on actual physical inability. The cultural expectation that women cannot or should not plow could be seen as a measure to limit women's control of assets. According to Masefield (1998), male farmers refuse to consider women as farmers because men feel that if women were provided the same access to land and other resources as male-headed households, they would then engage in repeated marriages without care and the entire socio-economic fabric of society would be destroyed.

Women also have less ability to purchase inputs and improved seed because they do not have control over assets such as land and oxen to serve as collateral for credit. The effect of this disparity on adoption of agricultural technologies is evident in the central highlands of Ethiopia where 30 percent of male-headed households (MHH) adopted improved varieties compared to only 14 percent of female-headed households (FHH) (Tiruneh et al., 2001).

Women (both as farmers and development agents) are underrepresented in the current agricultural extension system in Ethiopia. When women farmers are included in extension activities, they are mostly female head of household (FHH). Although it is important to include women from FHH, a comparison of only FHH and MHH provides limited insights about broader gender structures because it ignores the majority of women that live and farm in MHH (Doss, 1999). The current extension system rarely targets women in MHH although these women often participate equally in wheat farming activities and decision-making processes. In fact, when the entire wheat production process is analyzed, women may even contribute more to wheat production than men. This is due to the sole involvement of women in most post-harvest activities, such as processing for food preparation and seed cleaning, in addition to their involvement in wheat farming activities. Also, women from both FHH and MHH may face different constraints due to differences in the *household's* access to resources. For instance, women from FHH may have more decision-making power than women in MHH, but less access to land as collateral, resulting in lower comparable *household* access to credit and inputs than the female members in a MHH.

Because gender is thought to be an important factor affecting the perceptions of wheat traits and subsequent adoption of wheat varieties, examining only the gender of the head of household summarizes just one component of the many gender-linked barriers to technology adoption (Doss, 1999). Men and women often have different responsibilities in regards to farming, family nutrition, and off-farm income, which may result in differing preferences for traits in wheat varieties. The end-use purpose of the crop may also influence varietal trait preference. For these reasons, it is important to examine not only the gender of farmers but also management and usage factors.

Gender in development

The length of time from developing and releasing a variety to wide-scale adoption of a variety averages 15 to 20 years but this timeframe can be reduced through participatory breeding measures, varietal selection, and gender analysis (Lilja and Dixon 2008). Agricultural initiatives aimed at the adoption of improved varieties can be more targeted and responsive to the needs of women by understanding their preferences and constraints, thereby creating demand-based products that suit the needs of the target audience to improve variety adoption and wheat yields. The documentation of men's and women's preferences enables breeders to set priorities that incorporate gender preferences and usage criteria into their breeding process. The result of such breeding measures should produce varieties that can be targeted to specific segments of the population such as subsistence farmers, women farmers, or market-oriented farmers.

1.7 Objectives

The main objectives were to understand gender roles in wheat production in the central highlands of Ethiopia, to define important pre- and post-harvest characteristics of wheat (both negative and positive), to calculate the weighted preference that men and women farmers have for specific traits, and to characterize membership in preference segments based on similar demographic and management statistics. All of this information in combination may be useful in understanding the factors that influence the adoption of new wheat varieties. The research was carried out in collaboration with the Durable Rust Resistance in Wheat (DRRW) project, the Ethiopian Institute of Agricultural Research (EIAR), and the Kulumsa Agricultural Research Center (KARC). The study uses focus group discussions and semi-structured interviews to inform the field survey questions and the conjoint analysis survey.

The specific objectives were to:

- Understand the roles of men and women in all stages of wheat production including the decision-process of growing a new variety, purchasing/trading/recycling varieties, seed preparation, land preparation, planting, weeding, harvesting, threshing, processing, storing seed, transporting, and selling;
- Ask farmers to score familiar varieties based on their opinion of how well they perform in the different stages of production;
- Identify subjective properties of wheat quality during different bread processing stages (milling, kneading, leavening, cooking) that are perceived as positive or negative and why;
- Document farmer perception of a combination of wheat traits to determine the individual value that each trait has on the product as a whole;

- Identify segments of farmers that have similar preferences;
- Categorize membership in the preference segments based on demographic and management information;

Without research to understand farmer preferences, it is possible that new varieties of wheat may not meet farmer standards and adoption rates will remain low. As a result, wheat yields will continue to produce well below their potential and food security in Ethiopia will continue to be an issue.

2. Materials and methods

2.1 Gender-responsive study design

Many Ethiopian farmers will simultaneously grow several varieties for different purposes (cash crop vs. household consumption for specific traditional dishes vs. roofing material). It is necessary to include women (both HH and not) in preference studies because the differences in household activities and utilities may lead to important insights about the perceptions of wheat traits related to gender, utility, socio-economic status, decision-making authority, and constraints. Therefore, it is important to implement gender-responsive research designs to understand these factors.

Training on gender-sensitive research

The first step in planning this research was to conduct a training program on gender-sensitive research practices for the researchers at the Kulumsa Agricultural Research Center (KARC). Yeshi Chiche, the gender specialist from the Ethiopian Institute of Agricultural Research (EIAR), conducted a three-day workshop at KARC from March 28-29, 2011. Participants of the workshop included 11 researchers from KARC: wheat breeders, agronomists, soil/water scientists and socio-economists; and 14 agricultural extension agents from the Ministry of Agriculture (MOA) in Hetossa and Tiyo woredas (districts). The objective of the training was to equip participants with knowledge and tools in gender analysis. Gender analysis is defined as examining the differences in women's and men's lives, including those which lead to social and economic inequality for women, with the view of applying this understanding to policy development in order to address inequalities and power differences between males and females (CRS, 2010).

The major areas of training were:

- Concepts of gender
- Relevance of gender to agricultural research
- Gender as a development component
- Methods of gender analysis and participatory data collection
- Gender-sensitive research design

The participants came away with a core understanding of terminology and gender related issues. They learned practical methods to perform gender analysis relating to agriculture and the household economy. Several activities were initiated to raise awareness about gender issues and dynamics. Participants introduced themselves using symbolic illustration to understand how men and women view themselves based on cultural influences. These descriptions were then used as an example of how societal expectations contribute to norms, values, and cultural influences and how these can change over time or under different socio-economic circumstances. The participants had an opportunity to learn from each other through examples that were grounded in personal experiences. A main component of the training involved field-simulated problem solving based on realistic examples. Participants brainstormed solutions for contexts they might face while conducting the gender research for the DRRW project. A PowerPoint presentation, prepared in English, was used for defining concepts, while the local language (Amharic) was used for explanation and discussion. Exercises included brainstorming sessions, household mapping exercises, and time allocation charts. Some factors that influenced the particular approach used included the short duration of the training and limited prior knowledge of gender concepts and gender analysis tools.

Study design

In designing a gender-responsive study, it is critical to recognize the social and cultural constraints faced by women so the study can accommodate their schedules and address any limitations on their time. Several studies have shown that the adoption of improved technologies and participation in extension activities can have a negative impact on women's labor demands (Doss, 1999; Tiruneh et al., 2001). This is not a reason to stop including women in extension activities but, rather, it is proof that simply including women is not equivalent to designing agricultural innovations and interventions *for* women with their needs and labor demands in mind.

Women have valuable and varied perceptions of wheat production and processing based on their roles and responsibilities in wheat farming and cooking. The results of a perception study would be incomplete without the perspective of women. They contribute to decision-making processes and influence the household choices of which varieties to grow. Highlighting the preferences of both men and women (from FHH and MHH) will provide better insight into the development of acceptable varieties.

Due to the perception of wheat as a cash crop it is typically thought that women in Ethiopia play a minor role in wheat production, but women are in fact closely involved in almost every step. In the design of the gender-responsive study of wheat trait preferences, we conducted in-depth interviews, focus group discussions, and surveys with women and men farmers. These discussions were used to characterize and partition their activities allocated to the wheat farming enterprise, to understand how men's and women's respective relationships to production and assets affect pre- and post-harvest preferences for various traits in wheat, and to understand the value of individual wheat traits in farmer decision making processes.

In considering women's time, labor, and cultural constraints during the design of the study, the following guidelines were instituted:

1) Schedule interviews with women and men on separate days or time frames;
2) Invite women to bring their children;
3) Arrange activities in the morning when women were relatively less busy;
4) Schedule meeting locations that were convenient for respondents;
5) Include both female head of households and women in male headed homes;
6) Whenever possible, use women researchers to interview women farmers but when this is not possible, use men researchers who have been trained in gender-sensitive research practices

All participants in the conjoint study were compensated for their time and information at 105ETB ($6 USD). We felt it important to compensate respondents to show that we value their knowledge, perspective, time, and cooperation. The amount of compensation was recommended by Dr. Bedada Girma, principal scientist for the DRRW project in Ethiopia.

It is important to establish separate interview times for men and women because often when they are interviewed during the same time, men will directly answer for women or influence their answers. Since many of the questions pertain to the respondent's perception of a variety, it is critical that the respondent be able to answer based on their own preferences and not be influenced by others. When women are interviewed separately from men, they are able to speak openly about their opinions and roles in decision-making processes and farming activities. Interviewing men and women separately also gave women full control over their compensation. If they were interviewed with male family members, they may not have been able to keep the payment for their services.

During our initial planning of the research activities, it became evident that the most convenient time to interview women was during the morning so they could attend to their daily activities in the afternoon. For this reason, we scheduled morning meetings with women farmers so as to have the least impact on their schedules. In a few circumstances, the women were only available in the afternoon so we rearranged the schedule to fit their time.

In addition, we tried to reduce the travel time for women and men by arranging several locations within one village where we conducted interviews so that we reduced bias of including only farmers that were located close to the agricultural extension station. This also allowed us to travel to areas where women were already gathered for other purposes (i.e. training) so we did not add burden to them.

The purpose for employing both qualitative and quantitative research methods was to gain a better understanding of the context of Ethiopian wheat farmers and gender-roles through structured and unstructured methods of inquiry, and to be able to create preference models that help explain and predict farmer behavior so this information can be used to inform breeding criteria and variety release procedures. Qualitative interviews and focus group discussions allowed for the potential of many new and interesting directions of inquiry to arise that would be lost in the confines of a highly structured survey alone. Given that this research was positioned as gender-responsive, it was important to include women in all phases of inquiry and document their preferences for agronomic and quality traits as well as the perspectives that women hold on their ability to make decisions, and an understanding of their situation from their point of view.

The study consisted of two periods of data collection. Forty men and women farmers were surveyed on their perception of current varieties during a six week period from May to June 2011. Out of this group, 23 farmers participated in open-ended interviews about gender roles. The second period of data collection occurred during a six week period from December 2011 to January 2012 where 305 farmers were surveyed using conjoint analysis techniques (Green & Srinivasan, 1978).

The first period of data collection from May to June 2011 was conducted just before the wheat planting season. Four major wheat growing districts (woredas) were selected from the Arsi zone of the Oromia region (see Figure 1 for a map). This region was chosen because it is a main wheat growing region in Ethiopia characterized by a range of different agro-ecological conditions within a short distance. In addition, there are several national agricultural centers in the area that specialize in wheat production and collaborate with the DRRW project.

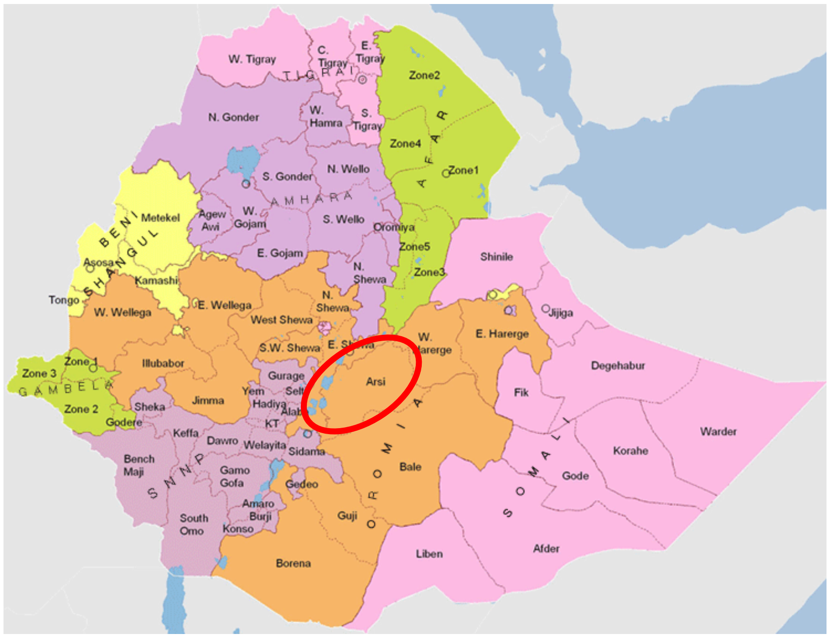

Figure 1 Map of Ethiopia highlighting the study area in the Arsi zone, a major wheat growing district in the Oromia region

2.2 Focus group discussions

Focus group discussions are a semi-structured method of qualitative data collection in which a purposively selected group of participants gather to discuss their opinion or perception on a topic or product that is presented by the researcher (Kumar, 1987). This method is often used in market research to evaluate consumer perception of a product before it is released. These discussions take advantage of the dynamic interaction between members in a group setting to generate insights and information that would be less accessible without the group interaction. Focus group discussions were used to identify wheat quality characteristics for food preparation including milling, flour, dough, leavening, cooking, taste, and storage quality.

I conducted two sessions of focus group discussions on wheat quality characteristics. During the first session, eight women from Hetossa district gathered in a local home and were asked to descriptively evaluate seven different wheat samples from the milling stage through to the quality of the bread. The samples included three distinct varieties – Kubsa, Millennium, and Huluko – and four mixed flours from two different mills – the 'First' and 'Third' grade flour from Asela mill and 'Special' and 'Abroad' flour from Gonde mill. The mill flours were a mixture of 'soft white' and 'hard red' wheat varieties that were combined to make an all-purpose flour. Each sample name or variety was undisclosed and labeled only with a number so the participants were not aware of the particular varieties or mixed flours that we were asking them to evaluate. It was important that the samples remain anonymous throughout the exercise as people's perceptions of a product are influenced by many factors that may not be intrinsic characteristics of the product but instead could be influenced by reputation, marketing, price, or physical appearance, none of which may actually be attributable to the superior quality of the product.

The women were asked to describe the milling quality based on the color and vitreousness (kernel hardness) of the grain, and the flour volume per unit of grain. The next group discussion involved transferring 200 grams of flour from each sample into separate mixing bowls and the women evaluated the flour based on color, texture, smell, and perceived protein content (higher or lower relative to each other). Then the women mixed water and yeast with the flour and hand kneaded while assessing the quality of dough in relation to the water absorption capacity, elasticity, stickiness, texture, color, and leavening. The dough was allowed to rise for three hours before it was wrapped in banana leaves, and baked in the traditional Ethiopian style on a clay plate over an open fire to make a local bread called 'diffo dabo'. Finally, the women evaluated the bread quality based on the traits of color, weight, texture, pore size, leavening, hardness, crumbliness, smell, and taste.

Some factors that influenced the study included language barriers in translating descriptive words (some description may have been lost in translation if words did not exist in one language or could not be translated into English). Additionally, the samples being compared were not equivalent because the single distinct varieties were milled with their bran on and the milled samples had the bran removed and were a mix of hard and soft wheat. So, there were many variables that could affect preference. I accounted for the latter problem during the second session by minimizing the number of variables so the varieties being compared were all distinct single varieties that were treated the same from grain to milling to bread.

The second session of focus group discussions took place at the kitchen of the Kulumsa Agricultural Research Center with nine women and three men. Four of the women were cooks in the kitchen and the other five women worked at the research station as accountants, agronomists, and seed specialists. The three men were wheat research scientists at the station. Five distinct varieties were evaluated during this session: Kakaba, Hogana, Pavon 76, Huluko, and Digelu. All of these variety samples were prepared in the traditional home-style (as opposed to purchasing mixed flour from a mill). The grain was soaked in water for several hours and then sun dried for two days. The dried grains were then placed in a large wooden mortar and pestle and pounded for 20-30 minutes to remove the germ. Then the women winnowed the grain to separate the removed germ from the rest of the grain. The samples were then individually milled at a local mill. Once milled, the participants mixed the flour with water and yeast to make dough. The dough was kneaded by hand and then left for three hours to leaven before cooking in an oven. The process of evaluating the flour, dough, and bread was the same for both focus groups.

2.3 Perceptions and evaluations of existing varieties

Agricultural marketing strategies are used to move food along the value chain from the farm to the consumer. These techniques are heavily employed in countries where most consumers purchase food in supermarkets (i.e., are not the producers of their own food). The market, thus, responds to consumer preference for products and willingness-to-pay. In a developing country context, the producers are often also the consumers. When studying the appropriateness of varieties to meet farmer and consumer needs, these marketing techniques can be adapted to a developing country context (Baidu-Forson, 1997). Understanding where existing products are positioned within the market allows for researchers to see where gaps may exist. These gaps represent the potential for new product development to meet consumer needs. Many varieties of wheat are currently available in Ethiopia and they may suit different agronomic and culinary purposes. Ethiopian wheat farmers sell wheat as a cash crop but they are also consumers and purchasers of wheat so it is important to understand their perceptions of the many varieties available.

Many products can be made from wheat flour including flat breads, leavened breads, crackers, cakes, cookies, pastries, and pasta. Wheat grains can be boiled, mashed, or roasted and wheat can also be fermented to make beer. Ethiopians use wheat for a variety of dishes and they also mix wheat flour with teff, sorghum, and barley flour to make injera (a national dish resembling a large, thin, pancake). Different varieties of wheat are characterized by varying levels of vitreousness, protein content, and elasticity that affect the quality of the end-use product (Pena, 2002). These large differences in grain composition and processing quality among wheat cultivars mean that one cultivar that is suitable to prepare one type of food may not be suitable to prepare a different one. For instance, very hard, light-colored, translucent grains are superior for making noodles, whereas dark, hard, high-protein wheat is best for making leavened bread products, and soft, light-colored, very low protein wheat is preferred for crackers and pastries (Pena, 2002). Ethiopians value different qualities of wheat flour depending on its purpose. If they are making leavened bread, they want strong elasticity in the dough, a good rise, and a shelf life of several days while still remaining soft, whereas, if they are making injera, they want a fermented thin batter that cooks into a flat, elastic pancake-like product that stays fresh for a week or more without refrigeration. Grain quality is an important factor in the acceptability of taste and appearance of wheat products as well as in marketability for small-scale farmers growing wheat as a cash crop. Adoption of new varieties of wheat depends on what farmers look for to satisfy both their grain yield expectations and their end-use quality needs.

The data were gathered over a six week period from May to June, 2011. I worked with two research assistants, one woman and one man, from the Kulumsa Agricultural Research Center who acted as enumerators and translators during the interviews. Four districts in the Oromia region of Ethiopia were selected based on different agro-ecological zones and their wide-ranging access to markets. Forty farmers, including 18 men and 12 women, were interviewed from the following four districts: 1) Digelu Tijo, 2) Hetossa, 3) Dodota, and 4) Munessa (see Table 1 for agro-ecological information). The districts are characterized by different soil types and length of growing period.

Table 1 Agro-ecological information from the four surveyed districts

District	Altitude range (meters above sea level)	Mean Annual Rainfall	Characteristics
Digelu Tijo	2500-3560 masl	1000-1200mm	High-altitude waterlogged soils
Hetossa	2000-2500 masl	800-850mm	Mid-altitude rust-susceptible
Dodota	1500-2000 masl	500-800mm	Low-altitude drought-prone area
Munessa	2200-3300 masl	1000-1200mm	High-altitude with limited access to commercial markets

Source: CSA, 2008.

The respondents were purposively chosen based on size of land holding, socio-economic status, and gender. Since it was a small sample size, this sampling procedure was appropriate because it helps to maximize the range of respondents within these zones. Ten wheat producing farmers were selected from each district to participate in individual interviews that lasted approximately two hours each. I selected farmers from three different wealth categories: less than one hectare of land; one to three hectares; and more than three hectares. I interviewed female and male heads of households as well as women in male headed households.

Farmers were asked several demographic questions including their age, family size, size of land farmed, amount of land allocated to wheat production, yield of wheat, frequency of renewing seed, and amount of seed for home consumption and sale (see Appendix 1 for the survey). They were also asked to talk about the varieties of wheat they currently grow and constraints to production including losses from rust disease and access to fungicide and rust-resistant wheat seed. They discussed the decision-making process in planting new varieties and the sources and cost of improved and local wheat varieties. Then respondents were provided a list of local and improved varieties and asked to rate their desire to grow these varieties the next season on a scale of one to five (one being “they would not grow the variety under any circumstances” and five being “they would definitely like to grow the variety”).

The interviews were used to identify the determinant wheat variety traits that influence a farmer’s decision to grow a wheat variety. Farmers were asked to evaluate two to three varieties that they had ranked as ‘familiar’ or ‘very familiar’ and rate each variety based on 36 trait characteristics (Table 2). They rated the performance of the variety on a scale of one to five (one meaning the term ‘does not describe the variety very well’ and five meaning the term “describes the variety very well”).

Table 2 Farmers evaluated familiar wheat varieties on 36 trait characteristics

Has excellent early vigor	Presents a low amount of risk to me
Is competitive against weeds	Seed is readily available when I need it
Is drought tolerant	Price of seed is a good value
Is tolerant to wheat rusts	Has large grain size (TKW – Thousand Kernel Weight)
Is tolerant to water-logging	Grain color is excellent for market sale
Is resistant to lodging / The stalk is strong	Has a high flour volume per unit of grain (test weight)
Matures at the right time for my region and my needs	Has excellent baking quality for dabo
Is the appropriate height for my needs (I am satisfied with the amount of straw residue)	Excellent water absorption of flour
Is easy to harvest and bundle	Dough has excellent elasticity
Does not shatter easily	Has a good ‘eye’ size for preparing injera
Is easy to thresh	Excellent malting quality
Stores well over time	Color is good for making tala
Has high yields	Makes soft dabo
Has long spikes	The color of dabo is excellent
Has a high density of kernels per head	The color of injera is excellent
Responds well with low fertilizer rates	Has good quality straw for animal feed
Has consistent yields year after year	Is resistant to pre-harvest sprouting
Is trusted by other farmers in my area	Has high tillering capacity

The scores of the 36 traits were subjected to a factor analysis procedure in the statistical program JMP 9.0 using the principal components method. This technique is used to analyze the correlation between traits to determine whether a smaller number of factors could explain most of the variability within the 36 traits. Based on the scree plot test (Cattell, 1966) to drop components where the elbow turns in the curve (see Figure 2), and the Kaiser criterion (Bandalos, 2009) to drop components with eigenvalues under 1.0 (see Figure 3), the thirty eight traits could be grouped into five (Cattell) or four (Kaiser) factors. Four factors were ultimately chosen because the group of four factors was more logical since only one trait, length of spike, separates into the fifth group and it accounts for only five percent of the total variability.

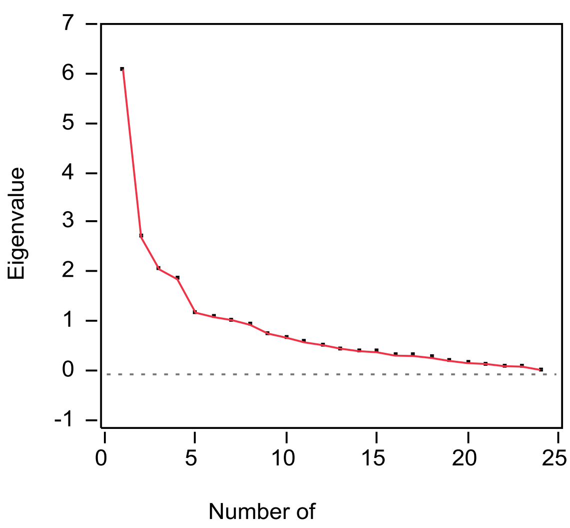

Figure 3 The Cattell scree plot test recommends to drop the components where the elbow turns in the curve

Number	Eigenvalue
1	5.8023
2	2.3396
3	1.6946
4	1.4425
5	0.7556
6	0.6785
7	0.6674
8	0.5274
9	0.3233
10	0.2944
11	0.2312
12	0.1628
13	0.1241
14	0.0375
15	-0.0156
16	-0.0433
17	-0.0746
18	-0.0853
19	-0.1258
20	-0.1553
21	-0.1854
22	-0.2204
23	-0.2568
24	-0.2836

Figure 2 The Kaiser criterion suggests dropping all factors with eigenvalues less than one

The results of the factor analysis are described in more detail below but it is necessary to note here that the traits were grouped into four independent categories according to four unobserved factors interpreted as: 1) Quality traits, 2) Agronomic yield related traits, 3) Disease resistance, and 4) Harvest/storage traits. Factor one explained 42 percent of the variance, and factors two and three explained 24 percent and 19 percent respectively. Six traits represent 85 percent of the variation and have the highest factor loadings in the Agronomic, Disease resistance, and Quality factors. The following six traits that were derived from the factor analysis procedure were used to develop the hypothetical varieties represented in the conjoint survey:

1) Number of productive tillers per plant
2) Density of kernels per spike
3) Size of grain
4) Disease resistance
5) Grain color
6) Price of seed

It should also be noted that traits that involve organoleptic evaluation, such as taste or smell, cannot be effectively assessed using the conjoint analysis technique because respondents would be required to evaluate more combinations than their senses can handle (Bakken et al., 2006). There are other types of subjective tests that can account for quality preferences using organoleptic evaluation but these are beyond the scope of this research. This is an area for further research that, when used in combination with the results of this conjoint analysis paper, would yield both the *expected* quality (visual cues) and *experienced* quality (organoleptic evaluation) of wheat traits. As a continued area of research, a comparison of how the taste experience measures up to the visual cues determining quality could provide interesting gender differences based on the roles of men and women in the household.

2.4 Gender-roles

Sixteen males and seven female farmers from the four districts previously mentioned were interviewed and asked to report on gender roles in wheat production. The respondents were asked to describe how various wheat farming activities were carried out and discuss their role in more than twenty different production, processing, preparation, and market-oriented tasks. The questionnaire listed the various tasks that are commonly thought to contribute to wheat production. We quickly learned during the interviews that the tasks are not as discrete as they may seem and further discussion into the roles was necessary. These led to more open ended interviews where the respondents discussed their individual tasks and new insights developed that led to further questioning.

Twenty three farmers, a sub-sample out of the total 40, were interviewed. The full sample was not needed to gather more information because we reached 'saturation of information' which is considered satisfactory for determining sample size in qualitative studies (Mason, 2010). Saturation is when the collection of new data does not shed any further light on the issue under investigation (Glaser et al., 1967). This is not to say that we have exhausted all inquiry or that we can generalize our findings to the entire population of Ethiopian farmers. Rather, for the purposes of this study, we were satisfied with the extent of information gathered from the 23 farmers.

In addition to wheat production roles, the farmers were asked to talk about decision making processes such as how they choose which crops and varieties to grow. The interviews inquired about intra-household bargaining and whether decisions are determined jointly by the household or solely by the head of household. Furthermore, respondents discussed women's participation in selling crops in the market and control over assets such as the sale of baskets, cooking equipment, homemade beverages, etc. The results of these discussions brought to light the complex roles of men and women in wheat production.

The data from the interviews were used to inform the quantitative survey and to provide a better understanding of the context of Ethiopian farmers. The data were descriptive and were used to support any theory that comes from the quantitative surveys.

2.5 Conjoint analysis study

The conjoint analysis technique was chosen for this research because it relies on the premise that a person's valuation of a product is based on the utility derived from the many attributes that comprise the product as a whole (Baker, 1998). Conjoint analysis is a statistical technique used in market research to estimate individual preference models based on how people value different traits that make up a product. This is an ideal technique to use in the case of Ethiopian wheat farmers because often when people are so familiar with an activity or object, they have a difficult time describing what they like about it or why they like it. In a conjoint analysis design, a controlled set of potential products with different combinations of traits is shown to respondents and, by analyzing how they rate these products, the implicit valuation of the individual traits making up the product can be determined. These preference models can be used to understand the market demand and potential for new varieties to meet this demand. Conjoint analysis techniques are also used as trade-off analysis tools to determine the systematic analysis of decision making.

The conjoint analysis study was conducted over six weeks from December 2011 to January 2012 just after the wheat harvest in four villages (kabeles) within the Hetossa woreda. The four villages were:

1) Hatee Handodee
2) Odaa Jila
3) Gonde Finchama
4) Boru Lencha

In addition to myself, the same two researchers from KARC that assisted with enumeration and translation on the previous study were joined by a female district agricultural officer and several local extension agents in administering the surveys. A total of 305 farmers were surveyed including 158 MHH, 70 FHH, and 77 female not head of household. A combination of purposive sampling and random sampling was employed for sample selection. The sample selection was purposive because specific villages were selected within the district based on their location to major roads and marketplaces and the fact that they are major wheat growing areas. I selected an even number of men and women to be surveyed from each village (some last minute substitutions were necessary based on respondent availability and no-shows, hence the uneven final number of 52% male and 48% female). I used lists provided by the agricultural extension officers at the district and village level to find out how many wheat household units were in each village, then I randomly selected 305 farmers from the four villages to participate in the survey. The surveys were conducted in the local language, Oromifaa, and responses were written in English on the questionnaire. The results of the survey are intended to show the value of certain traits to different segments of the surveyed population (see Appendix 2 for the survey).

Phenotypic traits and levels

The six traits to be evaluated were chosen based on the factor analysis results from the previous study (June 2011). The conjoint survey involved farmers rating hypothetical varieties that were based on combinations of the following traits and levels:

1) Number of productive tillers per plant (2, 5, and 8 tillers)
2) Density of kernels per spike (lax and dense)
3) Rust disease resistance (resistant and susceptible)
4) Size of grain (large and small)
5) Color of grain (white and red)
6) Price of seed (650 birr[3], 850 birr, and 1050 birr)

The trait levels were selected to represent realistic trait possibilities based on information gathered from discussions with wheat research scientists at KARC, farmers, extension agents, seed companies, and millers.

Varietal combinations and visual stimuli

Yield is thought to be one of the most important factors influencing a farmer's decision to grow a variety. However, yield is not a specific agronomic trait, but instead, can be broken into several attributes that contribute to yield: number of productive tillers per m^2, density of kernels per spike, and thousand kernel weight. I used the levels two, five, and eight productive tillers to portray low, medium, and high number of tillers per plant. These levels were described verbally to the respondents by a research assistant and they were shown a laminated 8.5"x11" card with a

[3] 17.39ETB = $1 USD Exchange rate on January 11, 2012

picture of a plant with either two tillers, five tillers, or eight tillers (see Appendix 3 for an example of the cards and Appendix 4 for tiller pictures).

The density of kernels per spike was divided into two levels, lax kernels and dense kernels. The laminated card showed a close up picture of a wheat spike depicting a lax kernel with approximately 40 kernels loosely spaced on the spike or a dense kernel with approximately 80 kernels tightly packed on the spike (see Appendix 5).

The ‘thousand kernel weight’ is a technical term that was unlikely to be understood by many farmers. Seed size contributes to the thousand kernel weight and is easily observable so participants were asked to rate small or large kernel size instead of thousand kernel weight. Since changes in size and color are relative to a standard, it is best to show actual seeds (as opposed to pictures or verbal descriptions) representing the small and large size and the red and white color. It is not possible to separate the color of grain from the size of the kernel so respondents were shown grain with the following size/color combinations: small, white grain; large, white grain; small, red grain; and large, red grain. These were displayed in a clear plastic container (see Appendix 6).

The two levels of response to rust disease were ‘rust resistant’ and ‘rust susceptible’. The laminated card included a close-up picture of a leaf that was either infected with rust or resistant to rust. Due to the fact that the relative rust response is contingent on an infestation of the rust disease, it was important that this picture was covered by an index card that could be revealed if the respondent wanted a visual representation of the rust response so their initial opinion would not be influenced by seeing a variety infected with rust. Before each survey, every respondent was told that the depiction of the rust response was based on zero fungicide application during a severe rust infestation similar to the rust epidemic experienced the previous year (growing season July through December 2010).

The price represented the cost of 100kg of seed at planting time and included three levels; low at 650 ETB/100kg for seed, average at 850 birr/100kg, and high at 1050 birr/100kg. The price was determined based on discussions with farmers, researchers, and seed companies that took the market price of grain at harvest in December 2011 (630birr/100kg) and the trend for the projected price of seed at planting time (average projected price of seed is market price plus 200birr).

During the explanation of the survey, the respondents were told that all other traits and management of the "varieties" in question were to be considered equal, meaning they mature at the same time, they were grown in the same soil under the same climatic conditions, they are all the same height and all management was the same including seed rate, and fertilizer application. All of the "varieties" were said to come from a trusted and reliable source.

Experimental design

The study uses six traits and a total of 14 trait levels (four of the traits have two levels each and the 'number of tillers' and 'price of seed' traits both have three levels). There are entirely too many combinations to have farmers evaluate all the trait combinations – 3x2x2x2x2x3 is the full factorial design and would have resulted in 144 combinations – which is why a fractional factorial design was used. Each of the trait levels was entered into a choice design from JMP 9.0 statistical software which generated 16 combinations. I added two more combinations to increase the degrees of freedom for a total of 18 trait combinations. The respondents were asked to rate these 18 combinations that represented hypothetical varieties and were depicted on laminated cards (see Appendix 3 for an example of the laminated card). They rated the trait combinations on a 7-point Likert scale (Likert, 1932) with zero indicating they "definitely would NOT buy" the seed and six meaning they "definitely would buy the seed" at the given price. The surveys were conducted at the village agricultural offices or in a village meeting room in a one-to-one interview style with the research assistants translating the varietal descriptions into the local Oromifaa language for each respondent. Each interview typically took 45 minutes to an hour.

Data entry

Each completed survey was thoroughly reviewed by the research assistants and primary researcher so as to avoid any missing data. The surveys were coded nightly during the data collection period. There were no surveys that contained missing data for the rating of hypothetical varieties. Very few surveys had missing variables in the demographic section and these were dealt with by either dropping the variable or estimating the response based on responses to similar questions (several questions were reworded versions of previous questions to check the validity of previous responses. For example: Q1How many hectares of wheat did you grown last season?; Q2 List the varieties of wheat grown and hectares allocated to each variety?).

Wealth index calculation

It can be difficult to establish the income for farmers in developing countries because much of their wealth may exist in livestock assets and they may rarely use currency, instead trading goods or services. In addition, self-reported income data are notoriously unreliable and the discussion of income may be a sensitive subject. To avoid these pitfalls and misreporting, it is common to calculate a wealth index by collecting an inventory of selected assets. The following variables were used to calculate the wealth index (with average price in parentheses):

- Number of each livestock – oxen (4394 ETB), donkeys (1020 ETB), goats (694 ETB), sheep (746 ETB)
- Number of 100kg sacks of wheat sold at harvest – 630 ETB
- Number of 100kg sacks of wheat sold at planting – 830 ETB
- Income from selling other crops
- Amount of off-farm income

The price for livestock was calculated using a live feed of Ethiopian Livestock Market Information (accessed January 3, 2012) based on the rate at the nearest market in Adama in January 2012. The rate for a 100kg sack of wheat at harvest was based on the Hetossa market price for wheat in December 2011 just after harvest. The rate for a 100kg sack of wheat at planting was calculated based on an average estimate of 200 ETB difference between the prices of wheat at harvest and planting (personal communication with farmers, extension agents and researchers in Hetossa, December 29 2011). Income from selling other crops and the amount of off-farm income were given by respondents as an estimated annual sum in Ethiopian birr. The amounts from each variable were summed and assigned to respondents as a continuous variable called the wealth index.

Ordinary least squares model

Ordinary least squares regression was used to estimate each respondent's preference coefficients for each trait level. The following model was used:

$$R_j=\beta_1+\beta_2\,(2tillers) + \beta_3\,(8tillers) + \beta_4\,(loDensity) + \beta_5\,(large) + \beta_6\,(red) + \beta_7\,(rustResist) + \beta_8\,(loPrice) + \beta_9\,(hiPrice) + E_j$$

Where R_j represents the rating value given by respondent j on the 7-point Likert scale; 2tillers = 2 productive tillers per plant; 8tillers = 8 productive tillers per plant; loDensity = low density of kernels per spike; large = large seed size; red = red color of seed; rustResist = rust disease resistance; loPrice = 650 ETB; hiPrice = 1050 ETB. Parameter β is the slope or the "preference coefficient" of the trait level. The independent variables were effects-coded. It is common in conjoint analysis to use an effects-coding procedure instead of dummy coding (Tano et al., 2002). In an effects-coding procedure for two trait levels, the usual dummy coding (0,1) is replaced by (-1,1) where -1 is used instead of zero for the variables that are excluded to avoid the "dummy variable trap" during estimation (Tano et al., 2002). When there are three trait levels, such as with number of productive tillers and price, a (-1,0,1) system is used. Unlike dummy coding, in effects-coding the reference levels have an average value of zero for each trait and are uncorrelated with the intercept (Bech and Gyrd-Hansen, 2005). This property simplifies the interpretation because the zero point is the average, so the interpretation is that any level above zero is more preferred than average, while those below zero are less preferred. Dummy-coded approaches specify that the least preferred value will be set to equal zero and all other levels will be positive values so they do not average any specific value (Bakken, 2006). Effects-coding generates estimates that measure the marginal change in the dependent variable as a result of a unit change in the independent variable (Pedhazur, 1982).

Adjusted R^2

The R^2, or coefficient of determination, indicates how much of the variation in the dependent variable is explained by the variation in the explanatory variable. One problem with the R^2 is that as more explanatory variables are added, the R^2 increases regardless of the value these explanatory variables add to the equation. We can account for this by using the adjusted R^2.

The adjusted R^2 adjusts for the number of explanatory variables in the model and includes a penalty for increasing numbers of right-hand-side (RHS) variables:

$$\text{adjusted } R^2 = 1 - \left[(1 - R^2) * \frac{n-1}{n-k-1} \right]$$

Where, the final term (n-1)/(n-k-1) gets larger as the number of RHS variables (k) increases resulting in a smaller adjusted R^2. So, in order for the adjusted R^2 to increase as variables are added, the R^2 needs to increase by enough to overcome the penalty associated with adding more variables. The main use for the adjusted R^2 is in comparing results across studies.

Relative importance

The preference coefficients from the conjoint model were used to estimate the relative importance (RI) of each trait. This can be achieved by considering how much difference each trait could make in the total utility of a product. That difference is the range in the trait's utility values. RI's are calculated by dividing the difference between the highest and lowest coefficient for each trait and then summing these ranges across all traits using the following equation (Hair et al., 2010):

$$RI_i = (\text{range}_i * 100) / \textstyle\sum_{i=1}^{6} (\text{range}_i)$$

RI values are calculated in percentages from relative ranges, obtaining a set of trait importance values that add to 100 percent. RI values are interpreted as the percent strength of importance the respondent placed on each trait in expressing the intention to purchase the product.

Cluster model

The cluster analysis procedure in JMP 9.0 was used to group respondents with similar preference coefficients together. The cluster procedure hierarchically clustered the observations in the data set using Ward's minimum variance method (SAS, 2009). This method minimizes the total within-cluster variance. The two clusters with the least distance between them are merged at each step of the process. All clusters start out as a single point. Then the two closest clusters merge to form a new cluster that replaces the two older clusters, repeating this process until the optimum number of clusters is met (SAS, 2009). The initial distance between individual objects must be proportional to the squared Euclidean distance using the following equation (SAS, 2009):

$$D_{KL} = B_{KL} = \frac{\|\bar{x}_K - \bar{x}_L\|^2}{\frac{1}{N_K} + \frac{1}{N_L}}$$

If $d(x,y) = \frac{1}{2}\|x-y\|^2$, then the combinatorial formula is $D_{JM} = \frac{(N_J+N_K)\, D_{JK} + (N_J+N_L) D_{JL} - N_J\, D_{KL}}{N_J + N_M}$

The resulting R^2 is the proportion of variance accounted for by the clusters. Several methods, using the R^2 and t^2 statistics, are useful in determining the appropriate number of clusters but this is somewhat subjective based on the characteristics of the cluster and usefulness of the data. Seven clusters were indicated as the best representation of the variation in the population but two of the clusters had very small sample sizes (*n* = 9 and *n* = 16). The members of these clusters represented quite different demographic characteristics to the other clusters so I decided to examine the seven clusters and report the summary statistics results. However, the multinomial logit analysis could not accommodate such small sample sizes so I used a five cluster model for that analysis.

Multinomial logit model

The clusters were created by analyzing the respondent's preference coefficients from their ratings of the hypothetical wheat varieties. However, cluster analysis does not account for any information based on demographic variables. As a stand-alone procedure, the cluster analysis can only determine that there are segments of the wheat farming population that have different strengths of preferences for specific traits, but these preference coefficients are not observable. The conjoint analysis tool is most effective when multinomial logit analysis is performed to reveal useful information about these segments. The multinomial logit model allows us to predict cluster membership based on demographic variables such as gender, socio-economic status, or education level. Each respondent's cluster number and demographic/usage information was fed into StataMP 12 statistical software (STATA, 2009) to calculate the probability of a respondent being assigned to one of the five clusters based on certain demographic and usage characteristics by using the following equation:

$$\Pr(I)_n = \frac{\exp\,(x_I{}'\beta_n)}{\Sigma_j \exp\,(x_j{}'\beta_n)}$$

Where, Pr(I)n is the probability that respondent *n* is in the *i*th cluster, x_I is a vector of demographic and management variables, and βn is the vector of preference coefficients for respondent *n*.

3. Results and discussion

3.1 Focus group discussions

I conducted two focus group discussions, both of which evaluated the flour, dough, and baking quality of different types of wheat. The two groups were differentiated by the samples they evaluated and the method of preparation for the samples. The first group compared three distinct single varieties that were milled with their bran on, as well as four commercially milled all-purpose (mix of hard and soft wheat varieties) samples. The second group evaluated five distinct varieties prepared using the traditional home method of soaking, sun-drying, and hand-grinding the grain to remove the bran before milling.

Flour quality

During the focus group discussions, the participants evaluated the milling quality based on the amount of seed (weight in kg) and the resulting flour volume after milling. The variety Millennium had particularly low flour volume (compared to the other varieties Kubsa, Huluko, Kakaba, Hogana, Pavon 76, and Digelu) which was considered a negative trait for that variety. Collectively, the first group rated the top flour as the ‘First grade’ flour from Asela Mill and described it as having a soft texture, white color, and fresh smell. ‘Bad’ smelling flour was described as smelling like it has been mixed with other crops or like it has been stored for a long time. The women said the ‘Third grade’ flour from Asela Mill had a harder texture which is not a good quality. Millennium was ranked the worst variety because the color was dark red and it had an old smell. The mixed ‘Abroad’ flour from the Gonde Mill was rated as the second favorite variety. This is interesting considering ‘Abroad’ is Gonde Mill’s B grade flour compared to the ‘Special’ A grade flour, which was not favored by the women. In fact, the women commented that the ‘Special’ flour was too soft and not suitable for making bread. The single variety, Huluko, was rated third over both the ‘Third’ grade Asela Mill mixed flour and the ‘Special’ mixed flour from Gonde Mill. This is somewhat surprising considering the single varieties were milled with their bran on which is not the traditional method of preparation. Several of the women commented that they know the protein content is higher when the wheat is milled with the bran on but they don’t like the brown color of the bread and prefer white bread made from wheat without the bran. One participant said she prefers the pure white flour for home consumption and market even though she knows the darker color flour contains higher protein. During the discussion the women remarked that they prefer Kubsa for making bread and Galama for market sale (although Galama was not evaluated). The variety Enkoy is preferred for its red color in making a local fermented alcoholic beverage similar to beer that is called tala. Galama is also reported to be good for making nefro and kolo because it has large grains. Kubsa reportedly has the highest flour volume, followed by Galama.

Dough quality

Crumbly dough is considered poor quality and often it is thought that crumbly dough has low protein content. Galama, although not evaluated, was mentioned by one participant as having a low protein, crumbly dough. The participants collectively discussed the qualities of the dough for the samples as follows:

- The dough from Kubsa was not well liked by the women (this is interesting because Kubsa was mentioned previously as making the best bread, so the poor quality could be due to the untraditional preparation). The women said the dough was rough, the color was too red, and there was no elasticity so the dough would just break apart when stretched. They did like that the dough kneaded well and was not sticky.

- The dough from the variety Huluko was preferred for making bread. The women described the dough as being soft in texture, good in water absorption, medium in color, and poor in elasticity. The participants of Group Two preferred Huluko the best and discussed that it had good elasticity without sticking to the pan or to your hands and that it has a good color.

- The most negatively perceived variety was Millennium. The participants said it had hard dough that was not sticky at all and very difficult to knead. It had a "bad brown color" and absorbed too much water.

- The 'Abroad' mix from Gonde Mill was too sticky which was said to be a negative quality that would not be good for making bread. It did have good elasticity and was considered to be medium in water absorption capacity.

- The white color of the 'Special' mix from Gonde Mill was one of the favorites of the women but the dough was "too hard" and the flour did not absorb very much water even though it still had good elasticity.

- The most preferred sample in the dough was the 'First' grade mix from Asela Mill. The women liked this dough best for bread. The white color was the "purest", it was "somewhat sticky" and easy to knead and had very high elasticity.

- The 'Third' grade mix from Asela Mill was sticky but the women remarked that it was good for making bread. It had a good white color and was medium in water absorption.

- Although Hogana was soft and had good elasticity, it was very sticky and dough is left on hands and the container, which the participants said was a sign of poor quality.

- Pavon 76, which is well-known to be a favorite for making bread, was rated the worst quality dough by the second group. The participants said it had poor water absorption and the dough was hard and would not stick to itself making it difficult to knead, crumbly, and had almost no elasticity.

- The second group preferred Digelu over the other varieties for its color. Digelu had poor water absorption but was rated medium in kneading and elasticity because it was not too sticky.

- The second group commented that Kakaba dough was not as soft as they prefer but it made up for this negative quality with good elasticity and stickiness.

Bread quality

The results for preference of bread quality were divided amongst both groups. Most of the women from the first group preferred the mixed samples that came from the commercial mill but two of the women preferred the variety Huluko. These two women said they like the dark colored bread for home consumption because the bran was left on and they think it is healthier and has more protein. But, they did say these varieties would not be good for market sale. Other women commented that the bread made from Huluko was crumbly and dry which they did not like but it had large pores which was good and they thought it would store well without molding. The majority favorite from the first group was the “Special” mix from Gonde Mill because the color was very white throughout; it had a good ‘spongy’ texture, good taste, and light weight. The “First” grade from Asela Mill compared almost equally but was rated second by most of the group.

It was noted that the dough from Kubsa was the first to rise and needed the least amount of time for leavening. Two women rated Kubsa as their second favorite because it made “heavy” bread and the color was not too dark considering it still had the bran on. The “Third” grade mix was said to have a “sweet” taste and medium texture “spongy-ness”. Although it was not “pure” white, the color was acceptable. Gonde “Abroad” mix was rated third favorite because of the white color, but otherwise it was unnoteworthy. The worst rated variety was Millennium which fermented/rose last, was dark red in color, and had a poor taste. The only positive comment was that it had a softer texture than the bread made from Kubsa.

The second group from KARC liked the overall quality of Huluko saying that it was porous, fluffy, had good color, and a sweet taste. Individual ratings were relatively consistent with the highest preference for the varieties Huluko, Digelu and Hogana, and the lowest ratings for Kakaba and Pavon 76. It was mentioned that Kakaba had small pores and made heavy bread which they did not like. One participant mentioned that the bread from Pavon 76 was very heavy and she thought it may be a sign that the grain had been exposed to moisture and sprouted. This was not confirmed since the grain sample had already been used at this point but it is a plausible explanation for why the well-liked variety known for good bread quality was not preferred during this evaluation. See Table 3 for a summary of the respondent's perceptions of good and bad quality pertaining to the different processing phases.

Table 3 Respondent summary of perceived quality traits for different processing phases

Processing phases	Good Qualities	Bad Qualities
Milling	High flour volume, white grain color	Low flour volume, red grain color
Flour	Soft texture, white color, fresh smell, perception of high protein content (related to color)	Hard texture or too soft texture, dark brown or red color, old smell
Dough	Soft texture, good water absorption, high elasticity, pure white to light red color, easy to knead, some stickiness, short leavening time	Crumbly (perceived as low protein), rough or hard texture, no stickiness or too sticky, very low or very high water absorption, low elasticity, red color, slow leavening
Bread	Large pore size, light weight, fluffy, spongy texture, good smell, sweet taste, pure white to darker white color, easy to ball up between thumb and forefingers	Dense weight, heavy, small pores, crumbly, dry, dark brown or red color, sour taste

The purpose of the focus group discussions was to draw out the traits that Ethiopian people characterize when evaluating the quality of wheat for making bread. These exercises were valuable for understanding what participants look for in determining ‘good’ and ‘poor’ quality and how this is measured descriptively by non-scientific standards. The results of the focus group discussions are not meant to be conclusive as to what exact traits define good quality because this is subjectively based on the perception of what ‘good quality’ means to each consumer. Some participants preferred darker colored bread because there was a perceived higher protein content while others only liked very pure white grains because they were best for market sale. These discussions highlight the variability of traits related to the different stages of making bread and show the complexities involved in testing for quality preferences. The results also show that the characteristics of flour and dough that are perceived as ‘good’ do not necessarily equate to good quality bread. Several participants mentioned that the dough quality was poor because it was too sticky, not elastic enough, or had poor water absorption (which are all thought to be important in the bread quality) and then rated the bread from this dough as their favorite. A decreased leavening time was preferred by the focus group women which could be significant in minimizing the length of preparation time and in freeing up more time for other activities. The men that participated in the second focus group discussion rated the bread from Pavon 76 highly and liked the taste while the women said it tasted off. This is just one example and I cannot conclude that men and women have different taste preferences from this but it is worth noting and could be a possible avenue for further study.

3.2 Gender roles in wheat production

Respondents reported on individual responsibilities for different wheat farming and household activities. When questions about role responsibilities were asked in a format requiring a person to assign either male or female to a farming role, generally all respondents answered the same. I will explore some of the reasons why this may be the case below. It was not until respondents were asked to describe *how* an activity takes place (such as preparing land or spraying chemicals) that the discrete family or individual level of involvement was elaborated. Respondents were asked which family member/s performed the activities listed in Table 4.

Table 4 List of tasks related to wheat production

Tasks in wheat production:
Land preparation
Planting wheat
Weeding
Applying fertilizers
Applying chemicals (fungicides, insecticides, herbicides, etc.)
Protecting crop from birds
Harvesting
Preparing the threshing site
Threshing
Winnowing
Preparing the gotera or degogo
Maintaining the gotera or degogo
Seed selection
Seed cleaning
Transporting grain to market
Selling grain (direct to buyers or to millers)
Milling grain for home consumption
Preparing and Cooking
Storing prepared products
Deciding which crops and varieties to grow
Purchasing or trading new varieties

Generally, respondents answered that men solely performed the activities of land preparation, applying fertilizers and chemicals, and preparing the gotera/degogo[4], while women's sole responsibilities were maintaining the gotera/degogo, seed selection, seed cleaning, milling grain for home consumption, preparing/cooking wheat products, and storing prepared products. All

[4] Grain and flour storage containers made from tree branches and/or mud mixed with straw.

other activities were performed by both male and female members of the household (although equal time was not necessarily allocated by both genders in completing the activity).

However, as we probed for more description of how the activities are performed, it became evident that women are, in fact, involved in the activities that are claimed to be the 'sole' responsibility of men. For example, men use oxen to plow the fields and, culturally, it is not acceptable for women to plow, so land preparation is considered a man's activity. But, women participate in land preparation by following behind the plow and breaking up the clods that were too large to be broken apart by the plow. This act requires women to use a hand tool and physically break up the large clods. According to the Tiruneh et al. (2001) study on gender differentials in agricultural production in the central highlands of Ethiopia, women do not participate at all in land preparation or planting; these activities are the sole responsibility of men. This is contrary to our findings, partly due to the descriptive quality of our questions that allowed respondents to elaborate on their role in each activity. Another contrast between our survey and that of Tiruneh et al. is that our respondents reported that both women and men participate in broadcast planting.

All respondents, regardless of gender, replied that chemical application was the sole responsibility of men. However, when asked to describe these activities further, it became clear that women have a prominent role: women fetch the water and bring it to the field for the men to mix with the chemicals. According to manufacturers' instructions, fungicide tank mixes require from 200 liters to 1000 liters of water per hectare (Syngenta Tilt 250E Approved Instruction Pamphlet, 2010; Syngenta Mancozeb instruction label, 2007) and may need to be applied several times throughout the growing season. Herbicides, such as 2, 4-D, require 100 liters of water per hectare (Dow AgroSciences Frontline 2, 4-D label, 2011). Given that a source of water can sometimes be several kilometers away from the field, bringing this much water to the field can be extremely physically demanding and time consuming for women.

In most cases, respondents claim that both genders contribute to the decisions about which crops and varieties to grow. However, when we asked men what would happen if their wife does not agree with their decision, men responded that they would make the decision without their wife's input. Many men asserted that it was a joint decision unless their wife disagreed, in which case it was the decision of the head of household. These findings are consistent with a study of gender roles in cereal crop production systems by Hassema (2008) showing that in 69% of the cases the husband makes the planting decision unilaterally, in 26% of the cases it is a joint decision, and in 3% of the cases the wife makes the decision unilaterally.

During interviews, a female respondent remarked that she was not happy with the food quality of the variety Mada Walabu and she told her husband she did not want to continue to grow this variety the next year. Her husband agreed to change to a new variety that was a better quality for food preparation. So apparently some women in male headed households do have some decision-making power, but it is generally not equivalent to the power of the head of household and the final say usually depends on their husband's preference.

Women do most of the transporting of grain to market unless there is a large amount of wheat to be sold, in which case the men take responsibility for transporting large amounts of commercial grain. Likewise, women can purchase and sell small amounts of grain for use in food preparation but men are responsible for the commercial sale of large amounts of wheat.

3.3 Perceptions and evaluation of existing varieties

Demographic statistics

The summary of demographic statistics is shown in Table 5. The average age of the respondents was 43.6 years old with a median of 40 years old. The median size of land holding was 3 hectares of owned land and 0.13 hectares rented. This sample included 70% male respondents and 30% female with 80% of the respondents being the head of household. Of the average 2.61 hectares of land owned by participants, 1.75 hectares was dedicated to wheat production. The majority of respondents (79%) reported a median yield loss of 13 quintals, or 0.74 t/ha, from yellow rust (1 quintal = 100kg). Based on yield statistics from Table 6, the average yield was 1.79t/ha. Therefore, 0.74 t/ha loss equates to 41% reduction in average yield. It must be noted that this data is from an abnormal year in which yellow rust infestation caused increased losses. Even so, 21% of respondents reported no loss or even a gain. Without longitudinal data, these gains are difficult to explain but may be due to a catastrophic event from the previous year (drought, flooding, lodging, etc) that wiped out some or their entire crop so that any yield would have been a gain over the previous year. The reported losses are consistent with the overall country losses from the yellow rust epidemic from 2010 (ICARDA, 2011). Although some respondents reported that they planned to allocate more land to grow wheat in the coming season (there was an average increase of 0.89 hectares of wheat), the median for the planned hectarage was the same as the amount planted to wheat the previous year (1.5 hectares).

Table 5 Summary of the respondent's demograhic statistics

	Age	Ha own	Ha rent	M	F	HH	Ha of wheat 2010	Yield Loss in 2010	Planned Ha of wheat 2011
Average	43.6	2.61	1.16	70%	30%	80%	1.75	-18.9	2.64
Median	40	3	0.13				1.5	-13	1.5
Minimum	24	0	0				0.5	-200	0.5
Maximum	78	5.5	10				5	20	20
Std Dev	11.52	1.46	1.98				1.00	36.44	3.28
CV	26%	56%	170%				57%	-193%	124%

Yield statistics

Determining the average yield can be complicated because many farmers grow several varieties of wheat for different purposes and these may have significantly different yields. Table 6 shows a summary of yield statistics separated by the number of varieties grown. All respondents grew at least one variety of wheat on an average of 0.99 hectares of land which had a mean yield of 2.03 tonnes per hectare (t/ha). More than two-thirds of the respondents grew a second variety of wheat on 0.92 hectares of land which averaged 1.64 t/ha yield. Eighteen percent of farmers interviewed grew three varieties, with the third variety averaging 1.69 t/ha and less land dedicated to these varieties. The total mean yield for the sample was 1.79 t/ha, which is slightly higher than the national average. Without longitudinal data, it is difficult to infer much about these statistics, especially since the data are compared to yields from a year that suffered from a yellow rust epidemic.

Table 6 Summary of yield statistics showing the percent of respondents growing more than one variety, the number of hectares allocated to wheat, and the yield in tonnes per hectare

	1 variety		2 varieties		3 varieties	
% of N	100%	100%	68%	68%	18%	18%
	# of Ha	t/ha	# of Ha	t/ha	# of Ha	t/ha
Average	0.99	2.02	0.92	1.64	0.61	1.69
Median	0.75	1.26	0.63	0.98	0.50	0.82
Minimum	0.25	0.00	0.04	0.00	0.04	0.00
Maximum	3.00	9.00	2.75	8.04	1.75	4.02
Std Dev	0.672	4.040	0.732	3.646	0.542	1.735
CV	68%	200%	79%	89%	89%	103%
Total avg yield: 1.79 t/ha						

Varieties

The data in Table 7 show the different varieties grown by farmers in the four districts. Note that the percentage of people growing these varieties is more than 100 percent because many people grow more than one variety. The most commonly grown varieties from these areas are Kubsa, Digelu, Tusie, and Galama. Kubsa was released in 1985 and is a very popular variety known for high yields and adaptability to many agro-ecological conditions. It became susceptible to the *Yr27* strain of yellow rust and was severely affected during the 2010 epidemic. Kubsa is an early maturing variety that is best grown in mid- to low-altitude areas like the Hetossa and Dodota districts. Digelu, Tusie, and Galama are all later maturing varieties better suited for the highland areas. Digelu is rust resistant and Tusie is tolerant to rust. Tusie is not preferred for its bread-making quality but it is used for making noodles and garners a good market price with traders. Farmers in Munessa will often grow Tusie for commercial sale and grow several other varieties like Digelu and Qamadii Guracha for home consumption. Munessa is more than 20 km from a main highway road but trade trucks will drive to this area to collect Tusie at the end of the season. Interestingly, the farmers in Digelu Tijo did not grow Tusie although the district is located near a main road with a market and easy access for traders. Farmers from Digelu Tijo grew mostly Digelu and Galama, which are used for home consumption, with any surplus sold to the market. Digelu is in high demand and farmers that have a surplus and storage capabilities prefer to sell it as seed (as opposed to grain). Approximately 30%-35% of the yield from Digelu is produced for seed. Both Kubsa and Galama have a high biomass to grain yield, albeit for different reasons. Kubsa has a high tillering capacity and Galama is a late maturing, tall variety, both of which are preferred by farmers for use as animal feed, fuel, and roofing material. Kakaba and Danda'a were the most recently released rust-resistant varieties and are in high demand. Farmers grow these varieties exclusively for the purpose of multiplying seed because the seed is far more valuable than grain. Digelu was released five years prior to this study and although it is being rapidly multiplied, it is still in short supply. There is undocumented evidence (observed in farmer's fields in January 2010) that Digelu is already starting to become susceptible to new strains of yellow rust. Since Digelu has only single-gene resistance, this shows how important it is to breed for durable resistance using multiple resistance genes. Multiplication and dissemination of varieties takes several years and by the time a variety, like Digelu, with single-gene resistance is widely adopted, it is possible that the rust disease has mutated and the variety is no longer resistant.

Table 7 Varieties grown by respondents in 2010 and the year the variety was released in Ethiopia

Variety	Year released
Kubsa	1995
Digelu	2005
Simba	2000
Kakaba	2010
Batu	1984
Tusie	1997
Hawi	2000
Galama	1995
Pavon 76	1982
Mada Walabu	2000
Danda'a	2010

Some farmers, especially women, show a preference (see Table 8) to revert back to older, local, or obsolete varieties like Batu, Mada Walabu, Israel, Qamadii Guracha, Enkoy, Kei, Romany BC, and Salmayo. The varieties that women were most interested in growing are known for superior bread quality (Batu, Israel, Romany BC, Salmayo), traditional dishes (Qamadii Guracha, Mada Walabu), home-made fermented beverages (Enkoy), and good straw for roof material (Israel, Kei). The varieties most preferred by men were the varieties with strong marketability and high yield (Kubsa, Digelu, Kakaba, Danda'a, Tusie, and Pavon 76).

Table 8 Percent of respondents desiring to grow select varieties in 2011 and the percentage that were female from that subset

Variety	% of N	% Female
Kubsa	33%	8%
Digelu	63%	45%
Simba	3%	0%
Kakaba	60%	25%
Batu	13%	60%
Tusie	18%	0%
Hawi	13%	40%
Galama	15%	33%
Pavon 76	28%	27%
Mada Walabu	10%	50%
Danda'a	55%	32%
Israel	18%	43%
Qamadii Guracha	5%	100%
Enkoy	10%	75%
Kei	8%	100%
Romany BC	3%	100%
Salmayo	3%	100%

Fungicide application

The epidemic of yellow rust in 2010 was caused by an outbreak of *Yr27*, an aggressive new strain of yellow rust, along with favorable environmental factors that sustained the disease throughout the growing season. The yellow rust disease attacks early in the growing season causing plants to be stunted and weak so timely spraying is critical. Many farmers in Ethiopia used fungicide to prevent major losses but the supply and distribution issues caused problems for timely application. Many farmers did not have access to fungicide during the critical application period (tillering to stem elongation) to have the maximum effect. In addition, training on proper use, mixing, and application rates, along with the necessary equipment for safe application, are not readily available. The main types of fungicide come either in liquid or powder form. The popular liquid fungicides are Bayfidan and Tilt. Mancozeb is a common chemical used in wettable powder form and was subsidized by the government. According to ICARDA (2010), at least 400,000 ha of wheat (equivalent to 44% of total wheat area) were affected in the 2010 yellow rust epidemic in Ethiopia.

Table 9 shows information about the fungicides including application and dilution rates. This information was difficult to find using internet resources and many of the sources provided inconsistent information. Based on the respondent's answers during surveys, the rates of application by farmers are not consistent with label recommendations. Discussions with local extension agents also showed a lack of knowledge regarding the application timing, rates, intervals, and dilution levels. Neither of the product labels for Mancozeb or Bayfidan includes wheat as a crop that can be treated using these brands nor do they include recommendations for application levels for wheat. According to the Grains Research and Development Corporation (2005) cereal growth guide, fungicide should be applied in the early stages of the disease between tillering and stem elongation (up to the first 37 days after planting). Tilt lasts about 3 weeks on the plant and then needs another application if the disease persists (second application before 55 days) (Syngenta Tilt 250E Approved Instruction Pamphlet 2010). According to Syngenta's Mancozeb instruction label (2007), the recommended application rate for soybeans and peanuts is 2.2kg per hectare (wheat was not included on label). The dilution rate is roughly 100L of water per 200g of Mancozeb and it should be applied at seven to ten day intervals. The minimum recommended rate of water to be mixed with Tilt is 200 liters per hectare. All fungicide applications require a significant amount of water to be mixed with the chemicals to dilute the solution. Many farmers' fields may be several kilometers away from a source of water and given that it is a woman's role to carry the water that is mixed for chemical application, this creates a considerable amount of extra work and can be quite time consuming for women.

Table 9 Information on popular fungicides used to treat rust in Ethiopia

Fungicide	Treats	Rate/hectare
Mancozeb • Dithane M-45 or • Manzate 200 or • Penncozeb	Septoria , Leaf and Stem Rust, Tan Spot **Product label does not include wheat*	1.7-2.2kg/Ha (recommendations from beans, and peanuts since label doesn't include wheat) - Mix 160-210g/100L of water
Propiconazole • Tilt 3.6 EC	Rust, Powdery Mildew and Septoria	500mL/Ha Minimum 200 L of water per hectare
Bayfidan • Triadimenol	Powdery mildew **Product label does not include wheat*	40mL/100L or 400mL/ha 150-200g/ha (CABI Crop Protection Compendium)

As shown in Table 10, 58% of respondents applied some kind of fungicide to their wheat crop in 2010. Of the respondents that grew a second variety, 56% applied fungicide, and 57% of those that grew a third variety used fungicide. The average number of applications was 1.7 times. The mean number of days after planting for the first application was 46.3 days and 58 days for the second application. Since the recommended time for the first application is before 37 days this implies that farmers were applying fungicide 10 days late on average. Delayed application decreases the effectiveness of the fungicide and decreases crop yields since yellow rust infects the crop early and retards its development.

An average of 1.56L of liquid fungicide was applied or two packets of powder (each packet contains 1kg of powder). Farmers spent on average 461 birr ($27 USD) per hectare to treat their fields. With an average of 1.75 ha of wheat, the expense for fungicide is 807 birr ($46 USD).

Even with government subsidies for fungicide, farmers spent a considerable amount to protect their crops from yellow rust ($46 USD is roughly half a month's wages).

Table 10 Summary of respondent fungicide statistics

	Apply Fungicide to 1st variety	2nd Variety	3rd variety	# of apps	DAP 1st app	DAP 2nd app	#Liters	#Packets	Cost/ha
% of N	**58%**	**56%**	**57%**						
Avg				1.7	46.3	58	1.56	2	461
Median				2	45	60	1	2	445
Min				1	30	37	0.1	1	40
Max				3	65	74	12	3	1200
Std Dev				0.76	11.83	8.89	2.59	0.82	351
CV				45%	26%	15%	167%	41%	76%

Note: DAP = Days After Planting

Factor analysis

The respondents evaluated two to three familiar varieties based on their perceptions of each variety's performance in 36 trait categories. The responses were subjected to factor analysis which combined the traits into four categories that were named based on the relationship between the traits in each category. Factor analysis establishes collinearity between variables and selects a smaller number of variables that can account for most or all of the variation in explanatory variables (Negatu and Parikh, 1999). The number of factors is established using the Kaiser method of accepting factors with eigenvalues above one and the Cattell scree plot method (as previously mentioned in the methods section).

The four categories were named: 1) Quality, 2) Agronomic yield related characteristics, 3) Disease Resistance, and 4) Harvest/storage (see Table 11). As shown in Table 11, the factor loading number for each trait in the different factor columns represents the weight that trait contributes to the factor. Factor analysis reveals that the most heavily weighted traits are tolerance to rust diseases, number of tillers, number of kernels per spike, grain size, price of seed, grain color, flour volume, baking quality and straw quality. Results of previous studies in central, southeastern, and northwestern Ethiopia are consistent with the findings that the most important characteristics to farmers are grain yield, grain color, grain size, marketability, and food quality (Negatu & Parikh, 1999; Bishaw et al., 2010; Kotu et al., 2000; Negatu, Mwangi and Tesemma, 1992; Alemayehu, 1999; Agidie et al., 2000). Yield, marketability, and food quality are not single traits that can be evaluated; they are broad categories composed of many traits. Factor analysis helps identify which traits from these categories are the most important to farmers.

Factor one, explaining 42% of the variance, was named ‘quality traits’ based on the inclusion of the following traits: grain color, flour volume, dabo quality, water absorption, dough elasticity, injera eye size, soft dabo, dabo color, and injera color. Length of spike was also included in this factor although it is not a quality trait. Factor two was named ‘agronomic yield related traits’ and contributed 24% of the variance based on the traits: early vigor, weed competition, lodging tolerance, height, threshing ease, yield, number of kernels/spike, and straw quality. Although seed price is not an agronomic factor, it was located in factor two (perhaps because higher yielding varieties are associated with higher priced seed). The two traits from factor three, tolerance to rust disease and grain size, contributed enough variation to be considered their own factor and represent 19% of the total variation. A fourth factor, named harvest traits, holds relatively less weight than the other factors (15%). This is not to minimize the importance of these traits which contribute significantly to yield losses if a variety shatters too easily or if it has a short storage life. Examination of the harvest traits were outside the scope of this study but it would make for an interesting future study to measure harvest losses by variety and how this influences adoption of new varieties that have longer storage capacity or more resistance against moisture and insects.

The six traits used to create hypothetical varieties for the conjoint study were selected from these factors. The traits were selected based on their factor loading weight from their category and the total across all categories (see Table 11). In addition, the trait should be singular and objective. For instance, the traits 'dabo color' and 'injera color' have strong factor loadings but it would be very difficult to isolate only the single color trait when asking a respondent to evaluate the color of dabo or injera without evaluating the entire product (which includes other traits like fluffiness, pore size, eye size, crumbliness, softness). However, the color of grain is directly attributable to the color of the end product and is therefore the preferred option for gauging respondent perceptions. As revealed in the focus group discussions, 'dabo quality' and 'soft dabo' are subjective traits that are based on each individual's opinion and would be problematic to quantify using conjoint analysis techniques so these were avoided in the design. Of the remaining traits with the highest factor loadings in the 'Quality', 'Agronomic' and 'Disease resistance' categories the following six traits were used in the conjoint analysis design:

1) Rust tolerance
2) Number of tillers
3) Number of kernels per spike
4) Seed price
5) Grain size
6) Grain color

Table 11 Factor loadings from factor analysis reveal the degree to which each of the trait characteristics contributes to each factor

Wheat trait characteristics	**Factor 1 'Quality'**	**Factor 2 'Agronomic/Yield'**	**Factor 3 'Disease Resistance'**	**Factor 4 'Harvest'**
Early vigor	0.136871	0.536989	-0.173806	-0.007839
Weed competition	0.068058	0.544188	-0.164107	0.087723
Rust tolerance	0.100800	0.116205	**0.585459**	-0.162507
Lodging resistance	0.016051	0.436972	0.131496	0.063528
Height	0.181743	0.183280	0.090135	0.111312
Harvest ease	0.149039	0.092128	-0.004016	0.541822
Shatter resistance	-0.013887	-0.155153	-0.209458	0.835727
Threshing ease	0.086394	0.406100	-0.097772	-0.498142
Storage length	0.041506	0.119543	0.250869	0.343355
Yield 'number of tillers'	0.291070	**0.685952**	-0.071647	-0.163041
Length of spikes	0.282895	0.117445	0.126350	0.069647
# of kernels/spike	0.349311	**0.647812**	0.066008	-0.007478
Seed price	0.028998	**0.418740**	0.088614	-0.000353
Grain size	0.427512	-0.014445	**0.582804**	0.190401
Grain color	**0.520158**	0.065128	0.289921	-0.074731
Flour volume	0.461980	0.123945	0.082954	0.293381
Dabo quality	0.860169	0.097828	0.010983	-0.062658
Flour H_2O absorption	0.626151	0.081162	0.006768	0.125547
Dough elasticity	0.551116	0.124484	-0.067270	0.273395
Injera eye size	0.587791	0.292162	-0.490549	-0.038776
Soft dabo	0.803145	0.114145	0.012156	-0.104813
Dabo color	0.756840	0.205007	-0.091630	0.023614
Injera color	0.652102	0.238687	-0.480123	-0.056551
Straw quality	0.256394	0.411376	-0.538036	-0.136566

3.4 Conjoint analysis

The results of the cluster analysis and conjoint analysis are presented for the overall population and for each cluster in Tables 12 and 13 and the most preferred levels are displayed in Table 14. Table 12 shows the preference coefficients for the trait levels and the strength of each trait's relative importance given by the overall population and the seven clusters. Figure 4 shows a graphic illustration of the strength of importance each cluster gives to the six traits. Table 13 presents the demographic, management, and perception information which is used to characterize membership in a cluster. Table 14 shows the percent of respondents that have specified each trait level as most preferred.

Table 12 Strength of preference, relative importance, and adjusted R^2 for the overall population and each cluster. The overall population had the strongest preference for the number of tillers trait with 8 tillers being their preferred level. Each cluster values the individual traits and levels differently.

Average preference coefficients, relative Importance, and adjusted R2															
Attributes and levels	Overall	Cluster I		Sub-Cluster I		Cluster II		Sub-Cluster III		Cluster III		Cluster IV		Cluster V	
N	305	56		16		36		9		51		45		92	
Share of 305 participants (%)	100%	18%		5%		12%		3%		17%		15%		30%	
Intercept	2.58	2.27	b*	1.69	c*	2.23	bc*	3.54	a*	2.98	a*	2.21	bc*	2.93	a*
Number of Productive Tillers															
8	0.68	0.86	b*	1.58	a*	0.62	c	0.32	cd*	0.65	c	0.38	d*	0.65	c
5	0.19	0.10	b	0.2	b	-0.06	b*	0.31	ab	0.02	b*	0.07	b*	0.48	a*
2	-0.87	-0.96	bc	-1.78	d*	-0.56	a*	-0.63	ab	-0.68	a*	-0.45	a*	-1.13	c*
Relative importance (%)	26.68	26.12	bc	35.34	a*	21.05	cd*	21.39	bcd*	28.99	ab	17.06	d*	31.66	a*
Density of kernels															
Lax	-0.43	-0.61	d*	-0.79	d*	-0.64	d*	0.37	a*	-0.13	b*	-0.41	c	-0.44	c
Dense	0.43	0.61	a*	0.79	a*	0.64	a*	-0.37	d*	0.13	c*	0.41	b	0.44	b
Relative Importance (%)	14.61	17.45	a*	16.55	ab	18.17	a*	10.8	ab	10.4	b*	13.15	ab	14.56	a
Rust Disease Resistance															
Susceptible	-0.60	-0.35	a*	-0.84	c*	-0.59	bc	-0.75	bc	-0.56	b	-1.24	d*	-0.4	a*
Resistant	0.60	0.35	d*	0.84	b*	0.59	bc	0.75	bc	0.56	c	1.24	a*	0.4	d*
Relative Importance (%)	19.33	11.4	e*	17.63	bcde	16.82	cd*	22.55	bc	23.01	b*	38.12	a*	13.88	de*
Seed size															
Small	-0.23	-0.64	d*	-0.41	c*	-0.04	ab*	0.15	a*	-0.26	c	-0.02	ab*	-0.14	b*
Large	0.23	0.64	a*	0.41	b*	0.04	cd*	-0.15	d*	0.26	b	0.02	cd*	0.14	c*
Relative Importance (%)	9.53	17.91	a*	8.91	bc	4.73	c*	6.57	bc*	11.65	b*	5.75	c*	7.37	c*
Seed color															
Red	-0.32	-0.47	c*	-0.44	c	-0.82	d*	0.46	a*	-0.19	b*	-0.21	b*	-0.22	b*
White	0.32	0.47	b*	0.44	b	0.82	a*	-0.46	d*	0.19	c*	0.21	c*	0.22	c*
Relative Importance (%)	11.13	13.21	b*	8.99	bc	23.68	a*	12.6	bc	8.57	c*	7.79	c*	8.22	c*
Price of seed															
650ETB/100kg	-0.35	-0.3	b	0.45	a*	-0.29	b	-0.96	c*	-0.32	b	-0.4	b	-0.47	b*
850ETB/100kg	-0.02	0.36	a*	0.21	ab*	-0.01	bc	0.26	ab*	-0.05	c	0.06	bc	-0.33	d
1050ETB/100kg	0.37	-0.06	c*	-0.65	d*	0.3	b	0.69	ab*	0.38	b	0.34	b	0.81	a*
Relative Importance (%)	18.73	13.92	c*	12.58	c*	15.55	c*	26.1	ab	17.38	bc	18.13	bc	24.3	a*
Adjusted R^2	0.55	0.56	ab	0.6	ab	0.54	ab	0.41	ab	0.47	b*	0.59	a	0.58	a
* Significantly different ($p<0.10$) from overall sample in a two-tail *t* test or z test, as appropriate.															
a, b, c, d, e Means with different superscripts are significantly different at alpha=0.10 in Tukey-Kramer HSD															

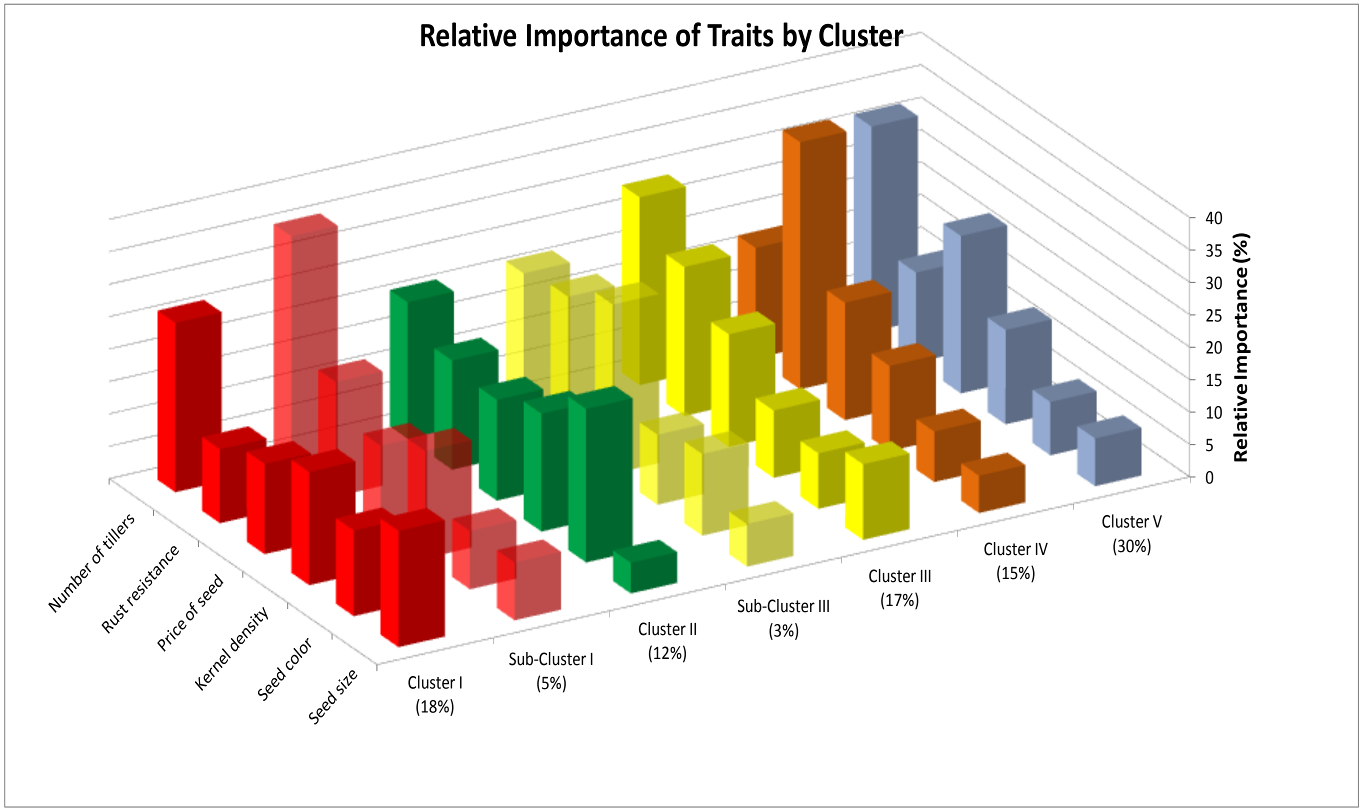

Figure 4 The graph shows color-coded bars that represent the seven clusters (the transparent red and yellow columns represent the small *n* sub-clusters that are combined with the clusters of matching colors for later analysis). The height of each bar represents the weight of importance that each cluster gives to the different traits. As evidenced by the graph, there are seven market segments with distinct trait preferences.

Table 13 Summary of the average demographics, management, and perceptions for the overall population and each cluster. The highlighted boxes show which factors differ significantly from the cluster mean compared to the mean of the overall sample and the other clusters.

	Overall	Cluster I		Sub-Cluster I		Cluster II		Sub-Cluster III		Cluster III		Cluster IV		Cluster V	
N	305	56		16		36		9		51		45		92	
Share of 305 participants (%)	100%	18%		5%		12%		3%		17%		15%		30%	
Demographic and Usage Info															
Hatee Handodee	26%	23%	bc	88%	a*	25%	bc	56%	ab*	14%	c*	42%	b*	12%	c*
Oda Jilaa	30%	43%	ab*	13%	bc	50%	a*	11%	abc	49%	a*	9%	c*	17%	c*
Gonde Finchama	25%	20%	bc	0%	c*	22%	abc	0%	bc*	8%	c*	44%	a*	36%	ab*
Boru Lencha	20%	14%	bc	0%	bc*	3%	c*	33%	abc	29%	ab*	4%	c*	35%	a*
Age	42.57	43.54	a	41.81	a	43.78	a	42.67	a	40.61	a	43.42	a	42.29	a
Cell phone	47%	55%	ab	81%	a*	31%	b*	33%	ab	39%	b	49%	ab	47%	ab
Total Ha	2.15	2.39	a	2.14	a	2.10	a	2.00	a	1.93	a	2.21	a	2.14	a
Ha owned	1.67	1.70	a	1.59	a	1.70	a	1.61	a	1.43	a*	1.77	a	1.74	a
Ha rented in	0.47	0.67	a	0.47	a	0.40	a	0.39	a	0.50	a	0.43	a	0.40	a
Yield Kun/ha	32.24	31.57	a	32.49	a	32.32	a	29.21	a	32.56	a	34.11	a	31.78	a
MHH	52%	59%	ab	81%	a*	44%	ab	78%	ab	45%	ab	58%	ab	43%	b
FHH	23%	18%	a	19%	a	28%	a	11%	a	29%	a	22%	a	23%	a
F not HH	25%	23%	ab	0%	b*	28%	ab	11%	ab	25%	ab	20%	ab	34%	a*
Wealth Index	40400	48125	a	40999	a	39257	a	32354	a	37165	a	38462	a	39569	a
Red/white same nutrition	10%	14%	b	50%	a*	3%	b	0%	b	4%	b	2%	b*	10%	b
Red grain > nutrition	15%	18%	a	0%	a*	11%	a	33%	a	20%	a	7%	a	17%	a
White grain > nutrition	75%	68%	bc	50%	c*	86%	ab	67%	abc	76%	abc	91%	a*	73%	abc
# of hand weedings	1.74	1.66	a	1.63	a	1.81	a	1.44	a	1.69	a	2.02	a*	1.71	a
# of spray weedings	1.68	1.68	a	1.63	a	1.86	a	1.33	a*	1.59	a	1.71	a	1.70	a
DAP in kg/ha	99.25	102.14	a	87.50	a	99.31	a	88.89	a	100.10	a	88.89	a*	105.11	a
Urea kg/ha	15.35	17.50	a	6.28	a*	23.61	a*	9.44	a	16.57	a	13.33	a	13.28	a
Compost kun/ha	27.98	34.45	a	39.94	a	22.39	a	22.78	a	23.78	a	34.53	a	23.77	a
Sprout > once in 10 yrs	38%	36%	a	63%	a*	33%	a	56%	a	33%	a	53%	a*	32%	a
Same resistance to sprouting	10%	7%	bc	38%	a*	3%	bc	0%	bc	8%	bc	2%	c*	17%	ab*
Red > resistant to sprout	64%	66%	a	50%	a	69%	a	78%	a	69%	a	71%	a	57%	a
White > resistant to sprout	25%	27%	a	13%	a	28%	a	22%	a	24%	a	27%	a	26%	a
Rust > once in 10yrs	18%	21%	a	31%	a	11%	a	22%	a	16%	a	27%	a	12%	a
Fungicide L/ha	0.74	0.60	a*	0.50	a*	0.66	a	0.67	a	0.82	a	0.68	a	0.88	a*
Fungicide birr/liter	395.10	401.43	a	331.38	a	415.56	a	294.44	a	411.18	a	390.96	a	397.27	a
Use straw roofing	84%	75%	bc*	56%	c*	97%	a*	89%	abc	88%	ab	84%	ab	87%	ab
# in family educ'd >grade 8	1.51	1.86	a	1.00	a	1.06	a*	0.89	a	1.49	a	1.80	a	1.50	a
Off farm income	24%	27%	a	6%	a*	14%	a	11%	a	25%	a	20%	a	33%	a*
Prefer higher prices	64%	63%	ab	13%	c*	69%	ab	33%	bc*	71%	ab	49%	b*	79%	a*

[*] Significantly different (p<0.10) from overall sample in a two-tail *t* test or z test, as appropriate.

[a, b, c, d, e] Means with different superscripts are significantly different at alpha=0.10 in Tukey-Kramer HSD

Table 14 The percentage of respondents from the overall population and each cluster that have rated the corresponding trait level as their 'favorite'. Note the highlighted boxes revealing the percent of respondents that preferred such trait levels as lax, small, red, susceptible seed.

Percentage of respondents								
Traits and Levels	Overall	Cluster I	Sub-Cluster I	Cluster II	Sub-Cluster III	Cluster III	Cluster IV	Cluster V
Number of Productive Tillers								
8	77	89	100	81	56	94	64	64
5	18	9	0	8	33	6	18	36
2	5	2	0	11	11	0	18	0
Density of kernels								
Lax	12	7	0	0	89	31	4	7
Dense	88	93	100	100	11	69	96	93
Rust Disease Resistance								
Susceptible	8	21	0	6	11	6	0	7
Resistant	92	79	100	94	89	94	100	93
Seed size								
Small	22	0	6	39	67	14	38	25
Large	78	100	94	61	33	86	62	75
Seed color								
Red	14	7	0	0	100	8	27	16
White	86	93	100	100	0	92	73	84
Price of seed								
650ETB/100kg	10	11	69	17	0	6	7	1
850ETB/100kg	25	63	31	28	33	18	29	1
1050ETB/100kg	65	27	0	56	67	76	64	98

Seven clusters were identified, each one defined by distinctive preferences for the different traits and levels. However, two clusters are made up of only 16 and 9 members and I will refer to these as sub-cluster I and sub-cluster III respectively in anticipation of the need to collapse the number of clusters to five for certain analyses requiring larger sample sizes. Although small in number, these members exhibit strong preferences that are unique to these clusters and the distinct group demographics are worth studying. For these reasons, I have included the small member clusters in the analysis for relative importance, demographics, and most-preferred level. The multinomial logit model, however, cannot handle small cluster sizes. Therefore, I have used five clusters for the multinomial logit model; hence the need to call them sub-clusters because the members of these sub-clusters will be merged into their two larger clusters for the multinomial logit analysis. Sub-cluster III is the smallest cluster with only 9 members and eventually becomes part of cluster III, whereas sub-cluster I joins cluster I. Appendix 7 includes a detailed illustration of the preference coefficients and relative importance from four clusters up to nine clusters showing where each cluster splits.

Cluster I prefers large grain size

Cluster I, with 56 members, represents 18% of the sample and is characterized by a strong preference for large grain size (see Table 12). Members of this group place the highest relative importance (17.91%) on large grain size in comparison to all the other groups which ranged between 4.73% and 11.65% relative importance. The preference for large grain is also significantly larger than the overall population's weighted importance of large grain size (9.53%). The positive preference coefficient of 0.64 for large grain indicates that a wheat variety with large grains would increase the average base rating (represented by the intercept) by 28% on the Likert scale, holding all other variables constant. The percentage of respondents in Cluster I (Table 14) that would choose large grain as their most-preferred level was 100% compared to the other clusters that ranged from 33% to 86%.

In addition, Cluster I has a strong preference for the middle seed price of 850birr (Table 12). This cluster gave an average relative importance of 13.92% for the seed price trait, and had the strongest preference for the middle price, 850birr. The positive preference coefficient of 0.36 for 850birr denotes an increase of 16% in the average base rating for wheat varieties priced at 850birr. This was the only group that preferred the middle price range, giving both the lower price and higher price a negative preference coefficient of -0.30 and -0.06 respectively. The negative coefficients on these levels would decrease the base rating by 13% for low priced wheat and 3% for high priced wheat. The results from Table 14 reveal that 63% of respondents from cluster I would choose the 850birr price as the most preferred level, while only 27% prefer the 1050birr price and 11% prefer the 650birr price.

At 13.21%, grain color was of relatively lower importance compared to the other traits for this group. However, Cluster I's strength of importance for grain color significantly differed from that of the overall population and clusters II, III, IV, and V. Ninety three percent of respondents from cluster I preferred white as their grain color (Table 14).

This cluster rated the number of productive tillers with the highest relative importance of all the traits (26.12%). Although the weight of preference for number of tillers is rated highly, it is slightly lower than the overall average preference coefficient (26.68%) demonstrating that the trait for number of tillers is strong among all groups and greater heterogeneity exists within the other traits that set this group apart from the overall statistics and the other groups.

Cluster I gave rust disease resistance the lowest relative importance rating (11.4%) compared to the other traits within this cluster and across the other six clusters. The overall sample placed 19.33% importance on rust disease resistance which proved to be significantly different than cluster I's rating. The relative importance for rust disease resistance was the lowest compared to all the other clusters with a preference coefficient of 0.35 for rust resistance and -0.35 for susceptibility, which would increase the average base rating by 15% for resistant wheat or decrease the base rating by 15% for susceptible wheat. The strength of preference for rust resistance was comparatively lowest among the seven clusters, with as much as 21% of the sample favoring rust susceptibility as their preferred choice (Table 14).

This cluster did not differ significantly from the other clusters based on the demographic, management, and perception of wheat grain/seed (Table 13).

Sub-Cluster I prefers high yielding, low price wheat seed

Sub-cluster I has the strongest preference for eight tillers compared to all the other clusters and placed the most weight on tillers, kernel density, and rust resistance. Members of this group placed 35.34% average relative importance on the tiller trait with a preference coefficient of 1.58 on eight tillers. This infers that their average base rating would almost double (94%) with the specification of high tillering wheat varieties. Conversely, this same group places an even stronger negative weighted coefficient on 2 tillers at -1.78. This would decrease the base rating by 105%. This sub-cluster represents only 5% of the sample population and all 16 members shared the same most-preferred levels on four out of the six traits (see Table 14), unanimously choosing eight tillers, rust resistance, dense kernels, and white color as their preferred levels.

This group comprised the only members that had a strong preference for the lowest priced seed, with a 0.45 preference coefficient compared to a range from -0.29 to -0.96 for the other clusters. The weight of this coefficient would increase the base rating by 27% for wheat seed priced at 650birr. Some members (31%) showed a preference for the middle priced seed, with an average coefficient of 0.21. Although there was a strong partiality towards low price, there was an even stronger negative response to high priced seed. The 1050birr seed received a negative weight of -0.65 which would decrease the average base rating by 39% for wheat priced at 1050birr.

According to Table 13, respondents in this group differed significantly from other clusters based on gender (81% were male headed households and 0% were female not head of household), cell phone ownership, the perception that grain color has an effect on grain nutrition, and the perception that grain color does not affect sprouting resistance. In addition, this cluster has the least number of members that use straw for roofing or who prefer high seed prices. It is interesting that the group that places the highest importance on a large number of tillers also has the least number of members that use straw for roofing. It was thought that one of the reasons that farmers prefer varieties with many tillers is because they have alternate uses for the biomass, such as roofing material. One explanation for this result could be that the members of this group don't use straw for roofing material because they sell straw or use it for different purposes. Perhaps they don't have enough straw and this is also why they place a strong value on high tillering varieties because they need the straw. It could also mean that farmers value many tillers for the presumed risk management that if there is a bad season, they will still get some productive tillers.

Cluster I Multinomial Logit modeling

To have enough observations for solutions, the multinomial logit model combines cluster I with the smaller sub-cluster I and quantifies the marginal effects of the demographic, management, and perception variables on the probability of membership in this cluster as shown in Table 15. The interpretation of the marginal effect of "cell phone" (a discrete variable) is that people that own a cellphone are 13.5% more likely to be in cluster I. The probability of being in cluster I increases by 22.9% for respondents from Odaa Jila. In addition, respondents are 19.1% less likely to be in cluster I if they have a straw roof. Therefore, cluster I is represented by members that prefer high yielding (eight tillers and dense, large seed) wheat varieties priced at 850birr, are more likely to come from Odaa Jila than Boru Lencha, own a cellphone, and not have a roof made from straw.

Table 15 Probability of cluster membership based on the effect of various demographic and management variables. The dark grey boxes reveal the variables that contribute to cluster membership within a 10% significance level (p<0.10) and the light grey boxes highlight variables within a 20% significance level (p<0.20).

Marginal probabilities by cluster with respect to the vector of characteristics computed at the means											
	Cluster I		**Cluster II**		**Cluster III**		**Cluster IV**		**Cluster V**		
Variable	**Coefficient**	**p value**	**Coefficient**	**p value**	**Coefficient**	**p value**	**Coefficient**	**p value**	**Coefficient**	**p value**	**Mean**
Constant	0.216	*0.32*	-0.377	*0.12*	0.208	*0.31*	-0.329	*0.10*	0.282	*0.25*	
Age	0.001	*0.86*	0.001	*0.48*	-0.004	*0.22*	0.000	*0.93*	0.002	*0.55*	42.6
Cellphone	0.135	*0.10*	-0.070	*0.14*	-0.124	*0.08*	-0.024	*0.59*	0.083	*0.32*	47%
Total # of hectares	0.012	*0.77*	-0.007	*0.79*	-0.022	*0.60*	0.026	*0.38*	-0.008	*0.85*	2.15
Hatee Handodee	0.144	*0.30*	0.166	*0.20*	-0.135	*0.24*	0.082	*0.41*	-0.257	*0.11*	26%
Oda Jila	0.229	*0.10*	0.208	*0.13*	0.107	*0.25*	0.013	*0.89*	-0.558	*0.00*	30%
Gonde Finchama	0.063	*0.65*	0.165	*0.20*	-0.282	*0.05*	0.249	*0.07*	-0.196	*0.12*	25%
MHH	-0.025	*0.75*	-0.032	*0.41*	0.057	*0.40*	0.026	*0.59*	-0.027	*0.75*	52%
Wealth index	0.000	*0.60*	0.000	*0.49*	0.000	*0.62*	0.000	*0.88*	0.000	*0.81*	40400
Red > nutritious	-0.011	*0.91*	-0.020	*0.69*	0.040	*0.61*	-0.077	*0.31*	0.069	*0.52*	15%
Red > resist sprout	-0.020	*0.78*	0.004	*0.91*	0.019	*0.76*	0.059	*0.22*	-0.062	*0.42*	64%
# of hand weeding	0.000	*0.99*	0.012	*0.56*	-0.003	*0.94*	0.051	*0.07*	-0.060	*0.18*	1.74
# of spray weeding	-0.005	*0.91*	0.006	*0.79*	-0.066	*0.17*	-0.006	*0.81*	0.072	*0.16*	1.68
Urea kg/ha	-0.001	*0.53*	0.001	*0.16*	-0.001	*0.67*	0.001	*0.42*	0.000	*0.86*	15.3
Sprout >1x in 10yrs	-0.062	*0.42*	-0.018	*0.62*	0.044	*0.48*	0.050	*0.29*	-0.014	*0.86*	38%
No waterlogging in 10yrs	-0.094	*0.18*	0.026	*0.47*	0.075	*0.25*	0.070	*0.17*	-0.077	*0.31*	69%
No drought in 10 yrs	-0.033	*0.68*	0.012	*0.76*	0.036	*0.65*	0.061	*0.24*	-0.076	*0.38*	71%
No lodging in 10yrs	-0.059	*0.42*	0.021	*0.57*	0.000	*0.99*	-0.010	*0.82*	0.047	*0.55*	70%
Rust >1x in 10yrs	0.045	*0.64*	0.030	*0.60*	0.083	*0.35*	0.064	*0.28*	-0.222	*0.06*	18%
Birr spent on fungicide	-0.002	*0.89*	-0.002	*0.85*	0.026	*0.09*	-0.037	*0.14*	0.016	*0.35*	807
Wheat straw roof	-0.191	*0.04*	0.167	*0.16*	0.102	*0.26*	0.002	*0.97*	-0.079	*0.47*	84%
# family educ'd>grade 8	0.023	*0.31*	-0.028	*0.13*	0.001	*0.95*	0.021	*0.16*	-0.017	*0.52*	1.51
Off-farm labor	-0.010	*0.90*	-0.041	*0.38*	-0.015	*0.82*	-0.027	*0.56*	0.093	*0.24*	24%
Prefer high priced seed	-0.155	*0.22*	-0.047	*0.53*	-0.034	*0.73*	-0.125	*0.19*	0.360	*0.02*	64%
n & respondent share	72.000	24%	36	12%	60	20%	45	15%	92	30%	
n predicted	34		11		21		20		59		
% correct	47%		31%		35%		44%		64%		
Multinomial logit model likelihood ratio statistic: chi-squared=188, df=92; p<0.0000											

In this case, the demographic information was relatively closely correlated to cluster membership but it is not very descriptive or explanatory. The multinomial logit model was able to correctly predict 47%, or 34 out of 72, of the respondents in this cluster based on their demographic information. The model incorrectly predicted that 11%, 13%, and 26% of members would be in clusters III, IV, and V respectively. Since the actual membership in a cluster is determined by the similarity of preferences, it is not surprising that the correlation of multinomial logit results are low considering the demographic, management, and perception responses are used as proxy variables to explain those preferences. Many of the demographic questions were asked with the expectation that they may explain preferences for the different traits. For example, the color of grain was known to be an important trait so, questions about the perception of color in relation to nutritional content and sprouting resistance were intended to draw out an explanation based on a preference for either white or red grain. I asked about straw roofs to see if this variable might be able to explain a preference for wheat with many tillers. The multinomial logit model does not always confirm these assumptions but in some cases the demographic responses are a good explanatory variable.

For cluster I, it is difficult to know why people that prefer high yielding, average price wheat seed are more likely to have a cell phone but it could be that they are market oriented commercial farmers that use their phones as a source to obtain market information. Likewise, the fact that cluster I prefers many tillers but is less likely to have a straw roof could be due to a current lack of sufficient straw and, hence, the desire for varieties that produce more straw. However, such interpretations would need to be based on further questioning of the respondents. There could be many underlying reasons for preferring different traits and it is not possible, or even helpful, to include them all or to speculate. More extensive knowledge of Ethiopian culture and farming, however, could provide better insight into why certain demographics, like owning a cell phone or having a straw roof, would explain membership in a specific cluster.

Cluster II prefers white grain

Cluster II is made up of 36 respondents, 12% of the sample, that have an overwhelming preference for white grain. The membership in this segment is strong as this is the only cluster that remained unchanged when moving from four clusters to nine clusters (see Appendix 7). This cluster gave grain color a 23.68% relative importance over the other traits, with a preference coefficient of 0.82 for white grain (Table 12). This denotes an increase of 37% in the average base rating for wheat with white grains. All 36 respondents preferred white grain over red grain (Table 14).

This cluster also had the strongest preference of any cluster for density of kernels at 18.17% relative importance (Table 12). Kernels arranged densely on the spike were preferred with a preference coefficient of 0.64 for dense and -0.64 for lax, meaning the base rating would either increase or decrease by 29% depending on whether the wheat variety had a dense or lax kernel structure.

Cluster II valued tillers and rust resistance at only 21.05% and 16.82% relative importance respectively, which were both significantly lower than the average relative importance of the overall sample. Seed price was given a relative importance of 15.55%, with the high price of 1050birr as the only positive coefficient at 0.30. A price of 1050birr for 100kg of seed would increase the average base rating by 14%, whereas the lowest priced seed of 650birr would decrease the base rating by 13%. The middle price range of 850birr had a negative coefficient of -0.01 which has a minimal effect on the base rating (0.5%) but, interestingly, 28% of respondents from this cluster chose 850birr as their most preferred level and 17% chose 650birr as their most preferred level (Table 14). Cluster II placed the least amount of importance on grain size at 4.73% relative importance. Although there was a low amount of importance on this trait, the members were most divided in their preferred level for grain size, 39% would prefer small grain versus 61% preferring large grain.

Cluster II differed in a few demographic variables (Table 13) from the overall sample and other clusters. The most notable descriptive characteristics were that they were least likely to own a cellphone (only 31% had cell phones), and 97% had straw roofs.

Cluster II Multinomial Logit Model

Using the multinomial logit model, a few more variables were identified as significant factors influencing membership in cluster II that were not identified in the demographic statistics. And some of the aforementioned variables were not considered significant using this model. For instance, the perception of white grain as more nutritious was not significant at the 20% significance level using multinomial logit. Referring to the model in Table 15, cell phone, village location, amount of urea, straw roofing, and number of family members with an education level above grade 8 were significant determinants of membership in cluster II. In order to discuss influential variables in cluster II, it was necessary to look at p-values up to 0.20. In this case, the multinomial logit model was a weak predictor of membership. The model correctly predicted only 31% of the respondents to be in cluster II. A weak multinomial logit model may not be unreasonable given that respondents were assigned membership to this cluster based solely on the similarity of preference for white grain and it may be overly ambitious to expect their demographic information to serve as strong proxy variables.

The marginal effects were negative for the characteristics ‘cell phone’ and ‘number of family members with education level above grade 8’. This is interpreted for a discrete variable, like cell phone, as the probability of membership decreasing by 7% for respondents that own a cell phone. This cluster was comprised of 56% female respondents and 44% male respondents which could explain the decrease in probability of cluster membership based on cell phone ownership (fewer females own phones). However, the marginal effect of gender was not identified as significant which suggests that there are complex characteristics shared by people that own a cell phone that are not drawn out by the other variables like age, gender, etc. For a continuous variable, like number of family members educated above grade 8, the interpretation is that for every additional family member with higher than grade 8 education, the likelihood of being in cluster II decreases by 2.8%.

The marginal effect is small for the continuous variable 'amount of urea usage', accounting for only a 0.1% increase in the probability of membership in cluster II for every 1kg per hectare increase in urea application. Respondents from Odaa Jila were 20.8% more likely to be in cluster II relative to those from Boru Lencha and having a roof made from straw increased the probability of membership in this group by 16.7%.

Sub-cluster III dislikes 650birr price and prefers lax, small, red wheat grain

Sub-cluster III in the seven cluster set was a very small cluster, comprised of only nine members (3% of the sample population), but it was so extremely different from the rest of the groups, it was worth examining. This cluster tended to prefer the opposite trait level from every other cluster. The members of this group placed the most importance on price, with a strong disliking for the lowest price of 650birr. The 650birr price level received a preference coefficient of -0.96 meaning that the average base rating would decrease by 27% at the 650birr price level. None of the members of this cluster chose 650birr as their first choice (33% chose 850birr and 67% chose 1050birr, from Table 14). Respondents preferred high priced seed giving it a preference coefficient of 0.69, which would increase the average base rating by 20%.

This cluster was the only group that preferred red grain color, small grain size, and lax kernel structure. The relative importance for grain color was 12.6%, which was the third highest relative importance across the seven clusters. The coefficient was 0.46 for red grain, which would increase the base rating by 13% and white grain would decrease the average base rating by 13%. Every respondent in this cluster preferred red colored grain. Seed density received 10.8% relative importance with a positive coefficient of 0.37 for lax grain, increasing the base rating by 11%.

Fully 89% of respondents preferred lax grain as their first choice. Grain size had the smallest relative importance of all the traits at 6.57% importance. Wheat varieties with small grains increase the rating by 4%.

Sub-cluster III valued the tillers trait at 21.39% relative importance. This group had similar preference coefficients for eight tillers (0.32) and five tillers (0.31) and a strong negative coefficient for two tillers (-0.63). This signifies an increase of 9% in the base rating for either five or eight tillers and a rating decrease of 18% for wheat varieties with two tillers.

Referring to Table 13, this group did not differ significantly from the other groups based on their demographics, management, or perception of wheat grain/seed. It is possible that the results are not significant due to the small sample size of this group. Nonetheless, this cluster is composed of members with unique preferences for the opposite trait level compared to other respondent preferences and this was worth examining further through the Tukey-Kramer HSD (honestly significant difference) test to find which means are different from each other. In a five cluster model, sub-cluster III joins to become part of the larger cluster III and much of its uniqueness is lost. The multinomial logit analysis will be discussed with cluster III.

Cluster III has typical preferences

Cluster III represents 17% of the sample with 51 members. Members of this group placed the highest relative importance on the traits for number of tillers (28.99%), rust disease resistance (23.01%), and seed price (17.38%) (Table 12). However, this cluster's preferences were more evenly distributed across the traits and did not place the highest weight of importance on any one trait unlike the other clusters that had a strong preference for single traits. This segment had a strong negative preference coefficient for two tillers (-0.68) versus 0.02 for five tillers and 0.65 for eight tillers. Therefore, a low tillering wheat variety would decrease the average base rating by 23% whereas a level of five tillers increases the rating by only 0.7% and eight tillers by 22%. A full 94% of respondents preferred eight tillers and none preferred two tillers. Likewise, 94% of members in cluster III preferred rust resistant wheat, which had a preference coefficient of 0.56 resulting in a 19% increase on the base rating. This group strongly preferred wheat priced at 1050birr and almost equally disliked the lowest price of 650birr. Cluster III also preferred dense kernels and large, white grains although the relative importance was not as strong for these traits (10.4%, 11.65%, and 8.57% respectively).

Referring to Table 13, cluster III did not differ significantly from other groups. I will discuss the demographic variables in more detail in the multinomial logit section.

Cluster III Multinomial Logit Model

Sub-cluster III and cluster III were joined together for multinomial logit analysis due to the small sample size of sub-cluster III. The multinomial logit model was relatively weak for this cluster, correctly predicting membership for only one out of three actual members of cluster III. The model incorrectly predicted that 20% of the members would be in cluster I, 10% would be in cluster II, 7% would be in cluster IV, and 28% would be in cluster V based on their demographic characteristics.

According to Table 15, the demographic variables that were significant ($p<0.10$) for cluster III included cell phone, village location, and the cost of fungicide. Ownership of a cell phone by the respondent decreased the likelihood of membership in cluster III by 12%. Similarly, respondents in cluster III were 28% less likely to come from the village of Gonde Finchama than Boru Lencha. The cost of fungicide was calculated based on each member’s response to the number of liters of fungicide used multiplied by the cost of a liter of fungicide. Fungicide cost is a continuous variable and the marginal effects tended to be small, with the probability of membership increasing by 2.6% for every additional 500birr (roughly 1L) spent on fungicide. This cluster placed 23% importance on rust resistance and spent the most on fungicide, confirming this statistic.

Cluster IV prefers rust resistant wheat

Cluster IV has 45 members, comprising 15% of the total population. This cluster overwhelmingly prefers rust resistance to all other traits, giving it a relative importance of 38%. The preference coefficient for rust resistance is 1.24 which increases the average base rating by 56%. Conversely, this group's rating would decrease by 56% for wheat that is susceptible to rust. Fully 100% of members in cluster IV preferred rust resistant wheat varieties.

Cluster IV placed 18% relative importance on seed price, weighting the highest 1050birr price with a preference coefficient of 0.34. A price of 1050birr would increase the average base rating by 15% while the lowest price of 650birr decreased the base rating by 18%. Sixty four percent of respondents preferred the highest price, while 29% preferred the middle price and 7% preferred the lowest price of 650birr.

In comparison to all the other clusters, this cluster placed the lowest relative importance on number of tillers (17%) and seed color (8%). Members had a stronger disliking for wheat with two tillers, giving it a preference coefficient of -0.45, while five tillers and eight tillers received 0.07 and 0.38 preference coefficients respectively. This means that wheat with two tillers decreases the average base rating by 20% while wheat with five tillers increases the rating by only 3% and eight tillers increases the rating by 17%. Grain color had a 9.5% effect on the base rating with white being the preferred color for 73% of the respondents. Members of cluster IV gave grain size the lowest relative importance of 6% with a preference coefficient of 0.02 which changes the base rating by 0.9%. Large grain was the preferred level for 62% of the respondents.

The demographics, management, and perceptions of the members of cluster IV differed from other clusters and the overall sample based on perception that white grain is more nutritious, and the perception that resistance to sprouting is not the same for both red and white seed.

Cluster IV Multinomial Logit Model

The only two variables that were significant at $p<0.10$ were village location and number of hand weedings. I extended the p-value to allow up to a 0.20 significance level and the variables for fungicide cost, number of family members educated above grade 8, and preference for high prices became significant. The marginal effects are interpreted such that members of cluster IV were 25% more likely to come from Gonde Finchama than Boru Lencha. Hand weeding is a continuous variable and is thus interpreted as, for every additional hand weeding, respondents are 5% more likely to be assigned to cluster IV. Unlike cluster III that also valued rust resistance relatively strongly, the marginal effects for cluster IV showed that members were 3.7% less likely to be assigned to this cluster for every unit increase in fungicide cost. Furthermore, for every additional family member that is educated above grade 8, the probability of being in cluster IV increases by 2.1%.

The multinomial logit model was a relatively good fit for cluster IV, correctly predicting membership for 45% of the respondents in this group. The model predicted 22% of members to be in cluster I, 7% to be in cluster II, 4% to be in cluster III, and 22% of members to be in cluster V.

Cluster V prefers high seed price

Cluster V was the largest segment containing 92 members or 30% of the sample population. This cluster placed 24% relative importance on seed price with a strong preference coefficient of 0.81

on the highest price of 1050birr. Wheat seed at this price would increase the average base rating by 28% and was the preferred level for 98% of the members.

Cluster V seriously dislikes low tillering wheat varieties, giving tillering a relative importance of 32%. The preference coefficient for two tillers was -1.13, which would decrease the average base rating by 39%. Members preferred eight tillers (22% increase in base rating) to five tillers (16% increase in base rating) which follows the trend that with every additional tiller, the base rating increases. None of the members preferred two tillers, while 36% preferred five tillers and 64% preferred eight tillers.

The relative importance for rust resistance (14%), grain color (8%), and grain size (7%) were all significantly less than the relative importance given to these traits by the overall sample. The preference coefficient for small size (-0.14) decreases the rating by 5%, red color (-0.22) decreases the base rating by 7.5%, and rust susceptibility (-0.40) decreases the rating by 14%.

There is a significant difference between the number of male head of households and female not head of households between Cluster V and Sub-cluster I. The demographic statistics also show that cluster IV has a significantly different preference for high prices when compared to the other clusters.

Cluster V Multinomial Logit Model

The multinomial logit model for cluster V picked up several variables that were not recognized as significant by the comparison of means tests in Table 13. All of the villages had negative marginal effects, which is interpreted in relation to the left out variable, Boru Lencha. Respondents in cluster V were 26% less likely to come from Hatee Handodee, 56% less likely to come from Odaa Jila, and 20% less likely to come from Gonde Finchama than from Boru Lencha.

For every additional hand weeding, respondents were 6% less likely to be assigned to cluster V and for every additional spray weeding they were 7% more likely to fall into this cluster. In addition, people that responded that they had a rust problem more than once in 10 years were 22% less likely to be in this group.

Given that this cluster preferred high prices in the variety rating exercise, logically, members also chose high priced wheat over low priced wheat when given the choice between two examples of the same variety with only a difference in price. The multinomial logit model confirms this showing that members are 36% more likely to be in cluster V if they would prefer a higher priced seed to a lower priced seed when all other traits were the same.

Based only on the demographic, management, and perception responses as explanatory variables, the multinomial logit model correctly predicted 59 out of the 92 members for cluster V, for an outstanding accuracy of 64%. The model incorrectly assigned 15% of the members to cluster I, while 2% were assigned to cluster II, 11% were assigned to cluster III, and 8% to cluster IV.

Since this technique is adapted from consumer research where lower prices are generally preferred, it came as some initial surprise that most clusters had an overwhelming preference for high seed price. But, wheat farmers in Ethiopia produce the food they consume and sell any excess to the market so it makes sense that they would prefer higher wheat prices that would provide a high return on investment. This trend has also been observed in other studies (Kole et al., 2009; Cox et al., 2011; Tempesta et al., 2010; Campbell et al., 2004) but there the preference for high price may indicate an association between higher prices and better quality products. Indeed, this phenomenon was confirmed by many of my respondents who claimed the reasons they prefer higher seed prices is because they can sell wheat for seed at a higher price; or they believe that a high seed price is an indication of superior quality. Respondents who claimed to prefer the lower priced wheat seed as long as everything else was the same, said if they paid less for wheat seed, they would have more money for other inputs, like fertilizer and fungicide.

4. Conclusion

Understanding consumer preferences is an important factor in predicting the uptake or adoption of new products. This is a well known concept in the private industry but studies on consumer preference are relatively less common in the public sector that produces wheat varieties in developing countries. The majority of wheat breeding programs focus more on increasing yields and less on consumer demand research. It is important to understand the needs of consumers and how products can fill gaps in the existing market or how products can create demand for new markets.

Wheat is an important staple crop in Ethiopia and many farmers depend on wheat as a sustainable source of food and income. Ethiopia is a major producer of wheat although yields remain well below the global and African average. Many constraints contribute to low yields including the infestation of wheat rust diseases, a lack of sufficient seed production and improved seed sources, inefficient management practices, and low adoption rates of improved varieties. Although Ethiopia releases more varieties of wheat each year than most other African nations, few of these varieties are widely adopted. Farmers in Ethiopia use wheat for many purposes, and, therefore, they value high-yield attributes as well as baking quality, grain marketability, and plant dry matter (used for animal fodder, fuel, roofing material, etc.). Limited information is available on the degree to which different wheat traits influence farmers' willingness to adopt a new variety. Given that gender and other demographic factors are thought to influence variety perception, I chose the conjoint analysis method as an ideal technique to use to define consumer preferences. Conjoint analysis is a statistical technique that is often used in market research to determine how people value different traits that make up a whole product. The technique is based on the premise that a farmer's valuation of a product is a result of the utility or satisfaction derived from the many traits that make up the product as a whole (Baker, 1998).

I first conducted focus group discussions and surveys with men and women farmers to determine the traits that are most influential in their decision to grow a new variety. Four independent categories were identified as important to farmers: 1) Quality traits, 2) Agronomic yield traits, 3) Disease resistance, and 4) Harvest/storage traits. The six individual traits derived from the factor analysis procedure that were used in the conjoint analysis survey represented 85 percent of the variation and had the most influence in their category. These traits were:

1) Number of productive tillers per plant
2) Density of kernels per spike
3) Size of grain
4) Disease resistance
5) Grain color
6) Price of seed

Based on my pilot tests, the limits of the study were defined by the number of varieties farmers could evaluate without becoming fatigued. The maximum number of varieties a farmer was able to evaluate was 20 so I had to limit the number of traits to six so there could be several combinations of these traits. For this reason, I did not examine harvest/storage traits in the conjoint analysis study, but these traits clearly have an influence on farmer perception and would be worth studying further.

The focus group discussion revealed many interesting quality traits including flour/dough texture, water absorption, elasticity, stickiness, perceived protein content, color, smell, and leavening time. The intention was to identify positive and negative baking quality traits related to the final bread product by connecting objective traits associated with the grain, flour, and dough to the subjective traits (taste/smell) of the end product. However, quality itself is a subjective trait and a product that is 'good' for one person may be 'poor' for another person. In addition, 'good' quality traits of grain, flour, or dough did not necessarily equate to 'good' quality bread even for the same respondents.

Some interesting traits were revealed from these discussions, including a perception of protein content based on grain color and milling method. The focus group discussions highlighted the variability of traits related to the different stages of processing and preparation. These discussions also emphasized the complexities involved in testing for quality preferences based on the subjective nature of organoleptic testing. The focus on quality testing was identified as a topic for further research which could be useful to reveal the relationship between end-use quality and adoption of improved varieties, as well as, the difference in quality preference between men and women based on their gender roles.

Interviews about gender roles revealed many interesting insights into the perception of women as farmers in Ethiopia. It is generally thought that a 'farmer' is the person who plows the land with oxen. Women are not considered farmers because traditionally they are not allowed to plow the fields. However, discussions with men and women farmers showed that women take part in almost all farming activities in some role. For example, although women do not typically plow the field with oxen, they are following behind the oxen and breaking up the large clods with hand tools. In addition, women were previously thought to have no role in the application of chemicals on farm but it became evident that women have a prominent role in this activity. It is women's responsibility to fetch the water that will be mixed with the chemicals and bring it to the field. According to the manufacturer's labels for the chemicals commonly used to combat rust disease, fungicide tank mixes require from 200 liters to 1000 liters of water per hectare (Syngenta Tilt 250E Approved Instruction Pamphlet, 2010; Syngenta Mancozeb instruction label, 2007) and may need to be applied several times throughout the growing season. The water source in a village can be anywhere from several meters to several kilometers away from a farmer's field or house and this activity could be extremely physically demanding and time consuming for women. An area for further research would be to examine more closely the roles of women in chemical application and the amount of time spent delivering water to the field as this subject is discussed relatively little in gender or wheat farming literature.

When asked to evaluate existing varieties, many women farmers showed a preference for older, local, or obsolete varieties like Batu, Mada Walabu, Israel, Qamadii Guracha, Enkoy, Kei, Romany BC, and Salmayo. There is a perception of better quality from local or older varieties in preparing traditional dishes, home-made fermented beverages, 'diffo dabo', and as straw for roofing material. The most preferred varieties for men were those with strong marketability and high yield, such as, Kubsa, Digelu, Kakaba, Danda'a, Tusie, and Pavon 76. As a follow-up study, it would be interesting to research the perceived quality versus the actual quality of familiar and unfamiliar varieties. For instance, at the point when this research was conducted, very few farmers that grow Kakaba and Danda'a have cooked these varieties because they are much more valuable as seed based on the high demand for rust resistant varieties. Very little was known about the product quality of these varieties and if they were likely to be widely accepted and adopted based on their end-use quality. An analysis of their baking quality and acceptability may provide valuable insight into the adoption of improved varieties.

For the conjoint analysis survey, 158 men and 147 women farmers were surveyed from four villages in the Hetossa district to evaluate their preferences for six attributes of bread wheat: *number of productive tillers* (2, 5, or 8); *density of kernels per spike* (lax or dense); *resistance to* *rust disease* (resistant or susceptible); *size of grain* (large or small); *color of grain* (white or red); and *price in Ethiopian Birr per 100kg bag of seed* (650, 850, or 1050). Male heads of household, female heads of household and female non-heads of household were interviewed using gender-responsive methods. A conjoint analysis of their responses to 18 trait combinations revealed that the number of tillers was the most important attribute in the overall sample. However, cluster analysis revealed seven distinct respondent segments characterized by primary preferences for large grain, high yield/low-priced seed, white grain, small/red/lax grain, rust resistant seed, high-priced seed, and a 'typical' segment that did not have primary preferences for any one trait but had balanced preferences for the expected trait levels. Segment membership was weakly correlated with gender, socio-economic status, usage factors, and constraints to production (e.g. prevalence of rust disease and drought).

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APPENDICES

Appendix 1 Positioning study survey

Positioning Study

Objective of study:

- Determine farmers' familiarity with various wheat varieties
- Identify which varieties of wheat were grown in 2010 meher season (Sep. – Feb.)
- Document the planting intentions (likelihood of using certain varieties of wheat seed) for the 2011 meher season
- Construct a perceptual map of available wheat varieties
- Determine the position/image/niche of three new varieties (Danda'a, Kakaba, and Digelu)
- Compare the position of new varieties to existing varieties

The primary focus of the interview is to evaluate wheat varieties on the basis of perceptions about their performance and image. Each respondent will be asked to compare two varieties according to how well a list of about 35 descriptions fits each one. They will rate the descriptions of each variety on a 5-point scale where 1 means the description "Does not describe the variety at all" and 5 means the attribute "Describes the variety extremely well".

The varieties evaluate by a respondent will be selected based on his/her self-stated familiarity with each one. Farmers will classify them as being "very familiar", "somewhat familiar", "not very familiar", and "not familiar at all". Varieties evaluated will be only those for which a respondent is "very familiar" or "somewhat familiar".

Informed Consent
Introduction: Hello, I am Katie Nelson from Cornell University in New York. I am conducting research on farmers' perceptions of wheat varieties to better understand farmer needs. The results of this study will be provided to the Ethiopian Institute of Agricultural Research and the Kulumsa Agricultural Research Center to guide selection criteria for new varieties that will be suitable to farmers. Your participation is completely voluntary, and at any time you can stop participation in any or all parts of the project.

What the study is about: This study seeks to better understand farmer preferences for wheat variety characteristics and the roles of women and men in wheat production so that this information can be used to influence breeder selection criteria and inform variety release procedures.

What I will ask you to do: Should you agree to participate, you will be asked about your familiarity with wheat varieties and your intentions to grow different wheat varieties, then you will be asked to rank familiar varieties on their performance for important traits, and finally you will be asked about your role responsibilities in wheat production.

The interview will take place in person with the researcher, subject (you) and a translator. Interviews typically last 1 hour.

Risks and benefits: Participation in this study poses no risks to you beyond those faced in everyday life. A possible benefit is that this study may provide plant breeders important information to guide their selection criteria so that appropriate and farmer accepted wheat varieties are developed.

Compensation: There is no pay or other compensation for participation in this study.

Confidentiality: Any personal information that could link you with the research data will remain confidential.

If you have questions: The researcher conducting this study is Katherine Nelson. Please ask any questions you have now. If you have questions later, please contact Katherine Nelson at 0923 210933 or Kmn46@cornell.edu. If you have any questions or concerns regarding your rights as a subject in this study, you may contact the Institutional Review Board for Human Participants (IRB) at www.irb.cornell.edu/irbhp@cornell.edu/ 607---255---5138.

Voluntary Participation: Your participation in this study is completely voluntary. If you do decide to participate now, you can withdraw later at any time. Just contact Katherine Nelson and she will destroy records related to your participation.

Statement of Consent: I acknowledge that I understand the above information, and have received answers to any questions I asked. I consent to take part in the study. The study has been described to me. I understand that my participation is voluntary and that I am free to withdraw my consent and discontinue my participation in the project at anytime without penalty.

Your Signature ___________________________________
Date _______________________
Your name (please print): ____

Wheat Variety Positioning Study

Respondent name ____________________________________

Respondent # _______________________________________

Woreda____

Kabele ____

Age ____________

Size of land holding __________________________________

Male ☐ Female ☐

Wheat varieties rated: Kubsa, Galema, Danda'a, Hawi, Simba, Kakaba, Pavon, Tusi, Israel, Digelu

Districts (Woredas): Dodota (lowland), Hetossa (mid-altitude), Digelu Tijo (highland), Munessa (high altitude?)

Q1 How many hectares of wheat did you grow last year? ______________________________________

Q2 What variety or varieties of wheat did you grow? ____

Q3 How many quintiles of wheat were harvested last year (2002)? Gross __________________________

Q4 Was this an increase or a decrease from the previous year (2001)? _______ How much?___________

Q5 How much of your crop did you lose to yellow rust? ____

Q6 Did you apply fungicide? YES _______ NO _______

How many days after planting did you apply? ____

What type/s of fungicide did you use? ____

How many times did you spray? ____

What was the total cost you spend on fungicide? Birr____________________________________

Q7 How many hectares of wheat will you grow this meher season? ______________________________

Q8 Please answer the following question with 'very familiar', somewhat familiar', 'not very familiar', 'not familiar at all':

Varieties:	Very familiar	Somewhat familiar	Not very familiar	Not familiar at all	Don't know
Kubsa	1	2	3	4	5
Galema	1	2	3	4	5
Danda'a	1	2	3	4	5
Hawi	1	2	3	4	5
Simba	1	2	3	4	5
Kakaba	1	2	3	4	5
Pavon	1	2	3	4	5
Tusi	1	2	3	4	5
Israel	1	2	3	4	5
Digelu	1	2	3	4	5
Other (specify)	1	2	3	4	5

Q9 Now I would like for you to tell me how likely you are to use these different varieties of wheat this year. Please rate how likely you are to use this variety on a scale of one to five where one means you are not likely to use the variety at all and five means you are very likely to use the variety. You may use any number between one and five, the higher the number, the more likely you are to use the variety. You may rate several varieties highly if you are likely to grow more than one variety.

Variety	Grew last year (from Q2)	Likelihood to grow this year
Kubsa		
Galema		
Danda'a		
Hawi		
Simba		
Kakaba		
Pavon		
Tusi		
Israel		
Digelu		
Other (specify)		

Wheat Variety Attribute Rating

(Ask ratings for up to three varieties of wheat based on respondents familiarity with wheat brands from Q8)

Now I would like you to think about different kinds of wheat varieties. I'm going to read some statements and would like you to rate up to three varieties of wheat on each statement. The varieties of wheat are (insert varieties from Q8). As I read each statement, please tell me how well the statement describes the variety using a scale from one to five.

A one means the statement "does not describe the variety at all" and a five means the statement "describes the variety extremely well". You may use any number between one and five, the more the statement describes the variety, the higher the number you should give it.

The first statement is (insert statement). How well does this statement describe (insert first variety)? How well does it describe (insert second variety)? (Repeat for each statement.)

Randomize statements	**Variety 1**	**Variety 2**	**Variety 3**
• Has excellent early vigor			
• Is competitive against weeds			
• Is drought tolerant			
• Is tolerant to wheat rusts			
• Is tolerant to water-logging			
• Is resistant to lodging / The stalk is strong			
• Matures at the right time for my region and my needs			
• Is the appropriate height for my needs (I am satisfied with the amount of straw residue)			
• Is easy to harvest and bundle			
• Does not shatter easily			
• Is easy to thresh			
• Stores well over time			
• Has high yields			
• Has long spikes			
• Has a high density of kernels per head			
• Responds well with low fertilizer rates			
• Has consistent yields year after year			
• Is trusted by other farmers in my area			
• Presents a low amount of risk to me			
• Seed is readily available when I need it			
• Price of seed is a good value			
• Has large grain size (TKW – Thousand Kernel Weight)			
• Grain color is excellent for market sale			
• Has a high flour volume per unit of grain (test weight)			
• Has excellent baking quality for dabo			
• Excellent water absorption of flour			
• Dough has excellent elasticity			
• Has a good 'eye' size for preparing injera			
• Excellent malting quality			

• Color is good for making tala			
• Makes soft dabo			
• The color of dabo is excellent			
• The color of injera is excellent			
• Has good quality straw for animal feed			

1. Roles in Wheat Production

Tasks in Wheat Production	Men	Women	Other (ie. children)
Land preparation			
Planting wheat			
Weeding			
Applying fertilizers			
Applying chemicals (fungicides, insecticides, herbicides, etc.)			
Protecting crop from birds			
Harvesting			
Preparing the threshing site			
Threshing			
Winnowing			
Preparing the gotera or degogo			
Maintaining the gotera or degogo			
Seed selection			
Seed cleaning			
Transporting grain to market			
Selling grain (direct to buyers or to millers)			
Milling grain for home consumption			
Preparing and Cooking - Dabo - Injera - Nefro - Kinche - Kolo - Dabo kolo - Areke - Tala			
Storing prepared products			
Deciding which crops and varieties to grow			
Purchasing or trading new varieties			

Thank you very much for participating!

Appendix 2 Conjoint survey

Conjoint Survey

Objectives of study:

- We want to know how important certain traits are to farmers so we can provide wheat breeders with information on the tradeoffs farmers make among traits
- Farmer's will evaluate 18 pictures of wheat (here called "varieties") that vary in 6 traits or characteristics (here called "levels of attributes")
- We will assess the *strength of preference* for the levels of each attribute and the *relative importance* of each attribute in farmer's decision to grow a variety
- Farmers with similar preferences will be grouped into *segments* to help identify groups with specific likes and dislikes
- Demographic and usage information will be collected to help explain membership in each segment

The primary focus of the interview is to evaluate farmers' perceptions of the performance and desirability of bundles of wheat attributes. Each respondent will be shown 18 pictures described as potential "varieties" and asked to rate them based on their likelihood to buy them for planting, using a scale from 'Definitely would NOT buy' to 'Definitely would buy'.

Informed Consent
The researcher conducting this study is Katie Nelson from Cornell University in New York. If you have questions, please contact Katherine Nelson at 0924 548 555 or Kmn46@cornell.edu. If you have any questions or concerns regarding your rights as a subject in this study, you may contact the Institutional Review Board for Human Participants (IRB) at www.irb.cornell.edu/irbhp@cornell.edu/ 607---255---5138.

What the study is about: This study seeks to better understand farmer preferences for wheat variety characteristics. The results of this study will be provided to the Ethiopian Institute of Agricultural Research and the Kulumsa Agricultural Research Center to help guide selection criteria for new varieties. Your participation is completely voluntary, and at any time you may stop participation in any or all parts of the project.

Should you agree to participate, you will be asked to rate your preference for different wheat varieties on how likely you would be to buy this seed to grow. The interview will take place in person with the researcher, subject (you) and a translator. Interviews typically last 1 hour.

Risks and benefits: Participation in this study poses no risks to you beyond those faced in everyday life. A possible benefit is that this study may provide plant breeders important information to guide their selection criteria in developing more and better wheat varieties for you and other farmers in your region.

Confidentiality: Any personal information that could link you with the research data will remain confidential.

Voluntary Participation: Your participation in this study is completely voluntary. If you do decide to participate now, you can withdraw later at any time. Just contact Katherine Nelson and she will destroy records related to your participation.

Statement of Consent: I acknowledge that I understand the above information, and have received answers to any questions I asked. I consent to take part in the study. The study has been described to me. I understand that my participation is voluntary and that I am free to withdraw my consent and discontinue my participation in the project at anytime without penalty.

Name ______________________________ Date ____________________________________

Survey on Wheat Attribute Preferences

Name____________________________________ Age ________ Respondent # _________________

Mobile number___________________________ Total hectare_____ Own______ Rented______

Kebele ___________________________________ Hectare of wheat _________________________

Male Head of household (HH) ☐ Female HH ☐ Female ***not*** HH ☐

Part I: We will show you 18 cards describing different wheat "varieties". Please mark the line based on how likely you are to purchase seed for each variety at the price listed.

Card 1

Definitely would NOT buy — Maybe buy — Definitely would buy

0……………………..1……………………..2……………………..3……………………..4……………………..5……………………..6

Card 2

Definitely would NOT buy — Maybe buy — Definitely would buy

0……………………..1……………………..2……………………..3……………………..4……………………..5……………………..6

Card 3

Definitely would NOT buy — Maybe buy — Definitely would buy

0……………………..1……………………..2……………………..3……………………..4……………………..5……………………..6

Card 4

Definitely would NOT buy — Maybe buy — Definitely would buy

0……………………..1……………………..2……………………..3……………………..4……………………..5……………………..6

Card 5

Definitely would NOT buy — Maybe buy — Definitely would buy

0……………………..1……………………..2……………………..3……………………..4……………………..5……………………..6

Card 6

Definitely would NOT buy — Maybe buy — Definitely would buy

0……………………..1……………………..2……………………..3……………………..4……………………..5……………………..6

Card 7

Definitely would NOT buy | Maybe buy | Definitely would buy
0……………………..1……………………..2……………………..3……………………..4……………………..5……………………..6

Card 8

Definitely would NOT buy | Maybe buy | Definitely would buy
0……………………..1……………………..2……………………..3……………………..4……………………..5……………………..6

Card 9

Definitely would NOT buy | Maybe buy | Definitely would buy
0……………………..1……………………..2……………………..3……………………..4……………………..5……………………..6

Card 10

Definitely would NOT buy | Maybe buy | Definitely would buy
0……………………..1……………………..2……………………..3……………………..4……………………..5……………………..6

Card 11

Definitely would NOT buy | Maybe buy | Definitely would buy
0……………………..1……………………..2……………………..3……………………..4……………………..5……………………..6

Card 12

Definitely would NOT buy | Maybe buy | Definitely would buy
0……………………..1……………………..2……………………..3……………………..4……………………..5……………………..6

Card 13

Definitely would NOT buy | Maybe buy | Definitely would buy
0……………………..1……………………..2……………………..3……………………..4……………………..5……………………..6

Card 14

Definitely would NOT buy | Maybe buy | Definitely would buy
0……………………..1……………………..2……………………..3……………………..4……………………..5……………………..6

Card 15

Definitely would NOT buy | Maybe buy | Definitely would buy
0……………………..1……………………..2……………………..3……………………..4……………………..5……………………..6

Card 16

Definitely would NOT buy Maybe buy Definitely would buy

0……………………..1……………………..2……………………..3……………………..4……………………..5……………………..6

Card 17

Definitely would NOT buy Maybe buy Definitely would buy

0……………………..1……………………..2……………………..3……………………..4……………………..5……………………..6

Card 18

Definitely would NOT buy Maybe buy Definitely would buy

0……………………..1……………………..2……………………..3……………………..4……………………..5……………………..6

Part II: Demographic and Wheat Usage questionnaire

Q1 What variety or varieties of wheat did you grow meher season 2004 (hectares of each variety)?_____

____

Q2 How many quintals of wheat were harvested this year from each variety? ______________________

____

Q3 How many quintals will you keep for home consumption? ___________________________________

Q4 How many quintals will you keep for seed for next planting season?___________________________

Q5 How many quintals will do you sell immediately after harvest?______ # of Quintals sell later?______

**(Note: Number of quintals from Q3, Q4, Q5 should add up to the # of quintals in Q2.)

Q6 Do you suffer storage losses? Yes ☐ No ☐ How much?_______________________________

Q6.1 Yes: What are the causes? Moisture______ Rodents_____ Weevils_____ Other______

Q7 How often do you renew seed? Every year ☐ 2 years ☐ 3 years ☐ 5 years ☐

Q8 Where do you get seed (mark all that apply)? Other farmers______ Farmer union_______

Ethiopian Seed Enterprise______ Market _______ Other __________________________________

Q9 List the traits that determine your decision of what variety to grow from most important (1) to least important (6):

____Baking quality

____ Price of seed (to buy)

____Market price (for sale)

____ Yield potential

____Disease resistance

____Seed color

Q10 Do you think the color of wheat grain (red or white) effects protein/vitamin content? No, they are the same ☐ Yes, Red grain has more ☐ Yes, White grain has more ☐

Q11 How many times do you weed your wheat field? _______________By hand ______ Herbicide_____

Q12 How much fertilizer do you use (kg/ha)? DAP___________ Urea __________ Compost __________

Q13 In the last 10 years, late rains causing pre-harvest sprouting is a problem: never___ once___ 2-3 times___ 4-8 times___ every year___

Q13a Do you think red or white grain is more resistant to sprouting? No, they are the same ☐

Red grain is more resistant ☐ White grain is more resistant ☐

Q14 In the last 10 years, waterlogging is a problem: never___ once___ 2-3 times___ 4-8 times___ every year___

Q15 In 10 years, drought is a problem: never___ once___ 2-3 times___ 4-8 times___ every year___

Q16 In 10 years, lodging is a problem: never___ once___ 2-3 times___ 4-8 times___ every year___

Q17 In 10 years, rust is a ***serious*** problem: never___ once___ 2-3 times___ 4-8 times___ every year___

Q17a Do you apply fungicide (Tilt or other)? YES☐ NO☐ If yes, liters/ha _____ Birr/liter_____

Q17b Where do you get fungicide? Farmers union ____ Market____ Government loan_____

Q18 How many of each livestock animal do you own: Oxen______ Donkeys______ Goats______ Sheep_____ Horses______ Chickens______ Male beef cow______ Female cow______ Other____

Q19 Do you use wheat straw for: Roofing____ Bed stuffing ____ Animal feed ____ Fuel ____

Q20 Do you prefer red or white wheat for making tala? I don't make tala ____ White ____ Red_____

Q21 What is your income from selling **other** crops? ____

Q22 Number of people living in your house including you and your spouse/spouses: Males ___________

Ages _________________________ Females ________________ Ages _________________________

Q23 How many people in your family have education level above grade 8?_________________________

Q24 Do you hire labor or use family labor only? Family labor only ___ Hire for: Plowing___ Planting ___

Weeding ___ Harvesting ___ Other _________________

Q25 Do any family members have other sources of income (off-farm labor)? YES ☐ NO ☐

Q25a If yes, what kind of work? ____

Q26 Suppose there are equal seeds except one is low in price (650birr) and one is high in price (1050birr), which do you prefer? Low ☐ High ☐ Explain why (ex. I can sell as seed to other farmers; I assume price is an indication of high or low quality; if it costs more, I can sell it for more and make more money)? ____

____

Thank you very much for participating!

Appendix 3 Examples of conjoint survey cards showing the visual representation of number of tillers and density of kernels per spike

Appendix 4 Images used for the conjoint survey to depict 8, 5, and 2 tillers

Appendix 5 Images used for the conjoint survey to depict lax and dense kernels

Appendix 6 Picture of the seed samples shown to respondents during the conjoint survey to depict seed size and color

Appendix 7 Division of four clusters to nine showing where each cluster splits to form a new cluster. This can be interpreted as Cluster II (green) that has a strong preference for white grain and Cluster V (blue) preferring high seed price are comprised of members that have the strongest similarity in preferences.