WHY DO HOUSEHOLDS CULTIVATE LANDRACES? WHEAT VARIETY SELECTION AND *IN SITU* CONSERVATION IN TURKEY

by

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ABSTRACT

Socioeconomic/household characteristics, agroecological heterogeneity, market access, and variety characteristics are used to empirically explain why households continue to cultivate traditional varieties of wheat in Turkey even though higher-yielding modern varieties exist. These determinants are then used to examine on-farm diversity outcomes and how the availability of modern varieties is affecting the *in situ* conservation of crop genetic resources from landraces.

Socioeconomic/household characteristics, agroecological heterogeneity, and market access are all found to jointly influence households' decisions to cultivate landraces and to affect on-farm diversity outcomes. Empirical estimation shows that variety characteristics do not jointly affect the probability that households plant landraces, nor do they affect on-farm diversity levels. Policy recommendations and ideas for future research are provided.

CHAPTER 1

INTRODUCTION

Although high-yielding, modern varieties of staple cereal crops exist in the world today, farmers in cradles of crop genetic diversity continue to plant landraces (Bellon and Brush 1994; Meng 1997). Landraces (traditional varieties) are varieties of crop plants whose genetic composition is shaped by household agronomy practices and natural selection pressure over generations of cultivation (Smale, Bellon, and Aguirre 2001). Modern variety refers to varieties that have been developed by professional breeders (Hintze 2002).[1]

The continued cultivation of diverse varieties of crops, including landraces, is one way to conserve crop genetic resources. The conservation of crop genetic resources in areas where the crops are grown is referred to as *in situ* conservation. The other method of conserving crop genetic resources is in gene banks, which is referred to as *ex situ* conservation.

Ex situ and *in situ* conservation are both ways of conserving crop genetic resources, but different costs and benefits are associated with each. The benefit of *ex situ* conservation is that scientists are able to maintain genetic diversity in stable environments. Seed is stored in isolated, sterile settings, thereby assuring the preservation of the genetic resources in the same state as when the seed is stored. The disadvantage of *ex situ* conservation is that once the seed is stored, the genetic evolution of the seed stagnates. *Ex situ* conservation is also expensive due to the costs associated with housing the seed and maintaining the storage. *In situ* conservation, alternatively, is advantageous in that the seed is continuously evolving. Crops are subjected to changing agroecological conditions and household selection practices. This helps the genetic resources to evolve over time. The disadvantage of *in situ* conservation is that there is no guarantee that households will continue to plant traditional varieties. That *in situ* conservation presently continues does not ensure that this method of crop genetic resource conservation will continue in the future, which could hinder future evolution of rare crop genetic resources from landraces over time as modern varieties are increasingly adopted.

The questions to be answered in this thesis are: 1) what are the plot-level determinants of traditional wheat variety cultivation on farms in Turkey; and 2) how do those determinants affect on-farm diversity outcomes?[2]

Crop genetic diversity can be defined and measured in many ways, ranging from a simple count of the number of different crop varieties within a farm or a region to indices based on morphological traits or genetic composition. Crop genetic diversity is important to agrarian households for several reasons. Different varieties can allow households to adapt crops to combat changing abiotic and biotic stresses (Brush 1992). Bellon and Taylor (1993) show that diverse varieties of one crop help optimize yields in heterogeneous environments. Households can manage production risks such as rainfall

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[1] As Hintze (2002) notes, landraces can also be improved, either through farmer selection practices or by ongoing attempts by breeders to improve them.

variability by planting diverse varieties of the same crop (Feder, Just, and Zilberman 1985). In the presence of incomplete markets, households are more likely to depend on producing their own food (Hintze 2002), and crop diversity can be used to provide variety to households that consume a large portion of a single crop (Hernandez X. 1985). Crop diversity can also be important for cultural ritual or to forge social ties within some agrarian communities (Bellon 1996b).

Meng (1997) empirically determines which households in Turkey would be most likely to plant landraces using a household land-use decision model. Land-use decisions in her analysis are a function of risk aversion, socioeconomic/household characteristics, agroecological heterogeneity, and market access. She also links land-use decisions to on-farm diversity outcomes and examines the implications for *in situ* conservation.

More recently, variety attributes have been incorporated into technology adoption models.[3] Smale, Bellon, and Aguirre (2001) study maize production and consumption attributes demanded by households and resulting maize diversity outcomes. Hintze (2002) researches the impact of maize variety characteristics and market characteristics on technology adoption. Most recently, Edmeades (2003) combines risk aversion, agroecological constraints, market access, socioeconomic/household characteristics, and variety attributes to model demand for individual varieties of bananas in Uganda.

In this study, socioeconomic/household characteristics, agroecological heterogeneity, market access, and variety attributes are incorporated into a household

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[2] A diversity outcome is defined in this study as the number of different wheat varieties, modern or traditional, that are found on the individual household's farm.
[3] Technology adoption in this context refers to the adoption of modern varieties for cultivation.

land-use decision model to examine the decision to plant traditional varieties in Turkey. These determinants of land-use decisions are then examined to see how they influence on-farm diversity outcomes.

The results of this study could have several policy implications. Identifying the variety attributes that households demand could have implications for breeding programs. If policy makers support *in situ* conservation of landraces, they could use information on which land-use determinants raise the probability of landrace cultivation to design programs aimed at maintaining this form of crop genetic resource conservation.

Wheat is chosen as the crop of focus for this study due to its overwhelming importance as the grain most consumed by humans in the world. World wheat consumption was around 600 million tons per year in 2000 (75 percent of which was used for direct consumption). Wheat is also the most traded grain in the world (Ekboir, J (ed.) 2002).

Turkey is the area of study because it has been shown to be a cradle of wheat domestication and diversity (Harlan 1951; Hawkes 1983). This is important because areas where crops were first cultivated have been shown to contain highly diverse populations of the crop due to the substantial periods of time over which agroecological and producer selection pressures have affected the crops (Brush 1992; Bellon and Taylor 1993). Thus, diverse arrays of landraces as well as modern varieties are encountered. Additionally, Turkish wheat consumption per capita in 2000 was 290 kilograms, making Turkey one of the highest per capita wheat consuming countries in the world (Ekboir, J (ed.) 2002).

This thesis proceeds as follows: chapter two reviews research on technology adoption models and *in situ* conservation; chapter three provides an examination of previous theoretical work as it pertains to land-use decision models; chapter four describes the survey methodology of the data collection and provides descriptive statistics that illustrate differences in households by province and agroecotype; in chapter five, the explanatory variables are described and hypothesis testing is conducted; and conclusions are drawn in chapter six and implications of this study are used to prescribe policy solutions designed to maintain landrace cultivation, as well as to suggest ideas for further research.

The contribution of this thesis is to extend existing empirical research on technology adoption and diversity outcomes by using socioeconomic/household indicators, agroecological heterogeneity, market access, and variety attributes as independent variables. New data are analyzed, and empirical results largely reinforce previous research on technology adoption in Turkey, including previous work by Meng (1997) that shows that asset wealth and livestock holdings are associated with higher probabilities of landrace cultivation in Turkey, which counters other existing technology adoption literature that typically shows that asset wealth and livestock holdings are associated with more modern variety cultivation. On-farm diversity outcomes are examined and the results add empirical evidence in support of previous work, though the present research shows high consistency in results across different diversity metrics used, which have traditionally been much more variable.

CHAPTER 2

LITERATURE REVIEW

As modern varieties of crops have become more accessible and widespread, research has increasingly focused on technology adoption decisions and diversity outcomes across households. Researchers have sought to explain adoption patterns of modern crop varieties that are supposed to generate much higher yields, as well as the decision by some households to continue to cultivate landraces. Although adoption rates in agriculture can range from full adoption of new technologies to zero adoption, most studies show that the adoption of new technologies is partial.[4] Although not a policy concern in Turkey at present, if *in situ* conservation of crop genetic resources becomes a policy concern, it will be important to understand the factors that influence household decisions to partially adopt new agricultural innovations and to understand how adoption decisions influence on-farm diversity.

In this chapter, theoretical and empirical research regarding technology adoption and *in situ* conservation of crop genetic resources is reviewed. It begins with a review of technology adoption determinants, including risk aversion, socioeconomic/household characteristics, agroecological heterogeneity, market access, and variety attributes. Diversity measures are then examined. On-farm diversity studies are subsequently discussed.

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[4] See, for example, Feder and Umali (1993) and Bellon (1996b).

Adoption of Technology

One of the first economists to examine technology adoption in agriculture was Zvi Griliches (1957). He examines acceptance and ceiling adoption rates of hybrid corn in the United States. He finds that variables representing profitability of adopting at the household level and later at the district and state levels help to explain differences in adoption of hybrids across the United States. His major goal is to demonstrate that economic variables can be used to explain technology adoption in agriculture, and from his innovative research, a wide body of technology adoption studies have been produced.

Risk aversion, often empirically represented by socioeconomic/household characteristics, can be an important factor in a household's decision of whether to adopt a modern variety or continue to plant landraces. Agroecological heterogeneity, market access, and variety attributes have been increasingly used as explanatory variables in empirical research on land-use decisions. This section reviews these four components of the household land-use decision model, all of which are used in this thesis.

Risk Aversion

Households potentially face production and consumption risk after the planting decision has been made, and risk aversion has been the most widely cited theory to explain why households continue to cultivate landraces (Meng 1997; Hintze 2002).

A risk-averse household is willing to trade off higher expected yield in return for lower yield variance. To make this tradeoff, a risk-averse household can diversify its crop portfolio by choosing among available alternatives that could include modern and traditional varieties.[5] The household has expectations about the yield of the landraces though years of cultivation experience. Although the expected yield of landraces may be lower than modern varieties in optimal growing conditions, they are viewed as less risky by the household because the household has more information about their yields through experience. The higher-yielding modern varieties may have larger expected gains in yield, but they may also present more risk because they are less known to the producer.[6]

Using the von Neumann and Morganstern expected utility approach, Sandmo (1971) theoretically shows that in a competitive market with price-taking firms, risk-neutral firms have a higher output than risk-averse firms. However, he stops short of examining risk mitigation by portfolio diversification. Instead, his analysis shows that with price uncertainty, producers reduce risk by reducing output.

Arrow (1970) presents portfolio diversification as a way to reduce risk. A risk-averse investor can choose to invest in an option that has a rate of return that is known at the time of investment or in an asset that has a variable rate of return. To decrease risk, a risk-averse investor will diversify her portfolio to contain both high-risk assets and low-risk assets.

Feder (1980) discusses risk aversion and the choice between modern and traditional varieties. Using the expected utility model, the risk-averse household is theoretically shown to plant less area to modern varieties as risk aversion increases.

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[5] Smale, Just, and Leathers (1994) characterize the choice between modern and traditional varieties as a portfolio problem.

[6] Feder (1980) cites studies showing that modern varieties have high variability in performance. This may be caused by biotic and abiotic stresses in the growing environment and how modern varieties react to these stresses.

Similarly, an increase in yield variability of modern varieties, *ceteris paribus*, leads to less land allocated to modern varieties. Also, as landholding increases, area planted to modern varieties increases, though Just and Zilberman (1983) theoretically demonstrate that the proportion of land allocated stays fixed as farm size increases if relative risk aversion is constant.[7] Risk aversion is represented in both studies as a farmer's decision to adopt a modern variety given modern or traditional varieties' mean yields, variances, and the covariances, and given that households can reduce risk by planting diverse varieties.

These studies, however, focus extensively on production risk. Finkelshtain and Chalfant (1991) theoretically extend the concept of risk to include consumption risk since many agricultural households in developing countries consume part of their production. The authors find that traditional univariate risk models that solely consider production risk do not apply to agricultural households in developing countries because most face production and consumption risk from their on-farm agricultural production.

Fafchamps (1992) extends the work of Finkelshtain and Chalfant (1991). In it, he considers households that participate in markets and consume a quantity of their production. He examines the crop and variety choices these households make when confronted by risk. His theoretical findings indicate that more risk-averse households seek to insure against consumption risk by increasing production of consumption crops, and that only households with a low share of expenditures in food will devote a larger share of production to cash crops.

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[7] This conclusion is empirically demonstrated in Brush, Taylor, and Bellon (1992).

Socioeconomic/Household Indicators

In many studies, production and consumption risk are empirically estimated using household/socioeconomic characteristics. Such factors, including farm characteristics like farm size and on-farm fragmentation, can influence land-use decisions. Socioeconomic/household characteristics that influence the wealth perception of a household, such as asset wealth and livestock holdings, can also influence technology adoption. Other determinants, such as education, farm experience, and the number of dependents in the household have also been shown to affect technology adoption rates in agriculture.

Perrin and Winkelmann (1976) empirically study the effect of farm size on technology adoption. They find that farm size plays a significant role in adoption rates, with large farmers more likely to adopt a modern variety before small farmers, though small farmers eventually catch up in adoption rates. They postulate that this can result for several reasons. One is that large farms possibly benefit from economies of scale in transactions costs. Second, large farmers are probably able to reduce the risk of experimenting with new crops much more easily than small farmers. A large farmer can dedicate a small cropping area to a new crop with less risk relative to a small farmer who is dependent on a smaller amount of land for consumption and market production. Also, large farmers may have lower per-unit input costs relative to small farmers. If they can obtain quantity discounts, they are more likely to choose to experiment with the inputintensive technology. Further studies have shown that farm size is a significant factor in land-use decisions.[8]

Brush, Taylor, and Bellon (1992) empirically examine the effects of on-farm fragmentation on the adoption of technology. Fragmentation refers to the number of separate plots that a household cultivates per unit of cultivated land. As the number of separate plots increases, so does the level of fragmentation. As fragmentation increases, the authors argue that environmental heterogeneity also likely increases because the plots can be spread out over several agroecological zones. This could make it riskier to cultivate only one variety because the plots of the farm may vary drastically in terms of overall land quality. The authors argue that more fragmented farms are likely to contain more diversity because several variety types could be needed to match the varying agroecological conditions. Although the authors conclude that fragmentation does not have a significant effect on area planted to improved varieties, it does have a significant, positive effect on the level of on-farm diversity.

Other household characteristics that have been empirically shown to influence land-use decisions include education (Lin 1991; Meng 1997), asset wealth and livestock holdings (Meng 1997; Winters, Hintze, and Ortiz 2005), years of experience farming and the number of dependents living on-farm (Edmeades, Smale, and Karamura 2005), and livestock holdings (Kurosaki 1996; Edmeades, Smale, and Karamura 2005).

The land-use decision model in this thesis includes socioeconomic/household characteristics. Previous empirical studies of technology adoption by agrarian

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[8] Examples of other technology adoption studies that show this result are Feder (1980), Feder and O'Mara

households in developing countries have shown these factors to play significant roles in land-use decisions households make.

Agroecological Heterogeneity

Another important set of determinants that could influence variety selection at the household level is that of agroecological constraints. The quality of the land that a household cultivates can strongly influence the decision to adopt a new technology or to continue to plant a landrace.

Households' cultivated land characteristics can vary from one plot to another (e.g., soil quality, rockiness, the slope of the plot, etc.). This can affect land-use decisions because modern varieties typically perform better than traditional varieties under optimal farming conditions (Feder 1980; Bellon and Taylor 1993).

Perrin and Winkelmann (1976) empirically examine agroclimatic conditions and topography (degree of slope of the plot) as explanatory variables in their study of adoption rates between large and small farmers. They conclude that, "relatively subtle agroclimatic changes in gradients can lead to dramatic changes in farmer behavior" (p.892). Heterogeneity in land quality can lead to large variation in expected yield for households within a small geographic area. Hence, technology adoption can depend greatly on the quality of a given household's land.

Jansen, Walker, and Barker (1990) empirically test agroecological constraints in their study of adoption ceilings (i.e., upper limit of adoption within a population of

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(1981), Feder, Just, and Zilberman (1985), and Brush, Taylor, and Bellon (1992).

households) in India for coarse cereal cultivars. They find that agroecological variables have significant explanatory power in adoption rates.

Bellon and Taylor (1993) empirically study "folk" soil taxonomies in Chiapas, Mexico, and find that the soils that are considered to be the best by households are associated with higher levels of modern variety cultivation.[9] Conversely, poor soil is often found to be associated with traditional varieties.

Meng (1997) finds that high quality soils are less likely to be planted to landraces, but highly sloped plots of land (degree of topography) are associated with landrace cultivation. Van Dusen (2000) finds that increasing degrees of topography and elevation correlate positively with the number of varieties planted.

Land-use decisions by households can be shaped in part by the quality of the land on the farm. Agroecological variables are thus considered in the household land-use decision model used in this paper.

Market Access

Another determinant of land-use decisions is market access and how it influences a household's ability to participate both in the market for seed and input acquisition and the market to sell output. Households in less developed countries may be confronted with markets in which not all inputs are available or in which they may not be able to sell their output, and at times with no market structure at all. This could impact the quantity of traditional and modern varieties the households decide to cultivate.

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[9] Folk taxonomies are taxonomies generated from colloquially named soil types, i.e., farmer-labeled soils.

To operate in the market, households face transactions costs that ultimately influence land-use decisions. A market failure occurs when the transactions costs associated with an exchange within the market cause a greater disutility to the household than the potential benefits from exchange, with the result that the household does not participate at all. Absence of a market altogether is the most extreme case of market failure. In most cases, however, markets exist but not all households have identical access. For this reason, market failures in the case of agricultural households should be considered household-specific and not commodity-specific (de Janvrey, Fafchamps, and Sadoulet 1991).

Goetz (1992) builds on the idea that market failure is household- rather than commodity-specific to test the impact of information on market participation. He empirically shows that households that are sellers in the coarse grain market are more likely to have better market access than non-sellers.

Along with risk aversion, socioeconomic/household characteristics, and agroecological constraints, Meng (1997) uses market access to empirically explain land-use decisions. Distance to market and road quality both influence the variety choices of households. Omamo (1998) empirically finds that high transport costs directly influence households and result in the decision to plant low-return food crops. Hintze (2002) also empirically tests road quality as an indicator of transactions costs and finds it to be positive and significant for modern maize variety adoption.

Distance to market, road quality, and access to input and output markets have been shown to affect households' land-use decisions. This thesis includes variables to measure the effect of market access on land-use decisions by households.

Variety Attributes

No variety of any given crop will have all of the characteristics valued by household farms (Bellon and Brush 1994). Hintze (2002) lists some of the characteristics that households value, including drought resistance, wind resistance (tall plants tend to lodge, or fall over, more than short plants), insect resistance, disease resistance, agroecological adaptability, time to maturity, yield and variance characteristics, and various consumption and storability characteristics. One variety is likely to embody some, but not all, of the characteristics that households value, so they may mix their portfolios to gain the attributes they desire. Landraces and modern varieties typically perform differently in terms of yield, require different amounts of inputs, and have different market and consumption characteristics. For example, Meng (1997) finds that modern varieties are valued more for their yield characteristics than are traditional varieties, and Bellon (1996b; Bellon et al. 1998) finds that traditional varieties perform better with households for consumption characteristics.

Lancaster (1966) theoretically develops the idea that consumers value goods because the goods possess certain characteristics that the consumers value. Demand functions for attributes are derived by maximizing utility over attributes as choice variables. He also argues that goods, when combined, may possess characteristics that are different from when those goods are judged on their characteristics alone and then aggregated. Ladd and Suvannunt (1976) theoretically extend this analysis by showing that the price paid for a good is the sum of the marginal values of the characteristics that the good possesses. However, Hintze (2002) argues that hedonic pricing studies are more appropriate when variation in price and characteristics exist and may not apply in the case of agricultural commodities due to the relative uniformity of prices within crops.

Adesina and Zinnah (1993) analyze perceived characteristics and the adoption of modern variety technology. They empirically find that production and consumption attributes are significant factors in determining adoption and variety use rates.

Smale, Bellon, and Aguirre (2001) use farmer perceptions of variety characteristics to empirically estimate the demand for maize varieties in Mexico. They then link the determinants of demand for variety attributes to community-level maize diversity. They apply a model based on Lancaster's model of consumer characteristics that shows how households maximize utility from multiple attributes of multiple varieties of maize. They show that variety attributes and agroecological conditions both have significant effects on technology adoption when each group of variables is tested jointly, and that consumption characteristics are more important than production characteristics in terms of significance and magnitude. They also show that household characteristics, when tested jointly, do not significantly affect demand for varieties.

Hintze, Renkow, and Sain (2003) empirically test socioeconomic/household factors, variety characteristics, and transactions costs as determinants of maize adoption in Honduras. Using a model based on Lancaster's (1966) characteristics model, the authors also incorporate research on the impact of transactions costs to test the determinants of household land use decisions. They empirically show that households perceive important differences among modern and traditional varieties and that no variety suffices for all of the characteristics households demand. Households typically favor modern varieties for their production attributes, but prefer traditional varieties for their consumption characteristics. The authors demonstrate that while transactions costs and production characteristics significantly affect modern variety adoption, consumption characteristics do not.

Recently, Edmeades (2003) incorporates variety characteristics, socioeconomic/household characteristics, risk aversion, transactions costs, and agroecological heterogeneity into a household land-use decision model for bananas in Uganda. She derives reduced-form demand for individual varieties. She stresses the importance of testing the demand for individual varieties because econometric estimation shows that the main determinants of individual variety demand are cultivar-specific. The empirical results show that explanatory variables for variety attributes and transactions costs are jointly significant across the six varieties tested, and that other explanatory variables vary in significance and explanatory power for each cultivar.

Variety characteristics likely contribute to the understanding of variety selection and portfolio composition of households, and are included in the empirical analysis conducted in this thesis.

The model to be used in this paper incorporates these determinants of land-use decisions. Socioeconomic/household characteristics, agroecological heterogeneity, market access, and variety attributes have each been empirically shown in previous research to make important contributions to our understanding of household variety selection.

The following section provides an overview of relevant research on *in situ* conservation. Much of the research on *in situ* conservation has sought to link land-use determinants to levels of on-farm diversity. Research that has linked technology adoption to on-farm diversity provides the motivation for this thesis, as we seek to link land-use decision factors to on-farm diversity outcomes.

In Situ Conservation

As discussed in chapter one, *ex situ* and *in situ* conservation are practiced by gene banks and households. *Ex situ* conservation depends on the willingness of research institutions to take on caretaker roles for crop genetic resources by managing gene banks. *In situ* conservation, on the other hand, is the result of production decisions of households. That *in situ* conservation currently continues without policy intervention does not ensure that the practice will continue in the future.

The study of technology adoption models is key to gaining an understanding of *in situ* conservation and if and to what extent it will continue. Many empirical technology adoption studies have been used to study levels of on-farm diversity and how the introduction of modern varieties has affected this diversity.

To examine diversity outcomes in this thesis, two diversity indices are constructed using “folk” names given to varieties by households in Turkey. After a description of diversity metrics is provided, studies that link land-use determinants to on-farm diversity are reviewed.

Diversity Measures

Crop diversity can be measured in various ways.[10] Some methods to measure diversity examine morphological traits (physical characteristics observable to scientists and farmers), while others use detailed molecular analysis to discern variation across crop populations. Economic studies that link household land-use decisions to levels of on-farm diversity vary in the methods that are used to quantify diversity, and the results from the same study can be sensitive to the diversity index used.

Spatial diversity refers to the amount of genetic diversity found over a given geographical area. It is the most commonly used indicator of diversity, and measures the number of species within a region. The number of species can be measured as simply the number of named varieties provided by farmers. The number of species can also be scientifically determined by genetic analysis. For this study, spatial diversity is measured using two indices, the Berger-Parker index and the Shannon index, using variety names given by surveyed households.

The Berger-Parker index is constructed by dividing one by the maximum proportion of an individual household's land planted to a single variety. It is designed to show the dominance, or relative abundance, of the varieties within a geographic area. A low score indicates that one variety dominates a large portion of the farmer's land. As in the case of Turkey where many households plant only one variety, the Berger-Parker index value will be one. As the index value increases, it signals that dominance of any one variety cultivated on the household farm decreases. The number of varieties grown does not matter per se, as this index reflects the most dominant variety per farm.[11]

The Shannon index measures both the number of varieties cultivated and their frequency over the study area. It is constructed by first multiplying the percentage of each variety grown on a single farm by the natural log of that proportion. The products for each variety are then summed and multiplied by -1. The majority of households in Turkey plant one variety, and the Shannon index for those households takes the value of zero. The Berger-Parker index only reflects the relative abundance of the varieties planted on a household's land. The Shannon index reflects both the number of varieties and their relative abundance, giving greater weight to the number of varieties cultivated by one household, even if those varieties are cultivated in relatively small proportions.[12]

Table 1: Spatial Diversity Indices Used for Diversity Regression Analysis.

Index	**Concept**	**Construction**	**Explanation**
Shannon	Evenness, equitability, proportional abundance	$D = -\sum \alpha_i \ln \alpha_i$ $D \geq 0$	α_i = area share of population share occupied by *i*th farmer-managed unit of diversity
Berger-Parker	Inverse Dominance	$D = 1/\max(\alpha_i)$ $D \geq 1$	Max(α_i) is the maximum area share planted to any single farmer-managed unit of diversity

[10] This section draws on Meng et al. (1998) and Smale (2005).
[11] To clarify, consider the following example: a household that plants two varieties equally on its land would have a score of 2, reflecting that the most dominant variety cultivated is planted to 50 percent of its land (1/0.5 = 2). A second household plants three varieties, but it plants one of those varieties to 70 percent of its land and the other two varieties to 15 percent of its land each. The score for the second household is (1/0.7 = 1.43). Even though the second house plants more varieties per se, the Berger-Parker index ranks it lower in terms of relative abundance because the household's land is dominated by one variety.
[12] To extend the example, using the Shannon index to compute the first household's diversity would give a value of: -1[2(0.5 x ln 0.5)] = 0.69; and the second household would have a value of: -1[(0.7x ln 0.7) + 2(0.15 x ln 0.15)] = 0.81. The Shannon index weights the number of varieties planted more than the Berger-Parker index.

Table 1 describes how each index is computed.[13] The following section reviews studies that link technology adoption to on-farm and community level diversity. The Berger-Parker index and the Shannon index are commonly used measures of diversity in the studies reviewed below.

Diversity and *In Situ* Conservation

Brush, Taylor, and Bellon (1992) study factors that influence the adoption of modern technology in Andean potato agriculture and the effects on on-farm diversity outcomes. They empirically test socioeconomic/household indicators and plot-level agroecological characteristics on modern variety adoption. They then use the same variables to measure the effect of technology adoption on diversity outcomes. The authors find that genetic diversity, measured as the number of named varieties of potatoes, declines on individual farms as the area in improved varieties increases. They are unable, however, to show that a loss in individual farm diversity results in a loss of diversity at the aggregate level within their study areas. This is due to several factors. Names given to varieties across regions tend to differ for the same variety, households across given regions vary in the amount of diversity they maintain, the level of household exchange of varieties differs, and households continue to diversify their crop portfolios.

Meng (1997) uses the household model consisting of risk aversion, socioeconomic/household characteristics, market access, and agroecological

[13] Table 1 is adopted from Meng et al. (1998). A farmer-managed unit of diversity in this analysis is a variety of wheat, regardless of the intra-variety diversity it may exhibit.

heterogeneity to link variety choice to observed levels of on-farm diversity in Turkey. To measure diversity, she uses two morphological indices, the Shannon index and the Coefficient of Variation (CV) index. The Shannon index uses morphological measurements from seed grown out under uniform conditions, and the CV index shows variation in yield between different varieties from experiment station measurements. Meng tests the effects of the variables used in the technology adoption model on on-farm diversity outcomes. She empirically shows that the diversity outcome results can be sensitive to the type of diversity index used, as the Shannon index has much higher explanatory power than the CV index for the variables tested.

Van Dusen (2000) empirically tests socioeconomic/household indicators, agroecological conditions, and market access on land-use decisions that households make and then links these variables to on-farm diversity outcomes within cropping systems.[14] He uses a Variety Count index and the Shannon index of morphological traits to measure diversity. His results show that the land-use determinants in his empirical model have varying effects on the levels of diversity for individual crops within cropping systems and that the factors are jointly significant in explaining on-farm diversity. He also shows that the Variety Count and Shannon indices produce statistically different diversity outcomes for the same individual variables estimated, showing that linking land-use decisions to diversity outcomes can be sensitive to the type of diversity index chosen for the study. General implications of the study suggest that market development decreases on-farm genetic diversity while dependence on family labor increases on-farm diversity. His major policy suggestion is that *in situ* conservation policy must encompass crop systems as the focus instead of single crops.

Smale, Bellon, and Aguirre (2001) incorporate the use of variety characteristics into the agricultural household model to help explain diversity outcomes. They empirically show that increases in consumption characteristics positively influence on-farm diversity.

Edmeades, Smale, and Karamura (2005) link demand for banana cultivars to diversity levels in Uganda. They empirically test the importance of consumption and production variety attributes, socioeconomic/household characteristics, market access, and agroecological heterogeneity on diversity outcomes using the Variety Count index and the Shannon index. Production characteristics of banana cultivars are found to increase on-farm diversity, yet consumption attributes do not significantly impact diversity outcomes. Livestock holdings increase diversity, but cash income decreases diversity. Of farm characteristics, both plantation age and stock of village cultivars positively impact diversity outcomes, but high rainfall tends to reduce diversity. Also, banana sales in the market have a positive influence on diversity outcomes.

Winters, Hintze, and Ortiz (2005) examine the determinants of on-farm diversity levels of potatoes in Peru with a specific focus on the household's decision to diversify agricultural income sources, in this case with milk production. They measure diversity

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[14] A cropping system is defined as all the varieties from all crops grown by a single household. For example, households in southern Mexico often grow maize and squash or maize and beans. A cropping

using the Variety Count, Berger-Parker, and Shannon indices and empirically test diversity outcomes on human capital variables of the household, agroecological variables of the farms, and rural development variables, including a wealth index, milk production, non-farm income share, access to credit and potato markets, and household participation in programs to reduce blight by planting new, blight-resistance tubers. Area of land owned, fragmentation, and altitude all have a significant, positive effect on on-farm diversity, while the cultivation of potatoes in only black soils negatively affects diversity outcomes. An increase in the number of harvests is associated with a decrease in diversity. The wealth index is found to be positively associated with diversity, as is access to an output market. Milk production and off-farm income both negatively affect diversity outcomes. Participation in programs associated with planting cultivars that are resistant to late blight is found to be positively associated with diversity.

Gauchan et al. (2005) empirically examine the determinants of rice diversity at the household level in Nepal and how the land-use determinants used to investigate diversity outcomes affect the probability that a landrace is cultivated. The authors use the Variety Count, Berger-Parker, and Shannon indices as measures of diversity. The education of the decision maker and availability of on-farm labor both positively affect rice diversity. Likewise, distinct land types and irrigation on-farm both positively contribute to diversity. Distance to market positively influences diversity outcomes, yet the sale of modern varieties on the market negatively affects diversity.

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system for these households would be all of the varieties of maize and squash or maize and beans grown on the household's land.

Gebremedhin, Smale, and Pender (2005) empirically test household characteristics, agroecological heterogeneity, market access, modern variety adoption, and village and regional factors on inter- and intra-specific crop diversity.[15] Instead of using the household as the unit of analysis, the authors use aggregate, village-level associations. The diversity metrics used are the Variety Count, Berger-Parker, and Shannon indices. The results of the regression analyses depend heavily on the crop of study, as maize, wheat, and barley are all used. The results reflect findings similar to the papers listed above.

Conclusion

In this chapter, research that is the most relevant to this thesis is reviewed. The determinants of land-use decisions have been thoroughly discussed. Diversity metrics and *in situ* conservation studies are then summarized. Landrace displacement by modern varieties may result in a loss of genetic diversity on-farm, and policy intervention could be necessary to maintain on-farm conservation in the future.

[15] Inter-specific crop diversity is genetic diversity among varieties of more than one crop. Intra-specific crop diversity refers to genetic diversity found between varieties of the same crop.

CHAPTER 3

REVIEW OF EXISTING THEORY

Current technology adoption studies combine risk aversion, socioeconomic/household indicators, agroecological heterogeneity, market access, and variety attributes into cohesive theoretical models to provide hypothesis predictions. However, these complex models do not produce definitive comparative statics predictions. When treated separately, though, researchers have been able to generate hypothesis predictions for variables of interest for this study. In this chapter, theoretical models regarding land-use and diversity determinants are reviewed.

Risk Aversion

As described earlier, Sandmo (1971) showed that risk-averse producers faced with price risk would optimally produce less output, *ceteris paribus*, than risk-neutral producers. This work, combined with Arrow's (1970) research on portfolio choice, gave rise to research that examined technology adoption using models of risk and uncertainty.

Some of the more important research regarding technology adoption and risk aversion is summarized in chapter two. In this section, comparative statics predictions that have been made involving technology adoption and risk are reviewed.

Feder (1980) and Just and Zilberman (1983) examine farm size, use of inputs, and the adoption of modern technology. The authors construct a model based on a single farm with fixed landholdings and a traditional technology. A new technology is introduced, allowing the household to plant a traditional crop and a new, modern variety.

The household decision maker is assumed to be risk averse. Wealth is equal to the return from production plus the total value of land. The household can incur a fixed cost to implement the new technology. The household thus maximizes utility over land allocated to the old and new technologies, subject to a land constraint.

Assuming the sufficient second-order conditions hold for a maximum, the authors derive an important comparative statics prediction. They show that the change in land allocated to the new technology is positively associated with a change in total landholdings when relative risk aversion is increasing and absolute risk is decreasing. If the correlation in yield between modern and traditional varieties is low or negative, larger farmers are more likely to cultivate more land to new technologies than smaller farmers. Modern varieties are often less known to the households than traditional varieties. This uncertainty presents risk to the household when facing the decision of what to cultivate. A household with more land to cultivate can mitigate production risk associated with cultivating a modern variety that is unknown to it. Hence, the cost of experimentation is lower and larger farmers will likely be more willing to cultivate modern varieties than small farmers. The authors also show that although the amount of land planted to modern varieties increases as landholdings increase, households do not necessarily plant more modern varieties as a proportion of total landholdings.

Fafchamps (1992) argues that although food markets may be present, only wealthy households are able and willing to grow proportionally less of a consumption crop, holding cropping area constant. As households spend proportionally less on food (e.g., as wealth increases), the need for food self-sufficiency decreases.

The model Fafchamps (1992) uses assumes that the household makes cropping decisions in the first period and then crops are harvested, sold, and consumption decisions are made in the second period. As a result, prices and income are known with certainty when consumption decisions are made. Households maximize the expected utility of agricultural income over land planted to individual varieties subject to production and land constraints.

By using the Taylor expansion of the first-order conditions derived from the utility maximization problem, the optimal crop portfolio is expressed as a function of consumption expenditure shares, income elasticity, relative risk aversion, correlation between prices and revenues, coefficients of variation of prices and revenues, and the ratio of expected returns from crop sales. From this function, comparative statics predictions are derived.

The first prediction is that a risk-averse household whose share of expenditures on food is large will produce more of the consumption crop than a household whose share of total expenditures on food is smaller. As wealth increases and food expenditures decrease as a proportion of total expenditures, we would expect to see households cultivate more modern varieties, based on the assumption that modern varieties are preferred for their production attributes (e.g., yield, disease resistance) and that traditional varieties are preferred for their consumption attributes (e.g., taste, storability, quantity of residue for feed).[16]

The next prediction of interest considers the effect of a change in income elasticity on crop portfolio. Fafchamps (1992) shows that when consumption prices and output are positively correlated, cultivation of a consumption crop insures the household against price uncertainty in the market for consumption goods. High income elasticity, however, leads to high expected gain from price variability. Hence, a household with high income elasticity for a particular variety will tend to cultivate less of it.

The last comparative statics prediction Fafchamps (1992) demonstrates concerns risk aversion. He argues that more risk-averse households will want to insure themselves against consumption risk by cultivating more of the consumption variety.

Fafchamps combines these three predictions to examine how an increase in farm size, wealth, or expected income affects crop portfolio decisions. By assuming constant returns to scale in production, a change in farm size has no effect on expected yields. Such a change only affects crop portfolio decisions because of its impact on consumption shares, risk aversion, and demand elasticities. He argues that an increase in wealth leads to an increase in non-consumption varieties based on the following assumptions: the price elasticity for staple crops is low; income elasticity for staple crops is smaller for wealthy households than for poor households, and; poor households with little means to insure

[16] Meng (1997), Hintze (2002), and Edmeades (2003) all discuss findings from their survey work indicating that these assumptions are generally true. Meng (1997) surveyed wheat producing households in Turkey and found that landraces were preferred for their consumption attributes while modern varieties were ranked better for their production attributes.

themselves against consumption risk are likely to be more risk averse than wealthy households.

Given the conclusions of Feder (1980), Just and Zilberman (1983), and Fafchamps (1992), variables that indicate farm characteristics and wealth should be included in the empirical analysis in this thesis. Farm size and fragmentation are both household-level farm characteristics that can influence landrace cultivation and on-farm diversity.

Livestock holdings present a method to help reduce risk by offering an alternative source of income from crop production, as well as the option to directly consume part of the holdings. Asset wealth is included and represented using off-farm property holdings, the number of rooms in the household, the number of buildings on the household's farm, and car ownership.

Socioeconomic indicators, such as the decision maker's years of farm experience and education, as well as a ratio indicating the proportion of dependents to the total family size, are also included in the empirical testing.

Agroecological Heterogeneity

The importance of agroecological heterogeneity has also been incorporated into recent models of technology adoption, typically represented by land quality, soil quality, topography, and/or irrigation. Bellon and Taylor (1993) formulated a theoretical framework to provide useful predictions regarding the effect of agroecological constraints on technology adoption.

The authors construct an expected profit maximization model in which the household can choose between two technologies: a local variety and a higher-yielding, modern variety. The household allocates a fixed quantity of land to the two technologies. Expected profits can vary by land quality because different technologies perform differently by land quality. For instance, they assume that modern varieties typically yield better under optimal land conditions than traditional varieties. Conversely, though, landraces outperform modern varieties on marginal lands. It is assumed that there is a sunk cost associated with adopting the modern variety that the household does not face when planting its existing traditional variety.[17] With the added possibility of imperfect credit and capital markets, three solutions to the maximization problem are discussed.

The first scenario is one in which the household has homogenous land quality and faces perfect capital markets. In this case, households will either fully adopt the new technology or continue to plant all land to the traditional variety. Expected profits and costs are the same on all of the household's land, so if the expected profits from adoption are greater for planting a modern variety, given the sunk costs of adopting the modern variety, the household fully adopts. If expected profits of adopting the modern variety are less than what the household expects from cultivating landraces, the household continues to cultivate the traditional variety.

The second outcome of the theoretical analysis regards technology choice when land is of heterogeneous quality and capital markets are perfect. In this case, the extent of technology adoption depends on the proportion of high and low quality lands.

[17] This sunk cost would mostly entail the cost of learning about available modern varieties, how they

Households will adopt when the expected profits of distinct land-quality niches exceed those of planting traditional varieties. A likely outcome is that modern variety adoption will be partial and that modern varieties will be planted to high quality land, while the household will continue to cultivate landraces on low quality land.

The last scenario examined is one in which the household has heterogeneous land quality and faces imperfect capital markets.[18] With imperfect capital markets, if the sunk cost of adoption exceeds the household's ability to borrow money on credit, the household will not adopt even if the expected profits of the modern variety exceed those of the traditional variety for a given land quality. If the sunk cost of adopting the modern variety does not exceed the capital constraint, the household will adopt the modern technology on land with the largest expected profit gains over old technologies until the credit constraint becomes binding, when the household will then shift back to landrace cultivation.

When combined, these three scenarios yield testable predictions about changes in land holdings. The first two scenarios imply that if high-quality land holdings increase, the household will be more likely to cultivate modern technologies. In case three, an increase in high-quality land holdings will result in adoption of the modern technology, but only until the credit constraint on the household becomes binding.

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perform, and of acquiring the seed.

[18] In this case, imperfect capital markets are characterized by restricted access to credit. Households that do not have access to credit may be restricted in their ability to purchase modern variety seed and inputs.

Based on findings derived in Bellon and Taylor (1993) and other literature reviewed in chapter two, variables indicating the land quality and availability of irrigation for each plot are used in the empirical testing presented in chapter five of this thesis.

Market Access

As a complement to the effects of risk aversion and agroecological heterogeneity on technology adoption, research has also begun to consistently include transactions costs associated with acquiring information and acting in input and output markets as an explanation of variety choice.[19]

Omamo (1998) develops a utility maximization model in which the household jointly makes its consumption, production, and trade decisions subject to an income constraint, a constraint that inputs into production must equal production outputs, the household's production function, and transactions costs. The household can be a net seller, a net buyer, or autarkic. The household is also assumed to produce two crops, a staple crop and a cash crop. For the purposes of this thesis, it is assumed that modern varieties are what the household grows for trade in the market, i.e., the cash crop due to household preferences for modern varieties' production characteristics. Traditional varieties are more demanded for their consumption characteristics and are thus used as the staple crop.

Omamo shows that transport costs have the same effect on households, regardless of whether the household is a net buyer or a net seller. For a household that is a net buyer in the market, an increase in transport costs is associated with an increase in production of the staple crop (i.e., landrace production). If the household is a net seller in the market, an increase in transport costs implies reduced production of the good of which the household is a seller, which is typically the cash crop (i.e., modern variety production).

Variables that indicate transactions costs and access to information are therefore included in the empirical testing conducted in this paper. Distance to mill is used as an approximation for transport costs. Knowledge of recommended varieties, which represents access to information about the best varieties per province and agroecotype, is used to show access to information and markets. The district-level supply of wheat varieties is also included to represent household access to diverse varieties.

Variety Characteristics

Different varieties exhibit differing combinations of production and consumption attributes, and households may cultivate combinations of varieties to maximize their utility from the attributes of the varieties.

As previously described, Lancaster (1966) develops a model in which the household maximizes utility over the attributes. In developing his model, Lancaster is able to derive demand functions for the attributes of goods that households desire, and therefore for the goods that the household can purchase. From Lancaster's work, Ladd

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[19] See, for example, Meng (1997), Winters, Hintze, and Ortiz (2005), and Edmeades, Smale, and Karamura (2005).

and Suvannunt (1976) show that the price paid for a good is equal to the summation of the marginal values of the characteristics to the household.

Hintze (2002) and Edmeades (2003) both set up comprehensive theoretical models that include risk aversion, socioeconomic/household characteristics, agroecological constraints, transactions costs, and variety attributes. In Hintze, the household gains utility through the consumption of maize characteristics, market goods, and leisure. The household grows maize varieties that exhibit different production characteristics subject to a production function, a budget constraint that incorporates full income and transactions costs of participating in input and output markets, and a time constraint. He derives the prediction that for a household that is a net seller or buyer in the market, a rise in transactions costs causes a decrease in the amount of maize produced by the household for sale in the market and an increase in consumption of home-produced maize. Hintze concludes that households that participate in the market will likely tend to satisfy at least some of their consumption needs. Households that are completely autarkic have to satisfy their consumption needs. When considering the production and consumption demands of households that participate in the market or are autarkic, Hintze concludes that variety characteristics must be considered as determinants of variety selection. His model does not, however, produce comparative statics predictions for the effect of a change in the amount of a production or consumption characteristic on the level of technology adoption for a modern variety.

Edmeades (2003) likewise develops a model in which a banana producing household maximizes utility through the consumption of banana variety characteristics, market goods, and leisure. The household is subject to income, time, variety, and non-tradability constraints, as well as the production function that depends on the production characteristics of the varieties as well as farm characteristics (e.g., agroecological conditions, rainfall). She derives the demand for each variety as a function of market price of the variety, the price of all other goods, and income, subject to exogenous household, farm, market, and risk variables. Edmeades examines comparative statics outcomes for changes in household, market, and risk factors on output supply and variety demand. The model, however, does not produce comparative statics predictions due to its mathematical complexity.

Conclusion

This chapter has reviewed the determinants of land-use decisions separately to theoretically show how each set of determinants can influence households' cultivation decisions. Recent research in which socioeconomic/household indicators, agroecological heterogeneity, market access, and variety attributes have been combined into cohesive models has failed to provide testable hypotheses.

Because theoretical predictions have not been generated from one cohesive model, socioeconomic/household indicators, agroecological heterogeneity, market access, and variety attributes are empirically examined in this paper and compared to the results of existing empirical research on technology adoption and on-farm diversity.

To develop an understanding of the surveyed provinces of Turkey, descriptive statistics that highlight differences between households are presented in chapter four.

These statistics help to shape expectations for the empirical testing conducted in chapter five.

CHAPTER 4

DATA SOURCES AND DESCRIPTIVE STATISTICS

In this chapter, the data used for empirical testing are summarized. First, the methodology of the household-level surveys is discussed. Descriptive statistics of the households are then presented. The statistics are used to develop a better understanding of differences in the surveyed provinces of Turkey, as well as to describe the empirical measures of the theoretical concepts of the model: socioeconomic/household characteristics, agroecological conditions, market access, and variety attributes.

Survey Methodology

The principal interest of the socioeconomic survey was to obtain information on agrarian household characteristics during the 1997-98 cropping cycle. A total of seven provinces from Turkey were selected as sites and surveyed from May to July of 1999. The provinces were chosen by researchers from the International Maize and Wheat Improvement Center (CIMMYT, Int.) to ensure that there would be regional variation in typical varieties grown, market infrastructure, and home consumption of wheat. Within each province, two districts were selected. The districts were selected based on subjective assessments of access to markets and the quality of the infrastructure, with one district selected to represent high quality market access and infrastructure and one to represent poorer access to markets and infrastructure. Market infrastructure was determined by the availability of outlets for the sale of wheat, such as mills, flour factories, and feed factories within each district. Market access and infrastructure were judged by the survey team in terms of the quality of roads within the area. Variation in the levels of wheat production and home consumption were other factors considered in choosing districts.

Once the districts were chosen, villages were selected based on three agroecotypes. In any given district, a village in each of a valley, hillside, and mountain agroecotype was selected, with a fourth village selected to represent the most prevalent of the agroecotypes in the district. Upon arrival at the village, approximately ten households were chosen as randomly as possible to be interviewed for the household surveys.

Two exceptions to this methodology exist. The first is that the provinces of Sivas and Kayseri were combined and treated as one province.[20] Thus, the process described above applies except that one district from each province was selected instead of two. The other difference in methodology applies to the provinces of Eskisehir and Kutahya. When possible, the households surveyed in these provinces were the same households that were surveyed as part of the research for Meng (1997). The survey methodology used at that time was the same as for this survey, so no disparity in methodologies should exist. When households previously surveyed for Meng (1997) were not available, other households were randomly chosen.[21]

[20] Sivas and Kayseri were chosen and combined because a researcher from the Agricultural Economics Research Institute who collaborated on the project with CIMMYT had previously researched these areas. The areas were included in this survey to help compile a panel data set.
[21] The same households were revisited when possible to create a separate panel data set for future research by CIMMYT. Panel data could reveal important trends that cross-sectional data sets do not.

The survey is included as Appendix A of this paper. Most of the variables described in this and the following chapter come directly from the survey. At times, though, new variables were generated from the original data collected.

Overview of Surveyed Households

Of the 486 households originally surveyed, 416 remain for use in the empirical analysis. Households were dropped from the analysis if they failed to provide information necessary for complete econometric analysis or did not cultivate wheat in 1997-98.

The data presented in this chapter are stratified at three different levels of analysis: 1) the household level; 2) the household-variety level; and 3) the plot level. Many of the summary statistics presented are at the household level of analysis and contain 416 observations per table.

Two of the tables in this chapter, though, are at the household-variety level. These tables contain 563 observations from 416 households. This is necessary because some households cultivated more than one variety, so information specific to each variety (e.g., source of seed, source of information) may vary within the same household. For example, one household may have cultivated two varieties, one of which came from farm-saved seed, and the other of which came from seed purchased on the market. This stratum of data is not used in the empirical analysis in chapter five, but is nonetheless useful to highlight differences in market access between households and within the same households.

The last tier of analysis is at the plot level and has 1,669 observations corresponding to every wheat plot cultivated by the 416 households. The plot-level analysis captures differences in land quality and irrigation that can vary within the same household's land cultivated to wheat.

Socioeconomic/Household Indicators

Table 2 presents an overview of the surveyed households. The surveyed households averaged 12.1 hectares in total land holdings, and roughly 50 percent of that land was planted to wheat. The 12.1 hectares of land were spread over 8 parcels of land on average and wheat was planted to roughly half of those parcels.

Table 2: Selected Household Characteristics, 1997-98.

	N	Total Land (Ha)	Total Land Planted to Wheat (%)	Total Parcels	Parcels Planted to Wheat (%)	Fragmentation Index	Modern Variety Only (%)	Traditional Variety Only (%)	Modern and Traditional Varieties (%)
All Households	416	12.1	49.6	7.8	52.6	13.0	47.6	35.8	16.6
Province									
Eskisehir	73	13.8	68.8	8.2	62.8	9.5	87.7	6.8	5.5
Kutahya	69	9.8	59.2	11.2	58.9	16.8	26.1	31.9	42.0
Kastamonu	59	5.7	56.1	7.8	55.1	18.7	40.7	25.4	33.9
Malatya	75	10.7	42.1	5.9	44.1	8.0	58.7	38.7	2.6
Sivas/Kayseri	68	25.7	40.5	9.1	41.8	5.3	45.6	39.7	14.7
Erzurum	72	6.7	35.8	4.9	44.9	20.3	23.6	70.8	5.6
Agroecotype									
Valley	128	13.1	54.2	7.7	57.1	12.2	59.4	24.2	16.4
Hilly	178	14.3	45.5	8.6	48.8	10.5	52.3	30.9	16.8
Mountain	110	7.4	51.4	6.6	54.5	19.0	26.4	57.3	16.3

The fragmentation index is used to represent the degree to which the land cultivated by a household is divided into separate plots (also referred to as parcels) of land and reflects agroecological heterogeneity.[22] The index is a ratio of the total number of plots cultivated by the household to the household's cultivated total area, so the index values represent plots per hectare. A high index value indicates a high level of land fragmentation. The average fragmentation index score across all households was 13, but the range varied from 5.3 in Sivas/Kayseri to 20.3 in Erzurum. The average score of 13 means that there were 13 cultivated plots per hectare cultivated to wheat on average for the households surveyed.

In provinces with relatively small farm holdings and high fragmentation index scores, such as Kastamonu, Kutahya, and Erzurum, the majority of households surveyed cultivated traditional varieties alone or with modern varieties. Also, households in the mountainous agroecotype had the smallest farms and the highest amount of fragmentation on average, and 73.6 percent of mountain zone farms planted traditional varieties alone or with modern varieties. These results may indicate a correlation between small farm size, a large degree of fragmentation, and traditional variety cultivation.

Of the households surveyed, 47.6 percent specialized in the cultivation of modern varieties only, 35.8 percent cultivated traditional varieties only, and 16.6 percent planted both modern and traditional varieties simultaneously.

[22] Plots can vary in size and can only be planted to one variety.

Table 3: Household Family Characteristics, 1997-98.

	N	Decision Maker Male (%)	Decision Maker Experience (Years)	Decision Maker Education (Years)	Dependency Ratio	Households for which Agriculture Was Most Important Source of Income (%)
All Households	416	99.3	30.2	4.8	0.33	82.9
Province						
Eskisehir	73	98.6	32.3	4.8	0.28	95.9
Kutahya	69	98.6	33.8	4.1	0.35	76.8
Kastamonu	59	98.3	30.8	4.6	0.35	93.2
Malatya	75	100.0	32.5	5.0	0.31	80.0
Sivas/Kayseri	68	100.0	28.3	4.9	0.32	76.5
Erzurum	72	100.0	23.6	5.1	0.36	76.4
Agroecotype						
Valley	128	100.0	30.9	4.8	0.33	89.8
Hilly	178	98.3	29.5	4.9	0.34	84.3
Mountain	110	100.0	30.5	4.4	0.31	72.7

Table 3 presents family characteristics of the surveyed households. The person responsible for determining the number and type of varieties in the household was typically a male with roughly 30 years of farm experience and close to 5 years of education. The average family size across the surveyed households was 5.7 persons. The dependency ratio, calculated as the number of children under the age of 13 plus adults over 60 years of age divided by total family size, is approximately 0.33 for all households. That indicates that roughly one-third of the members living in any given household are not of working age and are dependent on the working members of the household. For an average of 82.9 percent of households, agriculture was the most important source of income.

Table 4 shows the main sources of income for the surveyed households. Livestock was the most important source of income for roughly 50 percent of the households surveyed and was the main source of income for households in all provinces except Malatya, where fruit production was more important.

Table 4: Primary Source of Income by Percentage of Households, 1997-98.[23]

	N	Wheat (%)	Sugar Beets (%)	Fruit Trees (%)	Livestock (%)	Retirement Pension (%)	Labor Wages (%)	Other (%)	Total (%)
All Households	416	17.6	9.6	6.7	49.8	5.3	2.4	8.6	100.0
Province									
Eskisehir	73	23.3	23.3	0.0	50.7	0.0	0.0	2.7	100.0
Kutahya	69	21.7	14.5	0.0	36.2	14.5	4.4	8.7	100.0
Kastamonu	59	8.5	5.1	0.0	83.1	1.7	0.0	1.6	100.0
Malatya	75	30.7	1.3	37.3	12.0	9.3	2.7	6.7	100.0
Sivas/Kayseri	68	17.7	2.9	0.0	60.3	0.0	1.5	17.6	100.0
Erzurum	72	1.4	9.7	0.0	63.9	5.6	5.6	13.8	100.0
Agroecotype									
Valley	128	18.8	25.0	4.7	42.2	3.1	1.6	4.7	100.0
Hilly	178	21.4	4.5	9.6	46.1	5.6	2.8	10.0	100.0
Mountain	110	10.0	0.0	4.6	64.6	7.3	2.7	10.8	100.0

Wheat ranked as the second most important source of income for households in all provinces except for Erzurum, where wheat was the primary source of income for only 1.4 percent of households surveyed. Other main sources of income included sugar beets, retirement pension, labor wages, figs, and barley.

As livestock was the most important source of cash income on average, it is useful to examine livestock ownership. The decision to plant a landrace could depend on the household's wealth at the time of planting, as well as on the household's need for residue to be used as feed.[24] Livestock holdings may represent a way for households to reduce risk by augmenting their income as opposed to the sole production of wheat for

[23] Other may contain agricultural and non-agricultural sources of income.

income. Livestock holdings could also increase a household's demand for wheat residues.

Households were asked whether they considered themselves to be wealthy, of medium wealth, or poor. Wealth perceptions are not used in the empirical testing to indicate wealth because of the subjectivity of the classification, but are useful to demonstrate that households that considered themselves to be wealthy also typically had more livestock holdings.

Table 5 shows livestock ownership in 1996 by own-wealth perception. Households held an average of 12.7 head of sheep, 1.8 head of goats, and 7.2 head of cattle. For sheep and cattle, households that viewed themselves as wealthy owned more livestock on average than medium-wealth households, and medium-wealth households owned more head of sheep and cattle than poor households. Interestingly, household goat holdings increased as own-wealth perception declined, possibly indicating that goats are inferior livestock holdings compared to cattle and sheep.

Table 5: Household Livestock Holdings by Wealth Perception, 1996.

	N	Sheep (head)	Goats (head)	Cattle (head)
All Households	416	12.7	1.8	7.2
Wealth Perception				
Wealthy	55	27.6	0.9	11.7
Medium	288	11.8	1.8	7.0
Poor	73	4.8	2.6	4.5

[24] Residue refers to wheat straw that can be used as feed.

Other important indicators of household wealth are asset holdings. For this study, the number of buildings on the household's farm, number of rooms in their houses, car ownership, and off-farm property holdings are used to represent asset wealth. As discussed in chapter three, as wealth increases, risk aversion decreases, *ceteris paribus*, thus allowing for households to adopt modern varieties with less risk. Own-wealth perceptions are again used to help show that asset holdings accurately indicate wealth as households judge themselves.

Table 6: Household Wealth Indicators by Own-Wealth Perception, 1997-98.

	N	Off-Farm Property Holdings (%)	Numer of Rooms in the House	Number of Buildings on the Farm	Car Ownership (%)
All Households	416	24	4.25	2.44	15
Wealth Perception					
Wealthy	55	45	4.96	2.96	38
Medium	288	22	4.31	2.49	13
Poor	73	16	3.53	1.85	4

Table 6 shows asset holdings by own-wealth perception. Wealthy households outranked medium and poor households in all asset holdings. Approximately 45 percent of households that classified themselves as wealthy owned property outside the family farm, whereas only 22 percent of medium-wealth households and 16 percent of poor households had off-farm property holdings. Wealthy households lived in houses with an average of 4.96 rooms, while medium-wealth households had 4.31 rooms and poor households had 3.53 rooms. Wealthy households had 2.96 buildings on the farm on average, medium-wealth households had 2.49 buildings, and poor households had 1.85 buildings on the farm. Similarly, 38 percent of wealthy households owned at least one car, while 13 percent of medium-wealth households and only 4 percent of poor households owned a car.

Agroecological Heterogeneity

Table 7 summarizes plot-level agroecological characteristics of the land cultivated by the surveyed households. On average, 20.7 percent of the plots of land were judged by the households to be of high quality. The majority of the land was of medium quality, with less than 10 percent of the plots considered as low or extra low in quality. On average, 22 percent of the plots cultivated by surveyed households were irrigated, though there was a high variation depending on the province and agroecotype. Plots in Erzurum and Eskisehir exhibited high levels of irrigation, while the plots in Sivas/Kayseri rarely were irrigated.

Table 7: Plot-Level Agroecological Conditions, 1997-98.

	N	Plots Ranked as High Quality Land (%)	Plots Ranked as Medium Quality Land (%)	Plots Ranked as Low or Extra Low Quality Land (%)	Plots with Irrigation (%)
All Plots	1669	20.7	69.4	9.9	22.0
Province					
Eskisehir	368	29.1	64.1	6.8	38.0
Kutahya	454	19.4	70.5	10.1	16.1
Kastamonu	243	14.4	67.1	18.5	12.8
Malatya	192	14.1	80.2	5.7	14.1
Sivas/Kayseri	254	18.5	74.0	7.5	3.5
Erzurum	158	25.9	62.1	12.0	55.1
Agroecotype					
Valley	550	33.8	60.2	6.0	39.1
Hilly	732	14.5	76.1	9.4	13.1
Mountain	387	13.7	70.0	16.3	14.5

Market Access

Access to input and output markets can be an important determinant in land-use decisions. Table 8 details the average distance to a mill and household participation in the output market in 1997.[25] Households were roughly 16 kilometers from the nearest mill, though there was a wide variation between provinces. In Malatya, Erzurum, and Kutayha, mills were relatively close to the households on average and not more than 10 kilometers in distance. In Sivas/Kayseri, Kastamonu, and Eskisehir, on the other hand, the nearest mill was not closer than 18 kilometers in distance to the households on average.

Table 8: Market Access, Wheat Sales, and Output Markets for Households, 1997-98.

	N	Average Distance to Mill (Km)	Households that Sold Wheat in 1997 (%)	Households that Sold to Local Government (%)	Households that Sold to Merchant (%)	Households that Sold to Mill (%)	Households that Sold to Other Source (%)
All Households	416	15.7	51.5	22.5	25.1	3.2	3.5
Province							
Eskisehir	73	25.7	83.5	50.5	22.4	4.1	15.2
Kutahya	69	9.8	71.8	23.0	48.5	0.3	2.1
Kastamonu	59	18.0	24.3	1.7	13.7	10.6	0.0
Malatya	75	6.4	50.9	5.3	44.7	0.9	2.7
Sivas/Kayseri	68	28.0	57.9	41.0	14.7	2.9	0.0
Erzurum	72	7.6	16.7	11.1	4.2	1.4	0.0
Agroecotype							
Valley	128	13.7	72.6	36.8	31.7	3.7	5.3
Hilly	178	16.1	51.0	20.9	26.7	3.6	2.1
Mountain	110	17.5	27.9	8.5	14.8	1.8	3.6

[25] Distance to mill is used to represent distance to the nearest town or village with some level of market infrastructure.

Household participation in the output market was also markedly different from province to province. Roughly half of the surveyed households sold wheat in 1997. In provinces such as Eskisehir and Kutahya, a large majority of the surveyed households sold wheat. By contrast, less than a quarter of the households in Kastamonu and Erzurum sold wheat. Buyers of wheat from the households also differed by province.[26]

Households in mountain zones were the farthest distance from the mill on average. They also sold less wheat on average than the households in the other two agroecotype zones.

Table 9: Seed Availability and Sources by Province by Household-Variety, 1997-98.

	N	Problems Obtaining Desired Seed (%)	Farm Saved (%)	Neighbor / Relative (%)	Co-Op (%)	Seed Co./ Merchant (%)	Goverment Seed Supplier (%)	Other (%)	Total (%)
All Households	563	6.6	56.3	19.2	6.8	6.0	7.8	3.9	100.0
Province									
Eskisehir	93	5.4	55.9	17.2	16.1	0.0	4.3	6.5	100.0
Kutahya	122	5.7	61.5	17.2	9.8	2.5	7.4	1.6	100.0
Kastamonu	98	7.1	56.1	20.4	5.1	11.3	2.0	5.1	100.0
Malatya	91	4.4	65.9	20.9	0.0	11.0	0.0	2.2	100.0
Sivas/Kayseri	83	12.0	39.8	22.9	7.2	10.8	16.9	2.4	100.0
Erzurum	76	5.3	55.3	17.0	0.0	1.3	19.8	6.5	100.0

Table 9 highlights seed availability and sources by province for the surveyed households. As opposed to earlier tables in this chapter, this table has 563 observations. These observations are at the household-variety level. Most of the surveyed households only grew one variety, but some grew up to four. A household that cultivated more than

[26] Merchants that purchased wheat could include companies that produce food products using wheat. Mills grind wheat into flour for retail.

one variety may have had difficulties obtaining seed for one variety but not the other or may have had different sources for seed of different varieties.

Very few households had trouble obtaining the seed they desired. The majority of seed cultivated by the households was farm-saved or came from a neighbor, with some variation across provinces. Seed companies, cooperatives, seed merchants, and government agricultural offices also provided seed to the households surveyed, but with much lower frequency.

Households typically learned about new seed from neighbors and relatives. Table 10 gives an overview of the sources of information about new varieties common to the surveyed households. Seed merchants and neighboring villages also provided information to households about new varieties, as well as other sources, including extension workers, demonstration plots, newspapers, the radio, and government agricultural offices.

Table 10: Source of Information About Seed by Household-Variety, 1997-98.

	N	**Neighbor (%)**	**Relative (%)**	**Seed Merchant (%)**	**Neighbor Village (%)**	**Other (%)**	**Non-Response (%)**	**Total (%)**
All Households	563	63.9	19.5	12.3	1.1	2.1	1.1	100.0
Province								
Eskisehir	93	78.5	2.2	12.9	4.3	1.0	1.1	100.0
Kutahya	122	65.6	13.9	18.9	0.0	1.6	0.0	100.0
Kastamonu	98	71.4	21.5	2.0	2.0	3.1	0.0	100.0
Malatya	91	61.5	33.0	3.3	0.0	1.1	1.1	100.0
Sivas/Kayseri	83	48.2	22.9	20.5	0.0	4.8	3.6	100.0
Erzurum	76	54.0	27.7	15.8	0.0	1.2	1.3	100.0

Variety Attributes

The last category of potential influences on land-use decisions by households involves variety attributes. Consumption and production attributes vary by individual varieties and may help shape a household's preference for traditional and modern variety cultivation (Bellon and Taylor 1993; Hintze 2002).

Table 11: Top Three Ranked Wheat Characteristics by Specialization, 1997-98.

Percentage of Households that Ranked Each Factor as One of Three Most Important

	Modern Variety Only (N=198)	Traditional Variety Only (N=149)	Cultivate Both Modern and Traditional Varieties (N=69)	All Households (N=416)
Variety Characteristic				
Yield	95.5	94.6	100.0	95.9
Yield Stability	10.6	12.8	8.7	11.1
Drought Resistance	25.8	22.8	34.8	26.2
Cold Tolerance	35.4	37.6	49.3	38.5
Pest Resistance	3.5	5.4	1.4	3.8
Disease Resistance	34.3	33.6	36.2	34.4
Suitability for Soiltype	19.7	21.5	10.1	18.8
Resistance to Lodging	6.6	2.7	1.4	4.3
Good Bread Making Quality	22.2	40.3	15.9	27.6
Other Consumption Quality	0.0	1.3	0.0	0.1
Good Nutritional Quality	2.5	2.0	1.4	2.2
Good Market Price	21.2	8.1	18.8	16.1
Desirable Grain Color	3.0	0.0	1.4	1.7
Desirable Color of Food Product	1.5	0.0	0.0	0.1
Suitability for Early Planting	0.5	0.0	2.9	0.1
Suitability for Machinery	1.5	1.3	0.0	1.2
Quantity of Residue for Livestock	3.5	8.1	5.8	5.5
Good Quality Livestock Feed	2.0	2.7	1.4	2.2
Seed Resistant to Shattering	0.5	0.0	0.0	0.0
Acceptability in Market	9.6	5.4	7.2	7.7

Table 11 demonstrates the importance of several variety characteristics to the surveyed households. The characteristics represent a dummy variable that takes the value of one if the individual characteristic was ranked as one of the three most important to the household and zero if the characteristic was not one of the top three most important variety characteristics. The table is categorized by household variety-type specialization: whether the household produced modern varieties only, traditional varieties only, or whether it cultivated both modern and traditional varieties.

Of the production characteristics used in the survey, all households overwhelmingly ranked yield as the most important factor, with resistance to cold, disease, and drought as other major attributes of importance. Bread making quality was the most important consumption characteristic for households, and marketability was also a characteristic that households highly valued in a wheat variety.

Households that favored yield stability were typically households that cultivated traditional varieties only. Following from the discussion in chapter three that households would mix their variety portfolio to provide greater yield stability, this result is surprising in that households that cultivate both modern and traditional varieties would be thought to prioritize yield stability. Upon further review, households that listed disease, cold, and drought resistance as important characteristics the most often were all households that cultivated both modern and traditional varieties. This may suggest that depending on regional and agroecological settings, households valued planting both modern and traditional varieties in order to combat biotic and abiotic stresses, but when surveyed, they prioritized resistance to these specific stresses instead of the broader category of yield stability.

Other interesting characteristics to take note of are bread making quality, quality of residue for feed, and marketability of wheat. Households that valued the bread making quality of wheat were more often households that cultivated traditional varieties alone. Additionally, households for which the quantity of wheat residue to be used for feed was important were more often households that cultivated traditional varieties only. Households that only grew modern varieties favored marketability of wheat as a characteristic more often than traditional variety producers.

Support for Diversity Testing

Once land-use determinants are examined at the plot level for the surveyed households, the determinants will be linked to diversity outcomes at the household level. The purpose is to examine which factors affecting landrace cultivation also affect overall diversity levels. Diversity is measured using the Berger-Parker and Shannon indices, both of which are constructed using named varieties provided by households. The following descriptive statistics provide background information on the number of varieties cultivated by households and their reasons for selecting the number of varieties that they cultivated.

Table 12 illustrates the average number of varieties grown by province and agroecotype over a five-year period. The average number of varieties grown in 1998 across all provinces was 1.37, which was slightly less on average per household than in 1994. The only province in which producers were growing more varieties on average was in Kutahya. The majority of households, 78.1 percent, had not changed the number of wheat varieties they cultivated from 1994 to 1998.

Table 12: Average Number of Wheat Varieties Grown by Households, 1994-1998.

	N	Average Number of Varieties Grown per Household in 1994	Average Number of Varieties Grown per Household in 1998	Households Growing Fewer Varieties in 1998 than in 1994 (%)	Households Growing More Varieties in 1998 than in 1994 (%)	Households Growing Same Number of Varieties in 1998 as in 1994 (%)
All Households	416	1.46	1.37	13.7	8.2	78.1
Province						
Eskisehir	73	1.52	1.32	21.9	6.8	71.3
Kutahya	69	1.72	1.78	15.9	23.2	60.9
Kastamonu	59	2.05	1.68	30.5	8.5	61.0
Malatya	75	1.23	1.21	2.7	1.3	96.0
Sivas/Kayseri	68	1.31	1.25	10.3	5.9	83.8
Erzurum	72	1.07	1.07	4.2	4.2	91.6
Agroecotype						
Valley	128	1.55	1.43	14.8	7.8	77.4
Hilly	178	1.45	1.37	12.4	7.9	79.7
Mountain	110	1.39	1.32	14.5	9.1	76.4

Table 13 displays reasons that households gave for deciding to cultivate fewer varieties in 1998 than 1994. The most frequent response households gave was that with more varieties, they had more output than desired, which could be the case if the household did not have sufficient storage of access to output markets. Other households cited poor yield as a reason for cultivating fewer varieties, implying that they replaced at least one poor-yielding variety with a higher-yielding variety, alternate crop, or alternate form of land use. Several other reasons are listed, including, *inter alia*, unavailability of seed for desired varieties, land and agroecological constraints on production, poor market price, lack of storage, and lack of resistance to biotic and abiotic stresses.

Table 13: Reasons Given for Planting Fewer Varieties in 1998 than in 1994.

All Households (57 of 416 Households)		
Reason	**N**	**Percent**
More Production than Needed	10	17.5
Poor Yield	9	15.8
Land Constraint	5	8.8
Agroecological Constraint	3	5.3
Seed Unavailable	2	3.5
Poor Market Price	2	3.5
Lack of Storage	2	3.5
Discarded Varieties not Hail Tolerant	2	3.5
Labor Issues	2	3.5
Discarded Varieties not Suitable for Machinery	1	1.8
Discarded Varieties not Drought Resistant	1	1.8
One Variety Sufficient for Consumption Needs	1	1.8
Current Varieties Good for Marketing	1	1.8
Current Varieties Have Good Stability	1	1.8
Current Varieties Resistant to Lodging	1	1.8
Finished an Experiment with New Variety	1	1.8
Cannot Afford New Seed	1	1.8
Discarded Varieties Suffer Excessive Pig Damage	1	1.8
Non-Response	11	19.3
Total	57	100.0

Table 14: Reasons Given for Planting More Varieties in 1998 than in 1994.

All Households (34 of 416 Households)		
Reason	**N**	**Percent**
Yield Stability	7	20.6
Experiment	5	14.7
Increase Production	5	14.7
New Varieties Good for Infertile Land	1	2.9
New Varieties Drought Resistant	1	2.9
New Varieties Disease Resistant	1	2.9
New Varieties More Marketable	1	2.9
Non-Response	13	38.2
Total	34	100.0

Conversely, Table 14 shows reasons households gave for planting more varieties in 1998 than 1994. The most popular response was to increase yield stability, which is consistent with the theoretical explanation that households seek to mitigate risk by diversifying their crop portfolios. Households also planted more varieties to increase production and for experimentation with varieties unknown to them. Other reasons households gave include increasing resistance to drought and disease, increasing production on infertile and/or agroecologically variable lands, and increasing production of wheat that sells well in the market.

To better understand the breakdown of the numbers of households cultivating single and multiple varieties, Table 15 shows the percentage of households that grew one, two, three, and four varieties by province and agroecotype. Approximately 70 percent of all households cultivated one variety, while another 23 percent cultivated two varieties. Only 6.8 percent of households grew three or more varieties on average. Kutahya and Kastamonu are the provinces in which multiple variety cultivation was most common, as opposed to Erzurum, where roughly 93 percent of all households cultivated a single variety.

As Table 16 demonstrates, the district level wheat variety supply, which is measured as the total number of named varieties by all farmers in a given district (as described earlier, there are 2 districts per province) varies widely between provinces surveyed. Kutahya and Kastamonu, shown above to be the provinces in which multiple variety cultivation is was most common, also are the provinces which have the highest district supplies of wheat varieties. In Erzurum, only two varieties were available to households per district.

Table 15: Number of Varieties Grown per Household, 1997-98.

	N	Households Growing One Variety (%)	Households Growing Two Varieties (%)	Households Growing Three Varieties (%)	Households Growing Four Varieties (%)	Total (%)
All Households	416	70.4	22.8	5.8	1.0	100.0
Province						
Eskisehir	73	71.2	26.1	2.7	0.0	100.0
Kutahya	69	46.4	31.9	18.8	2.9	100.0
Kastamonu	59	50.8	33.9	11.9	3.4	100.0
Malatya	75	78.7	21.3	0.0	0.0	100.0
Sivas/Kayseri	68	78.0	19.1	2.9	0.0	100.0
Erzurum	72	93.1	6.9	0.0	0.0	100.0
Agroecotype						
Valley	128	64.8	28.1	6.3	0.8	100.0
Hilly	178	71.9	20.8	6.2	1.1	100.0
Mountain	110	74.6	20.0	4.5	0.9	100.0

Table 16: District Level Wheat Variety Supply, 1997-98.

	N	Number of Varieties
All Households	416	6.2
Province		
Eskisehir	73	7.0
Kutahya	69	11.5
Kastamonu	59	10.0
Malatya	75	4.0
Sivas/Kayseri	68	3.5
Erzurum	72	2.0

Table 17 distinguishes between households that specialized in cultivation of modern varieties only, traditional varieties only, or that cultivated both modern and traditional varieties, as well as the number of varieties each grew in 1998. Households that specialized in the sole production of landraces tended to grow one variety more often than those that only cultivated modern varieties.[27] Households that cultivated both modern and traditional varieties were the only surveyed households to grow four varieties.

Table 17: Number of Varieties Grown per Household by Specialization, 1997-98.

	N	Households Growing One Variety (%)	Households Growing Two Varieties (%)	Households Growing Three Varieties (%)	Households Growing Four Varieties (%)	Total (%)
Specialization						
Modern Variety Only	198	79.8	18.2	2.0	0.0	100.0
Traditional Variety Only	149	90.6	8.7	0.7	0.0	100.0
Modern and Traditional Varieties	69	0.0	66.7	27.5	5.8	100.0

Table 18 lists the reasons that households gave for why they cultivated one variety. The majority of households, 50.9 percent, said that growing a single variety provided them with the best yield potential, while another 28.7 percent stated that one variety was sufficient for all production and consumption needs of the household. A small number of households, 3.4 percent, answered that they were only able to obtain seed for one variety, which indicates that access to seed markets was good for most of the surveyed households.

When asked why they chose to cultivate more than one variety, households overwhelmingly responded that it was to mitigate risk. As Table 19 demonstrates, 61

[27] When tested, the difference in production of one variety was statistically significant at the 10 percent level.

percent of the households that cultivated multiple varieties said they did so in case one of the varieties planted were to fail. Another 10.6 percent responded that one variety was insufficient for all production and consumption needs. Other reasons given for cultivating multiple varieties included matching differing varieties to different agroecological plot types, experimental objectives, lack of desired seed for all plots, and ease of selling seed in the market.

Table 18: Reasons for Planting One Variety, 1997-98.
All Households (293 of 416 Households)

Reason	**N**	**Percent**
Best Yield Potential	149	50.9
Sufficient for Consumption and Production Needs	84	28.7
Ease of Seed Management	35	11.9
Only Able to Obtain Seed for One Variety	10	3.4
Only One Seed Available is Appropriate for the Land	2	0.7
Other	7	2.4
Non-Response	6	2.0
Total	293	100.0

Table 19: Reasons for Planting Multiple Varieties, 1997-98.
All Households (123 of 416 Households)

Reason	**N**	**Percent**
Risk Aversion	75	61.0
Insufficient for Production and Consumption Needs	13	10.6
Experiment	12	9.8
To Match Differing Agroecological Conditions on Farm	8	6.5
Not Enough Seed of Desired Variety Available for All Plots	5	4.1
Other	4	3.3
Non-Response	6	4.9
Total	123	100.0

Conclusion

The majority of households surveyed derived income from agricultural production, generally in the form of livestock and wheat production. Households that perceived themselves as wealthy held more livestock and asset wealth than medium and poor households. Agroecological conditions varied across households and regions and may have contributed to land-use decisions that matched appropriate varieties to agroecologically heterogeneous land conditions. Access to seed markets was widespread and the main sources of seed and information for households were neighbors and relatives. Roughly half of the surveyed households sold wheat, though wheat sales varied by province. Dual modern and traditional variety production households viewed yield and resistance to cold, drought, and disease as important characteristics in a wheat variety. Households that only cultivated modern varieties valued marketability of wheat more than other households, while households that only cultivated traditional varieties placed a greater importance on the bread making quality of wheat and quality of residue for feed.

Most households cultivated one variety in the 1997-98 cropping cycle, which is the same number of varieties that they cultivated in 1993-94. Households typically decreased the number of varieties cultivated because they had more production than needed or because the varieties did not yield well. Households that increased the number of varieties they cultivated typically did so to provide greater yield stability, experiment, or to increase yield. Households cultivating one variety typically did so because one variety provided them with the best yield potential. Households cultivating multiple varieties did so mainly to provide yield stability.

CHAPTER 5

EMPIRICAL TESTING

Surveyed households were shown in the last chapter to vary in socioeconomic/household characteristics, agroecological constraints faced, market access, and variety characteristic preference by province, agroecotype, and specialization. This chapter analyzes the factors that determine household cultivation choices by plot and household diversity outcomes.

Variable Definitions for Plot-Level and Household-Level Estimation

Several of the empirical studies reviewed in chapter two have shown that socioeconomic/household indicators, agroecological heterogeneity of farms, market accessibility of households, and variety characteristics all can play important roles in variety selection and on-farm diversity. The equation for the plot-level estimation takes the following general form:

5.1 $$\Pr\left(Landrace_j = 1 \mid SE, AE, MA, VC, P, AT\right) = \Phi(\beta_0 + \beta_1 SE + \beta_2 AE + \beta_3 MA + \beta_4 VC + \beta_5 P + \beta_6 AT + \varepsilon)$$

The variable of interest is a binary indicator representing the choice to plant a landrace on plot j. The symbol Φ represents the standard normal cumulative distribution function. The decision to plant a landrace on plot j is a function of socioeconomic/household indicators (*SE*), agroecological heterogeneity (*AE*), market access (*MA*), variety characteristics (*VC*), provincial indicators (*P*), and agroecotype (*AT*).

Equation 5.1 was estimated using maximum likelihood probit estimation. The data are stratified at the provincial, district, and village levels, which may lead to correlation between household responses within those strata. This could cause non-constant variance in the error terms of the observations between clusters on the dependent variable, which is referred to as heteroskedasticity.[28] To correct for heteroskedasticity, the Huber-White estimator of variance was used to calculate robust standard errors in order to help correct the standard errors of the independent variables for non-constant variance (Rogers 1993).

Because the focus of this paper is *in situ* conservation, the determinants that positively influence households to choose landraces over modern varieties are of interest. By determining which factors play an important role in landrace cultivation, policy recommendations regarding *in situ* conservation of landraces in Turkey can be made.

Theoretical models that combine socioeconomic/household indicators, agroecological heterogeneity, market access, and variety characteristics yield ambiguous comparative statics predictions. As such, predicted signs cannot be given for the variables used in the empirical testing in this chapter that are based on theoretical findings. The variables used in the plot-level and diversity outcome regressions are

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[28] The Breusch-Pagan test for heteroskedasticity was performed on an ordinary least squares model of landrace cultivation on the independent variables described below. The null hypothesis that the standard errors are normally distributed was rejected at the 1 percent level of significance, implying that the model needed to be correctly for heteroskedasticity (Wooldridge 2003).

described, tested, and interpreted in relation to other empirical results from studies that examine technology adoption and diversity outcomes.

Correlation tables are displayed in Appendix B and Appendix C of this paper. The variables used in the plot-level estimation are shown in Appendix B, and the variables used in the household-level estimation are in Appendix C. Correlations that are significant at the 5 percent level are indicated with an asterisk.

Socioeconomic/Household Indicators

The first set of exogenous variables that have been used to predict variety decisions that households make and diversity outcomes are socioeconomic/household characteristics (SE). These include the years of experience and education of the cultivation decision maker, the dependency ratio, the total area that the household cultivates, the fragmentation of the household's land, variables used to indicate wealth, and the amount of livestock a family owns (animals used are sheep, cattle, and goats).

Characteristics that directly describe the person in the household who makes the variety decisions could impact what the household chooses to plant on a given plot of land. Decision makers who have been farming longer have been shown to be more reluctant to experiment with modern varieties, while decision makers with more education are more willing to try modern varieties to expand production (Meng 1997).

A low dependency ratio could also mean a high number of family members working on the farm, which could increase the household's demand for wheat with better consumption attributes

Farm size has been empirically shown to be positively related to the adoption of modern varieties (Perrin and Winkelmann 1976; Feder, Just, and Zilberman 1985; Brush, Taylor, and Bellon 1992). Larger farmers may benefit from economies of scale, be willing to dedicate a smaller proportion of land to experimenting with modern varieties, or may have lower information costs relative to small farmers.

As fragmentation increases, landrace cultivation likely increases because households would face greater environmental heterogeneity, which may lead the household to use different varieties that adapt well to varying agroecological conditions.

Other socioeconomic factors that could play an important role in variety selection are those that affect the household's perception of wealth. Wealthier households may be able to experiment with new varieties with less risk relative to poor households. As such, with increased wealth, households may be willing to plant more modern varieties (Feder, Just, and Zilberman 1985; Brush, Taylor, and Bellon 1992; Meng 1997). However, wealthy households may be able to afford to choose to trade expected yield from modern varieties for consumption attributes in landraces. In this study, off-farm property holdings, the number of rooms in the house, the number of buildings on the farm, and car ownership are used to represent wealth of the household.

Livestock owned could likewise help the family to mitigate production and consumption risk through market sale or on-farm livestock consumption, in which case the household would cultivate fewer landraces. Livestock could also, however, increase a household's demand for landraces because landraces typically are preferred over modern varieties for texture, length, and abundance of straw used for feed (Meng 1997).

This study includes variables that indicate the number of head of sheep, goats, and cattle that households own.

The number of head of sheep, goats, and cattle are also squared and included in the regression. We suspect that households with small livestock holdings would likely favor landraces to provide more residue for feed. However, it could be more likely that a large herd of livestock would be viewed by the household as an alternative wealth and consumption source. If true, that would decrease the probability of landrace cultivation and encourage modern variety cultivation.

Agroecological Heterogeneity

Another set of potentially important explanatory variables for the decision to cultivate landraces is variables pertaining to agroecological conditions. These variables include plot-level land quality and irrigation.

High quality land, *ceteris paribus*, is expected to be planted to modern varieties because high-yielding modern varieties typically perform better than landraces under optimal agroecological conditions and worse under poor conditions (Feder 1980; Bellon and Taylor 1993). Irrigation is included as another indicator of high quality land.

Market Access

Variables that indicate a household's access to inputs, information, and output markets are also included based on previous empirical work. Households facing higher transactions costs to participate in the market may tend to be more self-sufficient in their consumption. Because landraces have been shown to outperform modern varieties in consumption quality, we would expect households to choose to plant landraces as market participation becomes more expensive or information is less available.

The distance to the nearest mill is used to indicate market access. It has been used in other studies as a proxy for market access (Goetz 1992; Meng 1997; Hintze 2002). As information becomes available more cheaply, we would expect households to learn more about improved varieties and experiment with them. For this reason, a dummy variable representing whether or not the household has knowledge of recommended varieties is included in the estimation.[29] Also, district supply of wheat varieties is included. A larger supply of varieties at the district level may indicate more access to landraces.

Variety Characteristics

As discussed in previous chapters, variety characteristics could also play an important role in the decision to cultivate landraces or modern varieties. Meng (1997) shows that in Turkey the higher the expected yield of modern varieties relative to traditional varieties in a given plot, the less likely households are to cultivate landraces. Studies have not demonstrated whether modern varieties or landraces perform better under drought conditions. Meng (1997) shows that landraces are preferred for their resistance to cold weather. Landraces are also more likely to be able to perform well when planted in a variety of soil types. Modern varieties are often bred by professional breeding institutions to be resistant to diseases to which landraces are susceptible. Landraces are shown in Meng (1997) to be preferred for their bread making quality.

[29]Recommendations of which varieties are best may come from government agriculture offices, extension agents, and/or research institutions.

Similarly, landraces typically have more residues after harvest, so households that require residue for animal feed may be more likely to cultivate landraces.

Provincial and Agroecotype Indicators

Provincial binary variables are included to account for differences across the six areas of study. These could capture differences in infrastructure, employment opportunities, market access, and other important explanatory variables that could affect the determination of landrace cultivation by households. Agroecotype indicators are also included to help account for possible differences in infrastructure and market access for households living within valley, hilly, and mountainous regions. Table 20 displays variables used in the plot-level regression analysis of land-use determinants.

Table 20: Plot-level Land-use Determinant Estimation Variables.

Variable Name	Description of Variable
Socioeconomic/Household Indicators	
Farm Experience	Years of farming experience of the decision maker
Education	Years of education of the decision maker
Dependency Ratio	Number of children under 13 plus number of adults over 60 divided by the number of persons living in household
Total Farm Area	Total farm area measured in hectares
Fragmentation	Fragmentation index representing ratio of number of cultivated plots to total area cultivated
Off-Farm Property Holdings	Dummy variable with a value of one if the household owns property not on the farm and a zero if it does not own property other than its farm
Number of Rooms	Number of rooms in the house
Number of Buildings	Number of buildings on the farm
Car Ownership	Dummy variable that is a one if the household owns a car and a zero if the household does not own a car
Livestock Holdings	Three variables indicating the number of head of sheep, goats, and cattle that the household owns
Livestock Holdings Squared	Three variables indicating the squared number of head of sheep, goats, and cattle that the household owns
Plot-level Characteristics	
Irrigation	Dummy variable indicating irrigation on plot
Land Quality	Vector of variables indicating whether the plot is judged by the household to be of medium, low, or extra low quality (with high quality as the omitted land quality)

Table 20: Plot-level Land-use Determinant Estimation Variables (continued).

Variable Name	Description of Variable
Market Access	
Distance	Distance to mill in kilometers
Knowledge of Recommended Varieties	Dummy representing knowledge of recommended varieties
District Variety Supply	The number of varieties available at the district level, which represents aggregate variety supply for households
Variety Characteristics	Dummies representing whether or not the household ranks each of the following characteristics as one of the three most important in a wheat variety:
Yield	High yield
Drought	Drought resistance
Cold	Cold tolerance
Soil	Suitability for soil type
Disease	Disease resistance
Bread	Quality of bread
Residue	Wheat residue for feed
Province	Dummy variables for each province (with Eskisehir as the omitted province): Sivas/Kayseri, Kutahya, Malatya, Kastamonu, and Erzurum
Agroecotype	Dummy variables for each agroecotype zone of the villages surveyed (with valley as the omitted agroecotype): hilly and mountain

Potential Endogeneity Issues

Livestock holdings could be endogenous to the decision to cultivate landraces in a given plot. As discussed, households may view livestock holdings as an alternative income or consumption source and hence be willing to cultivate landraces that potentially yield less than modern varieties. Landrace cultivation, though, could also lead the household to desire livestock holdings because landraces provide good residue for animal feed.

The potential endogeneity of livestock is debatable, however. Households can change the varieties of wheat they cultivate rather easily as access to desired seed is good for the vast majority of households (Table 9). However, changes in herd size are likely much slower and more difficult. Barring the sale of all livestock holdings, households likely decrease or increase herd size by small numbers year by year. Hence, it is likely that livestock holdings change slowly from year to year and livestock holdings of the household help determine variety selection.

Livestock holdings from 1996 are used in the empirical testing. The year 1996 is chosen because it is one year previous to the cultivation decision, and may help to limit potential endogeneity problems within the model. The Hausman test for endogeneity was conducted on the original model to determine if livestock holdings were endogenous. The null hypothesis that the endogeneity of livestock holdings in 1996 significantly biases the original model was rejected, indicating that instrumental variables regression was not needed. However, to further test for endogeneity, livestock holdings from 1996 were then estimated as instruments using two staged least square (2SLS). The Wu-Hausman test was then used to determine if the 2SLS instruments significantly affect the estimation of the model. Failure to reject the null hypothesis that the 2SLS instruments significantly affect the outcome of the estimation indicates that the original variables should be used. Based on the findings of the Hausman and Wu-Hausman tests, livestock holdings from 1996 were included in the estimation and not considered to bias the estimation (Woolridge 2003).

Fragmentation could also be endogenous. A household could cultivate landraces and modern varieties in order to maximize yields on agroecologically heterogeneous lands. However, if a household has one large plot that is planted to modern and traditional varieties, the household could consider it to be more plots, thus making the fragmentation index value higher for the household. Plots are typically inherited from the parents and divided among children. Based on field work experience, it is highly unlikely that fragmentation is the result of cultivating several varieties on one plot, especially since farms are already highly fragmented.

Other variables that might indicate fragmentation on farms could be distance to plot in kilometers or time to plot. Distance to plot, however, could understate agroecological heterogeneity as two plots that are very different in terms of topography or soil quality could be side by side. Time to plot was not chosen because farmers with animals or mechanized equipment could cause disparities in time of arrival to plots that are the same distance from the household.[30]

Irrigation on the plot could influence the cultivation decision as discussed, but the household's decision to plant a modern variety on a plot could potentially influence the household to irrigate or not irrigate. However, field experience shows that access to credit and the availability irrigation equipment are sparse. It is much more likely that households make cultivation decisions based on the availability of irrigation on-farm when the cultivation decision is made, and not that households decide what to cultivate and then purchase irrigation equipment based on those decisions.

Another potentially endogenous variable is district supply of wheat varieties. This variable likely does not affect plot-level cultivation decisions, but could bias diversity outcome estimation. On-farm diversity outcomes could be correlated to the supply of wheat at the district level, but if households make an effort to conserve

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[30] The instrumental variable regression analysis and testing described for livestock holdings was also performed on distance to plot and time to plot as potential instruments for fragmentation. Failure to reject the null hypothesis of the Hausman test indicated that fragmentation was likely not endogenous, and failure to reject the null hypothesis of the Wu-Hausman test showed that distance to plot and time to plot were not good instruments for fragmentation.

diversity, that impacts diversity throughout an area. District seed supply was chosen over provincial seed supply because Erzurum only has two varieties available in total and previous regressions perfectly predicted all observations of Erzurum due to perfect collinearity. However, field work and previous literature suggest that households do not consider on-farm diversity *per se* when making land allocation decisions.[31] For this reason, district supply of seed is likely not endogenous.

The variety attribute variables could all be potentially endogenous as well. Households could choose landraces because they value particular attributes, or they could choose particular attributes because those are what their cultivated varieties strongly exhibit. To avoid possible endogeneity, households were asked which five attributes were the most important in general for the household, regardless of the actual attributes their cultivated varieties display. From that, dummy variables were constructed to take the value of one if the household ranked an attribute among the top three most important and zero if the household did not. In this manner, households ranked attributes independently of what their cultivated varieties actually possess for attributes.

Table 21 shows descriptive statistics for the variables described above. The plot-level estimation is conducted using 1,669 observations, which correspond to each plot cultivated to wheat by the surveyed households.

[31] See below for a discussion of why diversity is not typically considered to be a determinant of land allocation by households.

Table 21: Plot-level Regression Variable Descriptions (N=1669).

Variable	Mean	Std. Dev.	Min	Max
Dependent Variable				
Landrace	0.401	0.490	0	1
Socioeconomic/Household Indicators				
Farm Experience (Years)	31.043	13.860	3	65
Education (Years)	4.796	2.025	0	12
Dependency Ratio	0.346	0.244	0	1
Total Farm Area (Hectares)	14.938	14.595	0.3	100
Fragmentation	0.130	0.116	0.003	1
Off-Farm Property Holdings (1=yes, 0=no)	0.321	0.467	0	1
Number of Rooms in House	4.378	1.824	0	15
Number of Buildings on Farm	2.605	1.126	0	8
Car Ownership (1=yes, 0=no)	0.210	0.407	0	1
Cattle (Head)	7.555	7.839	0	70
Sheep (Head)	14.167	38.194	0	400
Goats (Head)	1.456	10.939	0	200
Cattle^2	118.496	367.980	0	4900
Sheep^2	1658.576	10368.910	0	160000
Goats^2	121.700	1430.927	0	40000
Plot-level Characteristics				
Medium Quality Land (1=yes, 0=no)	0.694	0.461	0	1
Low Quality Land (1=yes, 0=no)	0.095	0.293	0	1
Extra Low Quality Land (1=yes, 0=no)	0.004	0.065	0	1
Irrigation (1=yes, 0=no)	0.220	0.414	0	1
Market Access				
Distance to Mill (Kilometers)	16.139	13.225	0	80
Knowledge of Recommended Varieties (1=yes, 0=no)	0.437	0.496	0	1
District Supply of Varieties (Number)	3.706	2.231	2	12
Variety Characteristics (1=Valued as Top 3 Most Important to Household, 0=not Top 3 Most Important)				
Yield	0.959	0.199	0	1
Drought Tolerance	0.287	0.452	0	1
Cold Tolerance	0.401	0.490	0	1
Disease Resistance	0.322	0.468	0	1
Soil Adaptability	0.176	0.381	0	1
Bread Quality	0.247	0.432	0	1
Residue Quality	0.044	0.205	0	1
Province (1=yes, 0=no)				
Sivas/Kayseri	0.152	0.359	0	1
Kutahya	0.272	0.445	0	1
Malatya	0.115	0.319	0	1
Kastamonu	0.146	0.353	0	1
Erzurum	0.095	0.293	0	1
Agroecotype (1=yes, 0=no)				
Hilly	0.439	0.496	0	1
Mountain	0.232	0.422	0	1

Results for Plot-Level Estimation

The results confirm that several of the variables influence land-use decisions by the surveyed households. When jointly tested, the estimated coefficients on all sets of exogenous variables except for variety attributes affect household cultivation decisions at the 1 percent significance level. Table 22 shows the original estimated coefficients of the probit estimation. It also displays the percentage change in the probability of landrace cultivation for a change of one standard deviation at the mean of the independent variables. Z-statistics are provided as well.

Table 22: Plot-level Land-use Determinant Regression Results (N=1,669).

Independent Variables	Estimated Coefficient	% Change in Probability from Change at Mean of One Standard Deviation	Z-Statistic
Socioeconomic/Household Indicators			
Farm Experience (Years)	0.0087 ***	0.0430	2.76
Education (Years)	-0.0439 **	-0.0318	-2.12
Dependency Ratio	-0.1679	-0.0147	-1.00
Total Farm Area (Hectares)	-0.0016 ***	-0.0083	-3.83
Fragmentation	0.4907	0.0203	0.93
Off-Farm Property Holdings (1=yes, 0=no)	0.1675 *	0.0283	1.93
Number of Rooms in House	-0.0221	-0.0145	-0.86
Number of Buildings on Farm	-0.0251	-0.0101	-0.56
Car Ownership (1=yes, 0=no)	0.3354 ***	0.0507	3.10
Cattle (Head)	0.0735 ***	0.2062	4.60
Sheep (Head)	0.0064 **	0.0879	2.39
Goats (Head)	0.0140	0.0547	1.55
Cattle^2	-0.0023 ***	-0.3008	-4.05
Sheep^2	-6.7E-06	-0.0249	-0.36
Goats^2	-0.0001	-0.0519	-1.55
Plot-level Characteristics			
Medium Quality Land (1=yes, 0=no)	0.4181 ***	0.0658	4.03
Low Quality Land (1=yes, 0=no)	0.3907 **	0.0433	2.49
Extra Low Quality Land (1=yes, 0=no)	1.7711 ***	0.0378	3.13
Irrigation (1=yes, 0=no)	-0.2722 **	-0.0387	-2.37
Market Access			
Distance to Mill (Kilometers)	-0.0053	-0.0250	-1.37
Knowledge of Recommended Varieties (1=yes, 0=no)	-0.2945 ***	-0.0517	-3.45
District Supply of Varieties (Number)	0.0811 *	0.0648	1.80

Table 22: Plot-level Land-use Determinant Regression results (N=1,669) (continued).

Independent Variables	Estimated Coefficient	% Change in Probability from Change at Mean of One Standard Deviation	Z-Statistic
Variety Characteristics (1=Valued as Top 3 Most Important to Household, 0=not Top 3 Most Important)			
Yield	-0.2586	-0.0193	-1.27
Drought Tolerance	0.0698	0.0114	0.74
Cold Tolerance	0.1924 **	0.0340	2.19
Disease Resistance	0.0186	0.0031	0.19
Soil Adaptability	0.2298 *	0.0323	1.94
Bread Quality	0.1224	0.0192	1.13
Residue Quality	0.1580	0.0119	0.89
Province (1=yes, 0=no)			
Sivas/Kayseri	2.0949 ***	0.2472	8.84
Kutahya	1.3672 ***	0.2228	5.28
Malatya	2.3231 ***	0.2274	10.56
Kastamonu	1.1215 ***	0.1496	4.85
Erzurum	2.7215 ***	0.2175	8.64
Agroecotype (1=yes, 0=no)			
Hilly	0.0401	0.0071	0.45
Mountain	0.6525 ***	0.1036	5.77

Pseudo R-Squared = .29

***denotes significance at the 10% level, ** at the 5% level, *** at the 1% level**

Socioeconomic/Household Indicators

A decision maker with more years of farming experience is more likely to cultivate traditional varieties, while a decision maker with more education is less likely to plant landraces.[32]

As total landholdings of the household increase, the probability of cultivating a landrace is significantly reduced. This result is consistent with other empirical studies discussed in previous chapters, such as Meng (1997) and Hintze (2002).

Households with off-farm property holdings and households that own cars are more likely to cultivate landraces. This may suggest that wealthier households are willing to tradeoff the larger expected yields of modern varieties for attributes of landraces that they value. This result is consistent with Meng (1997), who found that wealthier households also had an increased probability of landrace cultivation.[33]

As household ownership of sheep and cattle increases, so does the probability of landrace cultivation. This is likely explained by the superior residues for feed from traditional varieties. Yet, the sign on the estimated coefficient of cattle squared is negative and significant, which may indicate that as herd size increases, households use livestock holdings to reduce production and consumption risk and decide to cultivate modern varieties.

Agroecological Heterogeneity

All land quality coefficients are positive. Bellon and Taylor (1993) similarly show that as land quality decreases, traditional variety cultivation increases.

The estimated coefficient on irrigation of the plot is negative and significant, implying that modern varieties are preferred more than landraces under optimal growing conditions.[34]

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[32] These findings are consistent with Adesina and Zinnah (1993), Bellon and Taylor (1993), and Meng (1997).

[33] Wealth indices are popular for representing asset wealth holdings. They are typically linear combinations, sometimes weighted, of assets that households own.

[34] This result coincides with the finding that irrigation negatively influences wheat landrace cultivation by Brush, Taylor, and Bellon (1992) and Meng (1997), but is contrary to Gauchan et al. (2005), who find that rice landrace cultivation is positively impacted by irrigation in Nepal.

Market Access

Increased knowledge of recommended varieties within a region has a negative, significant impact on the probability of landrace cultivation. As households become aware of which varieties perform the best within their region, they are less likely to cultivate landraces and more likely to plant modern varieties recommended by experts.

As the number of varieties supplied at the district level increases, so does the probability of landrace cultivation by the households within that district. This may imply that households otherwise willing to cultivate landraces may not be able to find them in districts with a low supply of varieties and cultivate modern varieties as an alternative.

Variety Characteristics

Although the estimated coefficients on variety characteristics do not jointly impact landrace cultivation, households that prefer varieties for their resistance to cold are more probable to cultivate landraces than modern varieties, and households that value varieties for their adaptability to heterogeneous soil types are more likely to cultivate landraces.

Provincial and Agroecotype Indicators

The signs of the estimated coefficients of the province dummy variables are all positive. Based on the high level of modern variety cultivation in Eskisehir as compared with the other provinces (see Table 2), this result is not surprising.

The probability of landrace cultivation is significantly increased for households located in mountain agroecotypes, indicating that landraces likely adapt better to marginal agroecological conditions. This result is consistent with Meng (1997).

Percentage of Households Classified Correctly

Table 23 shows the ability of the model to predict plots cultivated to landraces. On plots for which the model predicted at least a 50 percent probability of landrace cultivation, 71.25 percent of the plots were planted cultivated to landraces. Furthermore, for plots for which the predicted probability of landrace cultivation was less than 50 percent, 79.55 percent of plots were not cultivated to landraces. These results indicate that the explanatory power of the probit estimation consisting of socioeconomic/household indicators, agroecological heterogeneity, market access, and variety characteristics correctly predicts about three-fourths of landrace cultivation decisions.

Table 23: Percentage of Plots Classified Correctly.

	Did Not Cultivate a Landrace on the Plot	Cultivated a Landrace on the Plot
Predicted Probability of Landrace Cultivation is 50% or Higher	186/647 = 28.75%	461/647 = 71.25%
Predicted Probability of Landrace Cultivation is Lower than 50%	813/1,022 = 79.55%	209/1,022 = 20.45%

Linkages between Plot-level Land-use Determinants and On-farm Diversity

Households in Turkey make their cultivation decisions based on a number of important determinants as demonstrated above. Based on previous fieldwork, farmers do not consider on-farm diversity as an important factor in land-use cultivation decisions. Diversity outcomes are instead the result of the original planting decision, making them recursive, or sequential, in nature.[35] Hence the variables used in the plot-level estimation are used in the household-level diversity estimation. Although the variables used in the household-level diversity outcomes estimation represent the same exogenous variables used in the plot-level regression analysis, some are modified to represent the household. For example, agroecological heterogeneity is represented using percentage of cultivated land that is irrigated and the number of named land qualities. Apart from some subtle differences, the variables are the same.

Of the 416 households used in the empirical testing, 293 only cultivated one variety, giving the value of one for the Berger-Parker index and zero for the Shannon index. The rest of the values are strictly positive and continuous. Because a large number of observations are corner solutions for the two indices, with the rest of the values being positive and continuous, the Tobit model was chosen for estimation.

The estimation of on-farm diversity outcomes takes the following form:

$$D_h^* = \beta_0 + \beta_1 SE + \beta_2 AE + \beta_3 MA + \beta_4 VC + \beta_5 P + \beta_6 AT + \varepsilon \quad (5.2)$$

$$D_h^* = \max(0, D_h^*) \quad (5.3)$$

As equation 5.3 demonstrates, the Tobit model gives nonnegative predicted values for the diversity indices. The latent variable D_h^* is assumed to be normally distributed

[35] Meng (1997) states that this is the case for households surveyed in three regions of Turkey. Other on-farm diversity studies that treat diversity outcomes as recursive are Brush, Taylor, and Bellon (1992), Smale, Bellon, and Aguirre (2001), and Gauchan et al. (2005).

and homoskedastic, though previous testing reveals heteroskedasticity in the model. For this reason, robust standard errors were also calculated.

The dependent variables being estimated are the Berger-Parker index and the Shannon index, which are described in chapter two. Household diversity outcomes are hypothesized to be a function of socioeconomic/household indicators (*SE*), agroecological heterogeneity (*AE*), market access (*MA*), variety characteristics (*VC*), provincial indicators (*P*), and agroecotype (*AT*).

Table 24 provides summary statistics of the independent variables used in the diversity estimation. The number of observations has changed from 1,669 to 416, representing the change from plot-level to household-level analysis.

Table 24: Household-level Diversity Regression Variable Descriptions (N=416).

Variable	Mean	Std. Dev.	Min	Max
Dependent Variable				
Berger-Parker Index	1.188	0.374	1	3.5
Shannon Index	0.195	0.331	0	1.352
Socioeconomic/Household Indicators				
Farm Experience (Years)	30.207	13.489	3	65
Education (Years)	4.760	2.104	0	12
Dependency Ratio	0.330	0.255	0	1
Total Farm Area (Hectares)	12.110	13.086	0.3	100
Fragmentation	0.120	0.122	0.003	1
Off-Farm Property Holdings (1=yes, 0=no)	0.238	0.426	0	1
Number of Rooms in House	4.257	1.647	0	15
Number of Buildings on Farm	2.438	1.014	0	8
Car Ownership (1=yes, 0=no)	0.147	0.354	0	1
Cattle (Head)	0.430	2.624	0	37
Sheep (Head)	12.683	36.749	0	400
Goats (Head)	1.849	14.282	0	200
Cattle^2	113.589	338.152	0	4900
Sheep^2	1508.072	9324.700	0	160000
Goats^2	206.916	2328.398	0	40000

Table 24: Household-level Diversity Regression Variable Descriptions (N=416) (continued).

Variable	Mean	Std. Dev.	Min	Max
Dependent Variable				
Plot-level Characteristics				
Percentage of Land that is Irrigated	0.317	0.388	0	1
Number of Named Land Qualities by Household	1.284	0.534	1	3
Market Access				
Distance to Mill (Kilometers)	15.715	13.578	0	80
Knowledge of Recommended Varieties (1=yes, 0=no)	0.401	0.491	0	1
District Supply of Varieties (Number)	6.202	3.600	2	12
Variety Characteristics (1=Valued as Top 3 Most Important to Household, 0=not Top 3 Most Important)				
Yield	0.959	0.198	0	1
Drought Tolerance	0.262	0.440	0	1
Cold Tolerance	0.385	0.487	0	1
Disease Resistance	0.344	0.476	0	1
Soil Adaptability	0.188	0.391	0	1
Bread Quality	0.276	0.448	0	1
Residue Quality	0.055	0.229	0	1
Province (1=yes, 0=no)				
Sivas/Kayseri	0.163	0.370	0	1
Kutahya	0.166	0.372	0	1
Malatya	0.180	0.385	0	1
Kastamonu	0.142	0.349	0	1
Erzurum	0.173	0.379	0	1
Agroecotype (1=yes, 0=no)				
Hilly	0.428	0.495	0	1
Mountain	0.264	0.442	0	1

Results for Diversity Outcome Estimation

Estimation results are shown in Tables 25 and 26 for the effects of land-use determinants on household-level diversity outcomes. The results show the estimated coefficients for the independent variables, the marginal effects for the expected value of the dependent variable conditional on being uncensored, and z-statistics that were computed with the marginal effects.

Table 25: Berger-Parker Index Diversity Regression Estimation Results(N=416).

Dependent Variable:	**Berger-Parker Index**		
Independent Variables	**Estimated Coefficient**	**Marginal Effects Conditional on E(y | 1≤y<∞)**	**Z-Statistic**
Socioeconomic/Household Indicators			
Farm Experience (Years)	-0.0051	-0.0010	-1.2800
Education (Years)	-0.0347	-0.0068	-1.2900
Dependency Ratio	-0.3613 *	-0.0704	-1.6700
Total Farm Area (Hectares)	0.0017 ***	0.0003	2.9500
Fragmentation	-0.4782	-0.0931	-0.8600
Off-Farm Property Holdings (1=yes, 0=no)	-0.0343	-0.0066	-0.2600
Number of Rooms in House	-0.0407	-0.0079	-1.1000
Number of Buildings on Farm	0.0401	0.0078	0.7500
Car Ownership (1=yes, 0=no)	-0.0072	-0.0014	-0.0500
Cattle (Head)	-0.0083	-0.0016	-0.4600
Sheep (Head)	0.0005	0.0001	0.1500
Goats (Head)	0.0732 **	0.0143	3.7500
Cattle^2	-3.64E-05	-7.08E-06	-0.0700
Sheep^2	-1.27E-05	-2.48E-06	-0.7100
Goats^2	-0.0011	-0.0002	-2.1600
Plot-level Characteristics			
Percentage of Land that is Irrigated	0.3147 **	0.0613	1.9200
Number of Named Land Qualities by Household	0.2814 ***	0.0548	2.8600
Market Access			
Distance to Mill (Kilometers)	0.0108 **	0.0021	2.1100
Knowledge of Recommended Varieties (1=yes, 0=no)	0.2170 **	0.0442	1.8500
District Supply of Varieties (Number)	0.2501 ***	0.0487	3.3700
Variety Characteristics (1=Valued as Top 3 Most Important to Household, 0=not Top 3 Most Important)			
Yield	0.2093	0.0338	0.9100
Drought Tolerance	0.2510 **	0.0550	1.9300
Cold Tolerance	0.1822	0.0371	1.4300
Disease Resistance	0.0071	0.0014	0.0600
Soil Adaptability	0.0954	0.0197	0.5800
Bread Quality	0.0145	0.0028	0.1000
Residue Quality	0.0069	0.0013	0.0300
Province (1=yes, 0=no)			
Sivas/Kayseri	0.8301 **	0.2696	1.7200
Kutahya	-0.1769	-0.0308	-0.6200
Malatya	0.9510 ***	0.3222	2.6300
Kastamonu	0.2613	0.0609	0.8300
Erzurum	1.0203 **	0.3613	1.6000
Agroecotype (1=yes, 0=no)			
Hilly	-0.3557 ***	-0.0667	-2.7400
Mountain	-0.0488	-0.0093	-0.3600
Log Likelihood = -236.8			
***denotes significance at the 10% level, ** at the 5% level, *** at the 1% level**			

The results are very similar between the indices used. F-tests indicate that all estimated coefficients of the sets of independent variables tested using the Berger-Parker and Shannon indices are jointly different from zero at the one percent significance level except for variety characteristics, which are not significant at the 10 percent level using either of the indices.

Socioeconomic/Household Indicators

Both indices gave similar results for all of the socioeconomic/household indicators tested. The estimated coefficient on dependency ratio is negative and significant using both indices. A smaller family size would increase the dependency ratio, and a small family may indicate a smaller pool of labor for managing the cultivation of diverse varieties. A small family would also have lower consumption needs and may not need to cultivate multiple varieties to satisfy these needs. This result is similar to Edmeades, Smale, and Karamura (2005) and Winters, Hintze, and Ortiz (2005).

Farm size has a positive, significant impact on diversity levels. Large farmers can experiment with unknown varieties or tradeoff yield for consumption attributes such as taste with less production and consumption risk than small farmers.[36]

[36] This result reinforces findings in Edmeades, Smale, and Karamura (2005) and Winters, Hintze, and Ortiz (2005).

Table 26: Shannon Index Diversity Regression Estimation Results (N=416).

Dependent Variable:	Shannon Index			
Independent Variables	**Estimated Coefficient**		**Marginal Effects Conditional on E(y | 0≤y<∞)**	**Z-Statistic**
Socioeconomic/Household Indicators				
Farm Experience (Years)	-0.0042		-0.0009	-1.1900
Education (Years)	-0.0313		-0.0067	-1.2900
Dependency Ratio	-0.3560	*	-0.0764	-1.7800
Total Farm Area (Hectares)	0.0015	***	0.0003	2.9900
Fragmentation	-0.2061		-0.0442	-0.4200
Off-Farm Property Holdings (1=yes, 0=no)	-0.0657		-0.0136	-0.5800
Number of Rooms in House	-0.0230		-0.0049	-0.6800
Number of Buildings on Farm	0.0495		0.0106	1.0000
Car Ownership (1=yes, 0=no)	-0.0605		-0.0124	-0.5300
Cattle (Head)	-0.0036		-0.0008	-0.2100
Sheep (Head)	0.0013		0.0003	0.3600
Goats (Head)	0.0641	**	0.0138	3.2800
Cattle^2	-0.0002		-3.24E-05	-0.3000
Sheep^2	-1.74E-05		-3.74E-06	-0.7800
Goats^2	-0.0009		-0.0002	-1.8500
Plot-level Characteristics				
Percentage of Land that is Irrigated	0.2427	*	0.0521	1.7100
Number of Named Land Qualities by Household	0.2598	***	0.0558	2.8800
Market Access				
Distance to Mill (Kilometers)	0.0099	**	0.0021	2.1800
Knowledge of Recommended Varieties (1=yes, 0=no)	0.1665		0.0370	1.5800
District Supply of Varieties (Number)	0.2250	**	0.0483	3.4800
Variety Characteristics (1=Valued as Top 3 Most Important to Household, 0=not Top 3 Most Important)				
Yield	0.1670		0.0307	0.7500
Drought Tolerance	0.2506	**	0.0608	2.0500
Cold Tolerance	0.1344		0.0298	1.1700
Disease Resistance	-0.0336		-0.0071	-0.3200
Soil Adaptability	0.0282		0.0062	0.2000
Bread Quality	-0.0496		-0.0104	-0.3800
Residue Quality	0.0676		0.0154	0.3100
Province (1=yes, 0=no)				
Sivas/Kayseri	0.7022	**	0.2365	1.6700
Kutahya	-0.1739		-0.0332	-0.6800
Malatya	0.8574	***	0.3082	2.6000
Kastamonu	0.1564		0.0376	0.5800
Erzurum	0.8893	**	0.3279	1.6600
Agroecotype (1=yes, 0=no)				
Hilly	-0.3284	***	-0.0679	-2.7600
Mountain	-0.1070		-0.0218	-0.8800

Log Likelihood = -232.07

***denotes significance at the 10% level, ** at the 5% level, *** at the 1% level**

The estimated coefficient on goat head owned by the household is positive and significant. This indicates that as the size of a household's goat herd increases, the household chooses to specialize in one variety that satisfies all of its needs, whether it is a landrace for residue used for feed or a modern variety planted for production attributes.

Agroecological Heterogeneity

The estimated coefficient on the irrigation variable is positive for both indices. This could signify that several varieties exist within the surveyed regions that perform comparably on irrigated land, but differ in production and consumption characteristics that the households desire. As the number of named land qualities by the household increases, so does on-farm diversity. Households likely match multiple varieties to maximize production on agroecologically heterogeneous land.

Market Access

As distance to the nearest mill increases, on-farm diversity increases, perhaps indicating that households rely more on consumption of their wheat production, using diversity to satisfy production and consumption needs. Edmeades, Smale, and Karamura (2005) and Gauchan et al. (2005) empirically show that as distance to market increases, on-farm diversity also increases.

The estimated coefficient on knowledge of recommended varieties tests positive as well, but only using the Berger-Parker Index. This could indicate that as information becomes more available, households are more likely to experiment with new varieties. As the district level supply of varieties increases, on-farm diversity increases.

Variety Characteristics

Variety characteristics do not jointly influence diversity outcomes in either of the estimations. The only attribute that had a significant estimated coefficient is drought. Households that value drought resistance also tend to have higher levels of on-farm diversity.

Regional and Agroecotype Indicators

The estimated coefficients on Sivas/Kayseri and Malatya tested positive and significant. These results are unexpected given the descriptive statistics provided in chapter four. Households in Sivas/Kayseri and Malatya were among the highest percentage of households to cultivate only one variety. These provinces also have low district-level wheat supplies when compared to the other provinces, and there do not appear to be any large correlations between any of the provinces or between Sivas/Kayseri, Malatya, and the two diversity indices. The estimated coefficient on the hilly agroecotype is negative across the indices, which is likely due to the fact that households in hilly agroecotypes cultivated fewer varieties on average than those in valley agroecotypes (Table 12).

Conclusion

In this chapter, empirical estimation of plot-level land-use determinants has been conducted. Estimated coefficients from variables representing socioeconomic/household indicators, agroecological conditions, and market access were jointly different from zero at the 1 percent significance level. The estimated coefficients on variety characteristics were not jointly different from zero at the 10 percent significance level.

The land-use determinants were then used to estimate diversity outcomes at the household level. Other diversity studies have shown that results can vary in terms of sign and significance based on which measure of diversity is used.[37] In this study, the indices used showed very little variation in terms of variable sign and significance, but this may be due to the high level of correlation that the indices exhibit (Appendix C). All sets of explanatory variables jointly impact diversity outcomes except for variety characteristics, which did not significantly affect household diversity outcomes in either set of estimations.

[37] See Meng (1997), Winters, Hintze, and Ortiz (2005), Gebremedhin, Smale, and Pender (2005), Gauchan et al. (2005).

CHAPTER 6

CONCLUSION AND IMPLICATIONS

The purpose of the empirical work in this thesis is to answer the following questions: 1) what are the plot-level determinants of traditional wheat variety cultivation on farms in Turkey; and 2) how do those determinants affect on-farm diversity outcomes? In attempting to answer these questions, relevant literature and theory have been reviewed, an extensive description of the survey data has been provided, and empirical testing has been conducted.

The literature review in chapter two synthesizes the literature that is most relevant to this research. Technology adoption models are extensively considered. Socioeconomic/household indicators, agroecological heterogeneity, market access, and variety characteristics have previously been shown to impact land-use decisions by producers throughout the developing world.

The last part of chapter two summarizes recent studies that link land-use determinants to on-farm and community diversity levels. No theory exists to provide *a priori* predictions on how land-use determinants will affect diversity outcomes, and the same determinants of on-farm diversity can vary widely in terms of sign and significance based on the indices used to measure diversity. Although the studies provide guidance for variables to empirically estimate in this study, they do not offer consistent predictions for expected impacts of land-use determinants on diversity outcomes.

Chapter 3 extends the literature review with a more detailed overview of the main contributions to the theory of technology adoption. Several theoretical works are reviewed that separately provide predictions regarding risk aversion, agroecological heterogeneity, and market access. Comprehensive theoretical models that incorporate socioeconomic/household indicators, agroecological heterogeneity, market access, and variety attributes are available, though they do not yield comparative statics predictions. Since no theoretical model provides comparative statics predictions with respect to household land-use decisions and diversity outcomes based on socioeconomic/household indicators, agroecological heterogeneity, market access, and variety attributes, the questions in this thesis are examined empirically.

Survey methodology and tables providing descriptive statistics that highlight differences in households between provinces and agroecotypes are provided in chapter four. A total of 486 households were surveyed across six regions of Turkey, and 416 households with valid observations were used for empirical testing.

The majority of the surveyed households derived income from agriculture, with the staples being livestock production and wheat cultivation. Households that perceived themselves as being wealthy had larger livestock and asset holdings than medium-wealth and poor households. Plot-level characteristics, such as land quality and irrigation vary within many households’ landholdings. Access to markets varied between households within the same region, as well as between regions. Households typically obtained information about new varieties from neighbors and relatives. Households that solely cultivated traditional varieties valued the residue and bread making quality of wheat, while sole producers of modern varieties typically valued marketability of their cultivated wheat. Households cultivating traditional and modern varieties valued resistance to abiotic and biotic stresses more than other households. The average number of varieties cultivated by all households dropped slightly from 1994 to 1998. Most households cultivated one variety in 1998.

The descriptive statistics in chapter four complement the theoretical and empirical studies described in chapters two and three to help provide the basis for the empirical testing conducted in chapter five. The first estimation examines land-use determinants at the plot level. The estimated coefficients on variables representing socioeconomic/household characteristics, agroecological heterogeneity, and market access all jointly impact household cultivation decisions at the 1 percent level. Variety characteristics are not found to jointly affect landrace cultivation decisions by households. Regional and agroecotype binary variables are also included in the analysis and are found to be significant.

The same variables are then used to test the effect of land-use determinants on on-farm diversity outcomes using two diversity indices constructed using named varieties. Socioeconomic/household indicators, plot-level agroecological heterogeneity, and market access variables jointly affect on-farm diversity outcomes at the 1 percent level, but the estimated coefficients on variety attributes did not test to be jointly significant using either diversity index.

Implications

This research has focused on landrace cultivation and *in situ* conservation. The empirical testing demonstrates that some of the factors tested are associated with increased probability of cultivating landraces, while other variables increase the probability of modern variety cultivation. It is not clear that *in situ* conservation of landraces is decreasing at present in Turkey. In all provinces surveyed, landraces were cultivated, and in some provinces the majority of households cultivated landraces on at least some plots of land. In fact, more than 50 percent of all households surveyed cultivated landraces on at least some of their plots of land (Table 2).

Although landrace cultivation is still dominant across the surveyed provinces, no guarantee exists that landrace cultivation will continue in the future. The purpose of this section is to provide an overview of the characteristics of households that cultivated landraces or were predicted to cultivate landraces, to prescribe policy interventions that could have a positive impact on landrace cultivation and *in situ* conservation, and to develop ideas for further research on landrace cultivation and *in situ* conservation.

Characteristics of Plots Cultivated to Landraces and Households by Specialization

Table 27 provides the mean values of all the explanatory variables used in the empirical testing that describe the characteristics of plots cultivated to landraces and modern varieties. Column one provides descriptive statistics of all plots that were actually cultivated to landraces. Column two examines the means of the explanatory variables for plots for which the predicted probability of landrace cultivation was greater than 90 percent. Columns three, four, and five all give descriptive statistics of the explanatory variables by household specialization.

Table 27: Characteristics of Plots Cultivated to Landraces and by Specialization.

	Plots Planted to Landraces (N=670)	Predicted Probability of Landrace Cultivation > 0.9 (N=49)	Plots Cultivated by Households Only Planting Landraces (N=460)	Plots Cultivated by Households Only Planting Modern Varieties (N=772)	Plots Cultivated by Households Planting Modern and Traditional Varieties (N=437)
Socioeconomic/Household Indicators					
Farm Experience (Years)	31.94	33.27	31.84	30.06	31.94
Education (Years)	4.50	4.39	4.41	5.10	4.67
Dependency Ratio	0.34	0.34	0.37	0.35	0.32
Total Farm Area (Hectares)	11.20	4.40	9.30	18.30	14.80
Fragmentation	0.16	0.29	0.17	0.10	0.14
Off-Farm Property Holdings (1=yes, 0=no)	0.51	0.35	0.25	0.41	
Number of Rooms in House	4.15	4.06	4.01	4.63	4.31
Number of Buildings on Farm	2.46	2.00	2.28	2.72	2.73
Car Ownership (1=yes, 0=no)	0.19	0.12	0.10	0.23	0.28
Cattle (Head)	6.93	7.73	6.81	8.03	7.49
Sheep (Head)	14.44	8.00	13.45	15.85	11.94
Goats (Head)	1.34	1.24	1.61	1.81	0.67
Cattle^2	78.99	82.59	78.81	157.34	91.65
Sheep^2	1301.54	253.35	1226.37	2308.82	964.82
Goats^2	97.64	9.65	134.60	174.71	14.48
Plot-level Characteristics					
Medium Quality Land (1=yes, 0=no)	0.75	0.76	0.75	0.64	0.73
Low Quality Land (1=yes, 0=no)	0.10	0.14	0.11	0.09	0.09
Extra Low Quality Land (1=yes, 0=no)	0.01	0.10	0.01	0.00	0.00
Irrigation (1=yes, 0=no)	0.16	0.31	0.18	0.28	0.16
Market Access					
Distance to Mill (Kilometers)	13.38	10.53	12.85	19.08	14.40
Knowledge of Recommended Varieties (1=yes, 0=no)	0.35	0.16	0.29	0.48	0.51
District Supply of Varieties (Number)	7.37	4.57	6.37	6.98	9.46

Table 27: Characteristics of Plots Cultivated to Landraces and by Specialization (continued).

	Plots Planted to Landraces (N=670)	Predicted Probability of Landrace Cultivation > 0.9 (N=49)	Plots Cultivated by Households Only Planting Landraces (N=460)	Plots Cultivated by Households Only Planting Modern Varieties (N=772)	Plots Cultivated by Households Planting Modern and Traditional Varieties (N=437)
Variety Characteristics (1=Valued as Top 3 Most Important to Household, 0=not Top 3 Most Important)					
Yield	0.95	0.94	0.93	0.95	1.00
Drought Tolerance	0.30	0.37	0.24	0.25	0.41
Cold Tolerance	0.43	0.33	0.35	0.39	0.48
Disease Resistance	0.28	0.04	0.27	0.35	0.32
Soil Adaptability	0.21	0.47	0.26	0.17	0.10
Bread Quality	0.32	0.61	0.40	0.21	0.14
Residue Quality	0.06	0.06	0.08	0.03	0.04
Province (1=yes, 0=no)					
Sivas/Kayseri	0.13	0.08	0.13	0.16	0.16
Kutahya	0.34	0.22	0.21	0.14	0.57
Malatya	0.16	0.04	0.23	0.10	0.01
Kastamonu	0.15	0.00	0.14	0.12	0.20
Erzurum	0.18	0.65	0.25	0.04	0.03
Agroecotype (1=yes, 0=no)					
Hilly	0.40	0.10	0.39	0.49	0.40
Mountain	0.37	0.90	0.42	0.11	0.25

Only 49 plots had a predicted probability of greater than 90 percent for landrace cultivation, and the plot and household characteristics associated with these plots are quite similar to expectations formed from the review of previous empirical works. According to the model, for example, the household member making the cultivation decisions has a high number of years of farm experience and does not have the education that the average decision makers possess. Also, the average farm size for these households is quite small and the degree of fragmentation is very high, at almost 29 plots per hectare.

The model predicts that landrace cultivation is highly likely on low or extra low quality land, but also on irrigated plots. Surprisingly, the model predicts a relatively short distance to market for households cultivating landraces. It also predicts a relatively weak knowledge of the recommended varieties and a small number of district level varieties available to households cultivating landraces.

The model provides insight into variety characteristics that would be expected based on literature and arguments made above. Households predicted to cultivate landraces do not prefer disease resistance (modern varieties are typically bred for disease resistance). Landrace cultivation is highly predicted for households that prefer soil adaptability and bread making quality of wheat varieties.

Furthermore, plots that have a high predicted probability of being cultivated to landraces are much more likely to be in a mountainous agroecotype as opposed to a hilly agroecotype.

Households surveyed either specialized in traditional variety cultivation only, modern variety cultivation only, or dual production of modern and traditional varieties. Some of the differences highlighted in the summary statistics are further developed in Table 27.

Decision makers from households cultivating modern varieties only typically have less farm experience and more education than other decision makers. Their farms are also typically larger and less fragmented.

Plot-level characteristics were typically homogenous across household specialization with the exception of extra low quality land, which was cultivated more frequently by households specializing in landrace cultivation. Households that cultivated landraces only also were typically closer to the market than other households.

Furthermore, households that only cultivated traditional varieties typically valued soil adaptability, bread making quality, and residue for feed quality more than other households. These households were found in mountainous agroecotypes more often than households with other specializations as well.

Policy Implications

In situ conservation of crop genetic resources, especially genetic resources from landraces, still is prevalent across the surveyed regions of Turkey. However, *in situ* conservation of landraces is not guaranteed in the future. Households continue to diversify their crop portfolios based on a wide array of factors, ranging from socioeconomic/household characteristics to agroecological heterogeneity on their farms, to differences in market access across provinces, to different tastes and preferences for production and consumption attributes of wheat, to differences in physical farm location in different provinces and agroecotypes. As long as these broad differences remain and households face different constraints, they will continue to maximize utility by choosing the best variety combinations, which likely include traditional and modern varieties. Households do not appear to need incentives at present to cultivate landraces, but as modern varieties become increasingly available to households, that could change. Hence, no policy intervention is necessary at present in Turkey to maintain landrace cultivation, but in the interest of increasing landrace cultivation and on-farm diversity, this research does provide some insights.

One of the most obvious ways to encourage households to cultivate landraces is through direct government subsidies. If households are reimbursed for potential losses in utility, for example from loss of income that could accompany smaller yields from cultivating landraces, they may be more apt to cultivate landraces. Yet subsidies can be costly to the government and society, and as discussed, landrace cultivation still thrives in Turkey. Based on this research, other options exist that could bolster landrace cultivation while augmenting on-farm diversity levels.

It is useful to examine the variables that are associated with increased probability of landrace cultivation from a policy standpoint. If *in situ* conservation of landraces is to be encouraged, it must be done so in a way that is not detrimental to the households. For example, from the plot-level testing of land-use determinants, we see that variables such as education and knowledge of recommended varieties are both negative and significant, meaning that they decrease the probability of landrace cultivation. But in the interest of preserving genetic diversity in the form of landrace cultivation, one would not want to implement programs that seek to decrease the education of household decision makers or decrease their awareness of the varieties that are available on the market. Similarly, we see a positive correlation between planting wheat on marginal lands and landrace cultivation. But just because landraces are preferred for cultivation on marginal lands does not necessarily imply that a household's time is better spent cultivating marginal land than being employed in other gainful activities.

Even if landrace cultivation is kept constant or increased, that does not necessarily imply that total diversity stays the same or increases. The ideal policy implementation would be one that increases the probability of landrace cultivation and increases on-farm genetic diversity.

From the plot-level and household-level empirical testing, we see that as the district supply of wheat varieties increases, the probability of landrace cultivation increases. Additionally, a larger supply of varieties at the district level is also positively correlated with on-farm diversity outcomes. A government program that seeks to increase the district supply of varieties available to households would be an excellent alternative to direct farmer subsidies. The government could provide funding to regional offices to collect and maintain a stock of varieties within each district, or it could provide financial incentives to growers associations or co-ops to house diverse wheat varieties.

Past and Future Research

This study relates most closely to two works that examine the probability of landrace cultivation and linkages to on-farm diversity outcomes. These studies are Meng (1997) and Gauchan et al. (2005).

Meng (1997) performs a very similar analysis on Turkey with many of the variables used in this study, less the group of variety characteristics. In her study, similar results are found for land-use determinants as cited in chapter five, but her diversity outcomes are sensitive to the diversity metric used. Meng also used morphological traits to construct the indices used in her study instead of using named varieties, which is the approach used in this thesis. From the results of her estimation of diversity using the Shannon index, Meng shows that wealth and labor variables have the largest impact on diversity outcomes. Variables used to measure these determinants, though, do not have significant coefficients in this study, and thus do not provide much insight into Meng's original work.

In Gauchan et al. (2005), results show that some of the variables tested, such as distance to market, land quality, and irrigation have the same effects on diversity as shown in this paper. Their research, however, focuses on rice diversity in Nepal. Nepal is a center of rice diversity and thus comparisons can be drawn to Turkey, but several differences between Turkey and Nepal prohibit making truly meaningful comparisons.

Most of the works cited in this paper have provided a base of evidence that socioeconomic/household characteristics, agroecological heterogeneity, market access, and variety characteristics impact technology adoption decisions that agrarian households make and can affect diversity outcomes. Yet the estimation of diversity outcomes can be strongly influenced based on the measure of diversity used. Several of the papers cited above showed differing results for diversity outcome estimation based on the type of index chosen to measure diversity. This research, on the other hand, shows a considerable amount of homogeneity between the diversity outcomes estimated, which results from a large correlation coefficient between the Berger-Parker and Shannon indices.

Hence, one direction for further research into technology adoption and diversity studies could be the implementation of better diversity metrics. If the *in situ* conservation of crop genetic resources from landraces is important, for example, indices could be constructed to give weight to landraces over modern varieties.

An additional direction for future research is the use of panel data to test changes over time in the importance of land-use determinants and diversity levels as modern technologies become increasingly available. Most of the studies cited in this paper were done using cross-sectional data. While these studies provide insights about land-use determinants and diversity outcomes, changes over time may reveal important trends in technology adoption and diversity outcomes, and may help to formulate stronger policy prescriptions to prolong landrace cultivation and maintain or increase on-farm genetic diversity.

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APPENDICES

APPENDIX A

SURVEY

Varietal Choice Decisions in Turkish Households and their Impacts on Wheat Genetic Diversity and Household Welfare

Collaborating Institutions:
Turkish Agricultural Economics Research Institute (TAERI)
International Maize and Wheat Improvement Center (CIMMYT)

Enumerator	|____________________|	Date	|____________________|
Household Name	|____________________|	Household Code	|____________________|
Village Name	|____________________|	Village Code	|____________________|
District Name	|____________________|	District Code	|____________________|
Province Name	|____________________|	Province Code	|____________________|
Telephone Number	|____________________|		

Checked by |____|

Section 1. Household Information

1. Number of household members this year (1999) (persons that have lived the first 6 months of the year in the household)? |_______|

2. Number of household members last year (1998) (persons living more than 6 months in the household)?
|_______|

3. Number of household members two years ago (1997) (living more than 6 months in the household)? |_______|

4. Is the family originally from the village?
1=yes 2=no |___________________________|

For each person, ask questions #5-17

	personcode	1	2	3	4	5	6	7
5	gender 1=male 2=female							
6	Relationship to hh head 1=hh head 2=spouse 3=child 4=grandchild 5=parent 6=brother/sister 7=son/daughter-in-law 8=parent-in-law 9=other relative 10=non-relative							
7	Years of education received							
8	Age							
9	# of months in 1997 not living in the household due to school							
10	Did this member work in a non-farm job during 1997? 1=yes 2=no => Sec. 2							
11	total # of months during 1997 of non-farm work							
12	Of total months responded in #12, # of months in 1997 not living in the household due to non-farm work							

Section 1. Household Information (continued)

13	location of non-farm work 1=household 2=own village 3=other village, same district 4=district capital, 5=other village, same province 6=provincial capital 7=village in other province 8=city in other province 9=foreign country (which one) 10=other (explain)							
14	type of non-farm job 1=agricultural processing 2=construction 3=commerce 4=other factory 5=service 6=other (explain)							
15	type of work 1=wage earner 2=self-employed							
16	duration of employment 1=permanent 2=contract 3=temporary							
17	more than one non-farm job? 1=yes 2=no							

Section 2. Farm Land

1. Which person in your household knows your farm business best?	Person code |_________|
2. How many years of farming experience does that person have?	|_________| years
3. Who is answering questions now?	Person code |__________|
4. How many years of farming experience do you have?	|_________ years
1255. What was the total area the household owned in 1997-98?	|_________| decares
6. What was the area of land share cropped by the household in 1997-98?	|_________| decares
7. Amount of land rented in by the household in 1997-98	|_________| decares
8. What was the total area of land cultivated by the household in 1997-98?	|_________| decares
9. Of the total amount of land (#5+#6+#7) what is the total area of mountainous (very sloped) land?	|_________| decares
10. Of the total amount of land (#5+#6+#7) what is the total area of irrigated land?	|_________| decares
11. How many parcels of land total in 1997-98?	|_________| # of parcels
12. How many parcels of land cultivated in 1997-98?	|_________| # of parcels
13. Amount of land rented out during 1997-98	|_________|| decares

Section 3. Household Plots (1)

Crop Code: 1=wheat 2=barley 3=chickpeas 4=beans 5=sugarbeets 6=lentils 7=sunflower 8=potatoes 9=maize 10=oats 11=garlic 12=tobacco 13=vegetables 14=vetch 15=alfalfa 16=sainfoin 17=fruit trees 18=fallow 19=empty 20=other (explain)

Note: Plots refer to individual parcels of land cultivated by the household in 1997-98 (harvested in 1998)

Parcel Code	1. area of the plot	2. planted area if different from plot area	3. What year did your household start to farm this plot?	Crop harvested on this plot in Summer 1998				
	decares	decares	year	4. crop code	5. wheat variety	6. yield (kg/dec)	7. seeding rate (kg/dec)	8. Type 1 fertilizer used 1=none 2=urea 3=TSP 4=DAP 5=CAN 6=compound 7=manure 8=ammonium nitrate 9=other (explain)
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

Section 3. Household Plots (2)

Parcel Code	Note: Plots refer to individual parcels of land cultivated by the household in 1997-98 (harvested in 1998)						15. type of disaster on this plot in 1997-98 1=none => #15 2=flood 3=drought 4=hailstorm 5=windstorm 6=snowstorm 7=disease 8=insect pests 9=other (explain)	16. compared with a normal year, output was reduced by %)
	9. Amount (kg/dec)	10. Type 2 fertilizer used 1=none 2=urea 3=TSP 4=DAP 5=CAN 6=compound 7=manure 8=ammonium nitrate 9=other (explain)	11. Amount (kg/dec)	12. More than two types of fertilizer used on this plot? 1=yes 2=no	13. Herbicide used? 1=yes 2=no	14. Pesticide used? 1=yes 2=no	List all responses if more than one disaster	%
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

Section 3. Household Plots (3)

Plot Code	17. Planting date of summer-harvested crop / # days needed date	18. Harvest date of summer-harvested crop / # days needed date	19. What is the optimal yield for wheat in this plot? (kg/dec)	20. In the last 10 years, how many years has the wheat yield in this plot been below 20% of the optimal yield?	21. In the last 10 years, how many years has the wheat yield in this plot been below 50% of the optimal yield?	22. Who decided which wheat variety to plant? 1=hhld head 2=spouse 3=other household member 4=joint household decision 5=coop recommendation 6=provincial directorate 7=muhtar 8=farmer leader 9=other (explain)	Crop Code: 1=wheat 2=barley 3=chickpeas 4=beans 5=sugarbeets 6=lentils 7=sunflower 8=potatoes 9=maize 10=oats 11=garlic 12=tobacco 13=vegetables 14=vetch 15=alfalfa 16=sainfoin 17=fruit trees 18=fallow 19=empty 20=other (explain) 23. 1997 Fall-harvested crop Crop Code	24. Yield (kg/dec)

Section 3. Household Plots (4)

Parcel Code	97 Spring-planted (Fall-harvested crop)		Crops planted on this plot in 1996-97 (two years ago)		Crop planted in this plot in spring 1996 and harvested fall 1996	Crops planted on this plot in 1998-99 (this year)		Crop planted in this plot in spring 1998 and harvested fall 1998
	25. Planting Date	26. Harvest Date	27. 1997 summer-harvested crop code	28. wheat variety	29. 1996 fall-harvested crop code	30. 1999 summer-harvested crop code	31. wheat variety	32. 1998 fall-harvested crop code

Section 3. Household Plots (5)

Parcel Code	33. What is the source of the irrigation on this plot? 1=none 2=canal (DSI) 3=canal (irrigation coop) 4=canal (municipality) 5=canal (irrigation) 6=well 7=artesian well 8=other (explain)	34. land quality 1=high 2=medium 3=low 4=extra low	35. land type 1=plain 2=low hills 3=medium hills 4=mountainous 5=other (explain)	36. plot soil type? 1=rocky 2=fertile 3=clay 4=dry 5=sandy 6=other (explain)	37. Ownership of plot? 1=household owned 2=rented 3=share cropped 4=other (explain)	38. how far is this plot from your house? (km)	39. how much time in minutes do you need to travel from your house to the plot using your usual mode of transportation?	Ask questions #40-56 ONLY for plots planted in wheat during 1997-98** 40. What labor did you use to prepare the land for planting? 1=hand hoe 2=animal plow 3=tractor 4=hoe+animal 5=hoe+tractor 6=animal+tractor 7= 8=other (explain) If 1 or 2 =>#43
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

Section 3. Household Plots (6)

Parcel Code	41. machine ownership for land preparation 1=own 2=rented 3=owned cooperatively 4=borrowed 5=othre (explain)	42. if machinery was rented, cost of rental (TL/dec)?	43. How did you seed the plot? 1=hand broadcasting 2=drilling in rows 3=both 4=other (explain)	44. Harvesting practice for this plot 1=scythe/sickle 2=tractor-pulled machine 3=combine 4=other (explain) if 2 or 3 => #47	45. machine ownership for harvesting 1=own 2=rented 3=owned cooperatively 4=borrowed 5=other (explain)	46. if machinery was rented, cost of rental (TL/decare)	47. Threshing practice for this plot 1=animal-pulled thresher 2=stationary thresher 3=combine 4=other if 2 or 3 => #49	48. machine ownership for threshing 1=own 2=rented 3=owned cooperatively 4=borrowed 5=other (explain)
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

Section 3. Household Plots (7)

Parcel Code	49. Labor used during preparation of land for wheat 1=household labor only 2=labor exchange with neighbors 3=labor exchange with relatives 4=labor hired from within village 5=labor hired from outside village 6=both household and hired labor 7=other (explain)	50. If labor was hired for land preparation, cost of labor per decare (TL/day)? Or if labor was exchanged, for what was it exchanged?	51. Labor used for wheat harvest 1=household labor only 2=labor exchange with neighbors 3=labor exchange with relatives 4=labor hired from within village 5=labor hired from outside village 6=both household and hired labor 7=other (explain)	52. If labor was hired for harvesting, cost of labor (TL/day) or if labor was exchanged, exchanged for what?	53. Labor used for wheat threshing 1=household labor only 2=labor exchange with neighbors 3=labor exchange with relatives 4=labor hired from within village 5=labor hired from outside village 6=both household and hired labor 7=other (explain)	54. If labor was hired, cost of labor (TL/day) or if labor was exchanged, exchanged for what?	55. How do you control weeds in the plot? 1=hand weeding 2=chemicals 3=both 4=do nothing 5=other (explain)	56. How many times was the plot weeded? 1=none 2=once 3=twice 4=three times 5=other (explain)
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

Section 4. Input Availability and Use

1. Was labor available for hire last year (1997-98) if desired? 1=yes 2=no |________________________|

Crop Code: 1=wheat 2=barley 3=chickpeas 4=beans 5=sugarbeets 6=lentils 7=sunflower 8=potatoes 9=maize 10=oats 11=garlic 12=tobacco 13=vegetables 14=vetch 15=alfalfa 16=sainfoin 17=fruit trees 18=fallow 19=empty 20=other (explain)

2. Did you hire labor in 1997-98? 1=yes 2=hayır => #5 |________________________|

3. For what crops did you hire labor? List all crops using crop code above |________________________|

4. If available, what is the cost of labor during harvest season? (TL/dec) |________________________|

5. If you didn't hire labor, why not? 1 = I have enough labor; 2 = labor is too expensive; 3 = no labor available; 4 = use of mechanization made it unecessary; 5 = diğer(açıklayınız) |________________________|

6. Last year (1997-98), did you have any problems with seed availability at the time you needed it for your wheat crop? 1=yes 2=no |_______________________|

7. Did you obtain all the seed for the varieties you wanted to cultivate in 1997-98? 1=evet 2=hayır |______________________|

8. If not, why not? 1=seed not available; 2=seed too expensive; 3=poor seed quality; 4=Recently replaced seed and did not need to this year; 5=too far to travel to obtain new seed; 6=other (explain) |______________________|

9. Where did you obtain your wheat seed? 1=farm saved; 2=borrowed/traded; 3=purchased; 4=other |______________________|

Section 4. Input Availability and Use (continued)

10. Are you aware of what variety(ies) your neighbors cultivate? 1=yes 2=no	|____________|
11. Would you consider changing your varieties if your neighbor changed his/hers? 1=yes 2=no	|____________|
12. Last year (1997-98), did you have any problems with fertilizer availability during the time you needed it for your wheat crop? 1=yes 2=no	|____________|
13. Last year (1997-98), could you afford to buy all the fertilizer you wanted to use for your wheat crop? 1=yes 2=no	|____________|
14. Last year (1997-98), did you use pesticides on your wheat crop? 1=yes 2=no =>#17	|____________|
15. Last year (1997-98), did you have any problems with pesticide availability at the time you needed it for your wheat crop? 1=yes 2=no	|____________|
16. Last year (1997-98), could you afford to buy all the pesticide you wanted to use for your wheat crop? 1=yes 2=no	|____________|
17. Do you use any other methods to control pests and diseases? 1=no 2=crop rotation 3=change in planting dates 4=fallow 5=other (explain)	|____________|
18. Last year (1997-98), did you use herbicides on your wheat crop? 1=yes 2=no =>#20	|____________|
19. Last year (1997-98), did you have any problems with herbicide availability at the time you needed it for your wheat crop? \1=yes 2=no	|____________|
20. Last year (1997-98), could you afford to buy all the herbicide you wanted to use for your wheat crop? 1=yes 2=no	|____________|
21. What other methods used to control weeds in your wheat crop? 1=no 2=hand weeding 3=planting density 4=other (explain)	|____________|
22. How many times have you had contact with an extension agent in the last two years (1998-99)?	|____________|

Section 4. Input Availability and Use (continued)

23. Did you have contact with an extension agent in 1997? 1=evet 2=hayır |______________________|

24. When was the last time you were in contact with an extension agent? |______________________|

25. Have you ever attended a farmers' field day or demonstration trial? 1=evet 2=hayır |______________________|

26. Do you know the recommended wheat varieties for your region? 1=evet 2=hayır |______________________|

27. If yes, what are they? |____|

Section 4 Use of Agricultural Credit

Please indicate your use of agricultural credit during the 1997-98 season (See codes at bottom of table)

Crop	Source of Credit	Type	Collateral Requirements	Use of Credit

Crop Code: 1=wheat 2=barley 3=chickpeas 4=beans 5=sugarbeets 6=lentils 7=sunflower 8=potatoes 9=maize 10=oats 11=garlic 12=tobacco 13=vegetables 14=vetch 15=alfalfa 16=sainfoin 17=fruit trees 18=fallow 19=empty 20=other (explain)

Credit Source: 1=TC Ziraat Bankası 2=agricultural credit coop 3=other bank 4=other cooperative 5=relative 6=neighbor 7=money lender 8=other
ype: 1=cash 2=in kind 3=other (explain)
Collateral requirments: 1=land 2=livestock 3= 4= 5= 6=other (explain)

Use of credit: 1=purchase seed 2=purchase fertilizer 3=purchase herbicide 4=purchase pesticide 5=hire labor 6=hire tractor/machinery 7=other (explain)

1. Did you try to obtain credit last year (1997-98)? 1=evet 2=hayır => Sec. 6 |________________________|

2. Did you have any problems obtaining credit?   1=evet 2=hayır |________________________|

3. If yes, what kind of problems?

1= Bank loans not available
2= Coop loans not available
3= Did not have required collateral
4= Interest rates too high
5= Other unfavorable repayment terms
6= Too much paperwork
7 = Diger (açıklayınız)

|________________________|

Section 6. Variety Selection

1. Have you ever planted an improved variety?
1=yes 2=no => #5 |________________| 2. Which varieties? |______________| |______________| |______________|

3. What was the first year you planted an improved variety? |________________|

4. From what source did you originally obtain information about improved varieties? |________________|

1=neighbor 2=relative 3=extension agent 4=demonstration plot 5=tv/radio 6=newspaper
7=research institute 8=TIGEM 9=other (explain) |________________|

5. How many varieties of wheat did you plant this year (1998-99)? |________________|

6. Of which how many were new varieties? |________________|

7. How many varieties of wheat did you plant in the 1997-98 planting season (last year)? |________________|

8. Of which how many were new varieties? |________________|

9. Which varieties planted for the first time? |________________| |________________| |________________|
|________________|

10. How many varieties of wheat planted 5 years ago? (1993-94) |________________|

11. Which varieties? |________________| |________________| |________________|

12. Who decided which wheat varieties to plant at that time? |________________|

1=household head	5=provincial directorate
2=spouse	6=muhtar
3=joint household decision	7=farmer leader
4=coop recommendation	8=other

13. How many varieties of wheat did you plant ten years ago? |________________|

Section 6. Variety Selection (continued)

14. Which varieties? |________________| |________________| |________________| |________________| |________________|

15. Who decided which wheat varieties to plant at that time?

1=household head
5=provincial directorate
2=spouse
6=muhtar
3=joint household decision
7=farmer leader
4=coop recommendation
8=other

|________________|

If response to #10 > #7 => #16

If response to #10 < #7 => #17

If response #10 = #7 = 1 variety => #19

16. Why do you plant fewer varieties now?

17. Why do you plant more varieties now?

18. If you planted more than 1 wheat variety last year (1997-98), which best describes your reason? |________________|

1 = If I only planted one variety and it failed, then I would have no output.
2 = I am planting a variety for the first time (new technology) and want to maintain others as a back-up.
3 = I have many different needs for the wheat that I am trying to satisfy (e.g., sale, household consumption, feed for livestock) and a single variety does not satisfy all the requirements.
4 = I need to plant several varieties with different times to maturity in order to better allocate my available labor.
5 = I have different soil types and plot conditions, and different varieties are best suited for different conditions.
6 = Available seed in one variety was insufficient for all my plots.
7 = I like having more than one variety
8 = other (explain)

19. If you only planted one variety of wheat last year, which best describes your reason? |__________________________|

1 = It is more efficient to sow and harvest for one single variety
2 = I wanted to plant all my land in the highest yielding variety
3 = This variety satisfies all my production and consumption needs.
4 = I was only able to obtain sufficient seed for one variety.
5 = other (explain)

20. In your opinion, is uniformity in a variety important? 1=evet 2=hayır |_________________|

21. Are there any varieties that you are particularly reluctant to stop growing? 1=evet 2=hayır |_________________|

22. If yes, why? |____|

Section 6. Variety Selection (continued)

Wheat Characteristics	23. IN GENERAL, which of these characteristics do you consider important when you choose a wheat variety? use a /	24. Of all the characteristics that you consider, rank the top 5 characteristics in order of importance (1=most important)	25. Which of the following characteristics do you associate with the varieties you cultivated last year (1997-98)? (use a /) Variety 1	Variety 2 …………	Variety 3 ……………	Variety 4 ……………	Variety 5 ……………	Variety 6 ……..……
a) yield								
b) yield stability								
c) drought tolerance								
d) cold tolerance								
e) pest resistance								
f) disease resistance								
g) suitability for plot soiltype								
h) resistance to lodging								
i) good bread making quality								
j) good storage quality of wheat								

Section 6. Variety Selection (continued)

k) good storage quality of wheat products								
l) other consumption quality (explain)								
m) good nutritional quality								
n) good market price								
o) desirable grain color								
p) desirable color of food product								
q) suitability for early planting								
r) suitability for late planting								
s) early maturity								
t) late maturity								
u) suitability for machinery								
v) quantity of residue for livestock								
w) good quality livestock feed								
x) seed resistant to shattering								
y) acceptability in market								
z) other (explain)								

26. Rank all the varieties you have grown since 1988-89 (including this year) in terms of the 5 most important characteristics you selected in question #24 (1=best)

Wheat Characteristic Copy responses from #23		Variety 1	Variety 2	Variety 3	Variety 4	Variety 5	Variety 6	Variety 7 . . . .
1								
2								
3								
4								
5								

27. Have you stopped growing wheat varieties in the last ten years (since 1988-99 planting season)?
1=yes 2=no >> next section |__________________|

28. Which wheat varieties have you stopped growing and why?

Primary reasons (use code on previous page for variety characteristics)

Variety name		Most important reason	Second reason	Third reason
1				
2				
3				
4				
5				

29. In the last five years, what was the variety you were most satisfied with? |________________________|

30. Which of the above characteristics do you still feel are not adequately present in the varieties currently available?

		Desired characteristic that is most inadequately available	Second	Third	Fourth
Variety characteristic (use characteristic codes from #23)		|________________|	|_________________|	|_________________|	|_________________|

Section 7. Source of Seed

Note: All information pertains to seed used in the 1997- 98 season (harvested in 1998)

Wheat variety	1. When was the first year you planted this variety?	2. How many years have you planted this variety?	3. How did you originally learn about the variety? 1=neighbor 2=relative 3=demonstration plot 4=extension agent 5=seed company 6=seed peddler 7=TIGEM 8=radio/tv 9=newspaper 10=other (explain)	4. Have you ever purchased seed of this variety? 1=yes 2=no	5. How much did the seed cost the first year purchased (TL/kg)? Or if exchanged, for what was the seed exchanged?	6. What was the last year you purchased speed of this variety?	7. How much did it cost in the most recent year purchased (TL/kg)?	8. Where did you obtain the seed for planting in 1997? 1-farm saved => #9 2=neighbour 3=relative=> #9, then #20 4=seed company 5=cooperative 6=seed merchant 7=TIGEM 8 other (explain) => #20
1								
2								
3								
4								
5								
6								

Section 7. Source of Seed (continued)

Buğday çeşidi	9. For those who did not purchase seed in the market in 1997 - why did you not purchase the seed in the market? 1=too expensive 2=too far to travel 3=variety was difficult to find in the market at that time 4=variety is not available for purchase in market 5=other (explain)	10. what proportion of harvest of this variety was saved as seed (%)?	11. What standards did you use to select your seed? 1=plumpness of grain 2=seed weight 3=seed color 4= lack of disease in plot 5=uniformity of height in plot 6=overall uniformity of appearance in plot 7=lack of weeds in plot 9=other (explain)	12. If farm saved, when was seed selected? 1=from plants in field before harvest 2=from spikes after harvest but before threshing => #14 3=from seed after threshing 4=at home after storage 5=immediately before planting 6=other (explain)	13. How do you transport your production from field to household? 1=animal cart 2=tractor 3=truck 4=other (explain)	14. If you gwor more than one variety do you transport them separately from the field? 1=evet 2=hayır	15. Did you use gravity methods or other mechanical methods to select seed? 1=yes 2=no	16. Did you treat your seed? 1=yes 2=no
1								

Section 7. Source of Seed (continued)

Buğday çeşidi	17. Did you store wheat selected for seed separate from other wheat? 1=yes 2=no	18. Where do you store the seed? 1=in bags kept in house 2=in bags kept in storage area separate from house 3=other (explain)	19. What storage problems do you have? 1=storage weevils 2=rodents 3=humidity/fungi 4=other (explain) 5=none	20. Did you experience any disease problems with the variety in 1996-97? 1=no 2=yellow rust 3=stem rust 4=smut 5=suni bug 6=other (explain)	21. Have you always obtained the seed at the same location as #8? 1=yes 2=no	22. If no, where else have you obtained it? (use codes from #8)	23. Why did you acquire new seed? 1=own supply insufficient 2=needed to improve purity of seed planted 3=disease problems 4=other (explain)	24. On average, how often do you replace your wheat seed?
1								
2								
3								
4								
5								
6								

Section 8. Wheat Consumption and Marketing

1. What is the average amount of wheat (kg) that an adult in your household consumes each day? |_____________| A child (under 13 years old) in your household? |_______________________|

2. How much wheat (kg) on average does your total household consume from one harvest to the next? |_______________________|

3. Is there a mill in the village? 1=yes => #6 2=no |_______________________|

4. If no, what is the distance to the nearest mill (km)? |_______________________|

5. Where do you mill your wheat? 1=village mill 2=mill in another village (explain) 3=do not mill wheat => #9 4=other (explain) |_______________________|

6. What is the cost per kg for milling wheat?

7. Do you receive flour from the same wheat you take for milling? 1=always => #9 2=often 3=sometimes 4=rarely 5=never |_______________________|

8. If not always, is the flour you receive from the same variety? 1=always 2=often 3=sometimes 4=rarely 5=never 6=mix of varieties 7=don't know the variety |_______________________|

9. Does the mill ever mix together the wheat varieties you take for milling? 1=always 2=often 3=sometimes 4=rarely 5=never |_______________________|

10. Do you prefer that your wheat varieties be mixed together or kept separate when being milled? 1=kept separate 2=mixed 3=indifferent |_______________________|

11. In general, does your household purchase additional flour between harvests? 1=always 2=often 3=sometimes 4=rarely 5=never |_______________________|

If #11=5 and #12=5 go to #18

12. In general, does your household exchange or borrow additional flour between harvests? 1=always 2=often 3=sometimes 4=rarely 5=never |_______________________|

Section 8. Wheat Consumption and Marketing (continued)

13. If you purchase or exchange flour, do you know the wheat variety of the flour? 1=yes 2=no |__________________|

14. Do you make an effort to purchase/trade a specific variety of wheat/flour? 1=yes 2=no => #16 |__________________|

15. Which variety or varieties? |__________________| |__________________| |__________________| |__________________|

16. If you purchased or exchanged flour, are there any wheat products for which you DO NOT use this flour? 1=yes 2=no => #18 |__________________|

17. What are the food products for which you DO NOT use purchased wheat/flour? |____|

18. Does your household bake its own bread? 1=always 2=often 3=sometimes 4=rarely 5=never |__________________|

19. Which other wheat products are made in the household and/or purchased?

Product	Made in Household?	Preferred Variety	Purchased?
1. somun			
'2. çörek			
3. Bulgur			
4. yarma			
5. yufka			
6. bazlama			
7. pasta			

Product	Made in Household?	Preferred Variety	Purchased?
8. gozleme			
9. makarna			
10. tarhana			
11. manti			
12. asure			
13. other (explain)			

Section 8. Wheat Consumption and Marketing (continued)

20. Which wheat product do you make the most in your household? |________________________|

21. If you purchase wheat products, where do you purchase them? 1=district shops/bakeries
2=village shops/bakeries 3=neighbor 4=other (explain) |________________________|

22. Do you prefer products made with wheat varieties you grow to purchased products?
1=yes 2=no 3=indifferent |________________________|

Wheat Consumption and Marketing June/July 1998 - June/July 1999

23. Do you mix your wheat varieties following harvest? 1=yes => do not fill out table by variety 2=no => fill out table by variety

	Variety Name	Total Production in Variety harvested in 1998 (kg)	Beginning Stock of Variety (Production from 1996-97 still in storage prior to harvest in 1998)	Wheat Purchases June/July 1998 - June/July 1999			
				Wheat Purchases 1998-99 (Quantity and Price) (not including seed purchases)			
				Amount (kg)	Price (TL/kg)	From whom purchased (e.g., flour factory, etc.)	Location
Variety 1							
Variety 2							
Variety 3							
Variety 4							
Variety 5							
Variety 6							

Section 8. Wheat Consumption and Marketing (continued)

Variety Name	Flour Purchases June/July 1998 - June/July 1999 Un				Straw Purchases June/July 1998 - June/July 1999 Saman			
	Amount (kg)	Price (TL/kg)	From whom purchased (e.g., flour factory, etc.)	Location	Amount (kg)	Price (TL/kg)	From whom purchased (e.g., flour factory, etc.)	Location

Variety Name	1998-99 Wheat Sales Sales to TMO				1=own tractor 2=own truck 3=rented tractor 4=rented truck 5=other (explain)	Sales to Private Merchants		
	Amount (kg)	Price (TL/kg)	Location of Sale (name)	Distance from Farm (km)	Transportation	Amount (kg)	Price (TL/kg)	Location of Sale (name)

Section 8. Wheat Consumption and Marketing (continued)

Variety Name	Sales to Private Merchants	1=own tractor 2=own truck 3=rented tractor 4=rented truck 5=other (explain)	Sales to Flour Factory/Mills				1=own tractor 2=own truck 3=rented tractor 4=rented truck 5=other (explain)
	Distance from Farm (km)	Transportation	Amount (kg)	Price (TL/kg)	Location of Sale (name)	Distance from Farm (km)	Transportation

Variety Name	Other Sales (Explain)				1=own tractor 2=own truck 3=rented tractor 4=rented truck 5=other (explain)	Wheat Bartered/Exchanged	
	Amount (kg)	Price (TL/kg)	To Whom Sold and Location of Sale	Distance from Farm (km)	Transportation	Quantity (kg)	In exchange for:

Section 8. Wheat Consumption and Marketing (continued)

Variety Name	Gifts of Wheat/Wheat Products		Wheat Used for Livestock Feed	Seed Saved for Next Planting	Total amount consumed by household in 1998-99	Ending Stock (prior to 1999 harvest)	18. What wheat products do you make using wheat of this variety? 1=somun 2=çörek 3=bulgur 4=yarma 5=yufka 6=bazlama 7=ekmek 8=pasta 9=gozleme 10=macaroni 11=other (explain) Not: Birden fazla verilen aynı cevaplarda sıklık sırasını esas alınız
	Amount In	Amount Out	Quantity (kg)	Quantity (kg)	Quantity (kg)	Quantity (kg)	

Section 9. Changes in Household Wheat Utilization

In the past ten years, have you noticed changes in any of the following:

1= increased 2=no change 3= decreased 4= don't know 5=NA (not applicable)

1. Wheat yields in your fields	
2. Area planted to wheat	
3. Quantity of wheat consumed in the household	
4. Quantity of wheat sold in market	
5. Quantity of wheat products purchased	
6. Income from wheat sales	
7. Wheat quality	
8. Wheat nutritional content	
9. Ability to obtain flour milled from desired traditional varieties	
10. Ability to obtain seed of desired traditional varieties	
11. Interest in consuming traditional varieties	
12. Interest in producing traditional varieties	

Section 10. Household Income Sources and Assets

1. Of all the crops you grow, which ones provide the most cash income? Most |____________| Second |____________| Third |______________|

Crop Code: 1=wheat 2=barley 3=chickpeas 4=beans 5=sugarbeets 6=lentils 7=sunflower 8=potatoes 9=maize 10=oats 11=garlic 12=tobacco
13=vegetables 14=vetch 15=alfalfa 16=sainfoin 17=fruit trees 18=fallow 19=livestock 20=other (explain)

2. What is your most important source of income?
1=agriculture 2=non agriculture |________________|

3. Did you receive remittances in 1998 from relatives not living in the household?
1=yes 2=no |________________|

4. Did you receive remittances in 1997 from relatives not living In the household?
1=yes 2=no |________________|

5. 1997 yılında olagan dışı herhangi bir harcamanız
varmı? (düğün, hastalık vs) |________________| Explain ____________________________

5.1 In 1998 did you send financial support to relatives outside the village? 1=yes 2=no

5.2 In 1997 did you send financial support to relatives outside the village? 1=yes 2=no

6. Do you own property outside the village? 1=no 2=land 3=house 4=apartment
5=other (explain) |________________|

7. How would you consider your household relative to others in the village?
1=wealthy 2=medium 3=poor |________________|

Section 10. Household Income Sources and Assets (continued)

Housing

Please answer the following questions regarding your place of residence

8. Primary construction material of house	1=mud brick 2=brick 3=concrete 4=stone 5=wood 6=other (explain)	
9. Number of rooms (all rooms, including storage)		
10. Type of floor	1=dirt 2=concrete 3=wood 4=other (explain)	
11. Type of roof	1=brick tile 2=wood 3=other (explain)	
12. Source of water	1=village fountain 2=village well 3=village reservoir 4=other (explain)	
13. Type of drainage	1=village sewage system 2=household septic system 3=other (explain)	
14. Electricity	1=yes 2=no	
15. Number of separate buildings for production-related activities (e.g., barns, etc.)		

Section 10. Household Income Sources and Assets (continued)

Ownership of Machinery, Equipment, and Consumer Durables

Which of the following does your household own? 1=yes 2=no

16. Tractor		26. Tractor plow	
17. More than one tractor		27. Fertilizer sprayer	
18. Animal plow		28. Motorcycle	
19. Animal cart		29. Car	
20. Pump		30. Truck	
21. Tractor trailor		31. Minibus	
22. Stationary thresher		32. Refrigerater	
23. Planter		33. TV	
24. Chemical distributor		34. Washing machine	
25. Tractor-pulled harvesting machine		35. Telephone	

Section 11. Animal Ownership

Animal	1. Number owned end of 1996	2. Number born in 1997	3. Number purchased in 1997	4. Number sold in 1997	5. Number consumed by household in 1997	6. Number lost in 1997 (due to disease, accidents, etc.)	7. Number owned end of 1997	8. Primary type of feed 1=wheat straw 2=other wheat byproduct 3=barley 4=oats 5=fodder crops 6=purchased feed 7=sugar beet meal 8=other purchased meal 9=legume hay 10=pasture 11=silage 12=wheat 13=other (explain)
Sheep								
Goats								
Bull								
Milking Cow								
Calf								
Ox								
Buzağı								
Other Cattle								
Horses								
Donkey/Mule								
Honey Bees								
Poultry								
Other (explain)								

Bölüm 12. Ailenin Kadın
Başkanına Yönelik Sorular

1. Does your household bake its own bread? 1=always 2=often 3=sometimes 4=rarely 5=never |________________|

2. Which other wheat products are made in the household and/or purchased?

Product	Made in Household?	Preferred Variety	Purchased?
1. somun			
'2. çörek			
3. Bulgur			
4. yarma			
5. yufka			
6. bazlama			
7. pasta			

Product	Made in Household?	Preferred Variety	Purchased?
8. gozleme			
9. makarna			
10. tarhana			
11. manti			
12. asure			
13. other (explain)			

3. Which wheat product do you make the most in your household? |_____________________|

4. If you purchase wheat products, where do you purchase them? 1=district shops/bakeries 2=village shops/bakeries 3=neighbor 4=other (explain) |_____________________|

5. Do you prefer products made with wheat varieties you grow to purchased products? 1=yes 2=no 3=indifferent |______________________|

6. Do you know which wheat varieties your household is cultivating this year (1998-99)? 1=yes 2=no (If answer is no, look at survey form p. 7 to help her remember) |_________________|

7. Which ones? |____|

8. Do you know which varieties your household cultivated last year (1997-98)? 1=yes 2=no (If answer is no, look at survey form p. 4 to help her remember) |_________________|

9. Which ones? |____|

10. Can you distinguish among the dough from the different wheat varieties you are growing or have grown in the past? 1=yes 2=no |_________________|

11. Can you distinguish among the finished products made from the different wheat varieties you are growing or have grown in the past? 1=yes 2=no |_________________|

12. Please describe the varieties your household grows

Wheat Variety	General Characteristics

13. In general, how often do you make these products and how long will they remain good?

Product	Frequency Made in Household	Number of Days Product Remains Edible	Preferred Wheat Variety (if any) and Reason
Somun			
Bazlama			
Yufka			
Corek			
Sac Ekmek			
Tarhana			

14. How many days do the products made from the wheat varieties you grow remain fresh (edible)?

Product/Wheat Variety	Variety 1	Variety 2	Variety 3	Variety 4	Variety 5
Somun					
Bazlama					
Yufka					
Corek					
Sac Ekmek					
Tarhana					

15. Please rank the varieties with respect to the characteristics and products

Product/Wheat Variety	Variety 1	Variety 2	Variety 3	Variety 4	Variety 5
Color of Wheat					
Color of Product					
Dough Quality					
Good bread making quality					
Good storage quality of wheat					
Good storage quality of wheat products					
Livestock Feed					
Somun					
Bazlama					
Yufka					
Corek					
Sac Ekmek					
Tarhana					

16. Does you household purchase or exchange for flour? 1=always 2=often 3=sometimes 4=rarely 5=never

17. Is there any wheat product for which you will not use purchased flour? 1=no 2=yes (explain) |__________________|

Bölüm 12. 1998-99 yılında Islah edilmis Tohum Çeşitlerinin Sevk ve İdare Bilgileri

Not: Tüm bilgiler 1998-99 sezonunda kullanılan tohuma aittir(1999 'da hasat edilen buğday).
1997-98 YILINDA KULLANILAN TOHUM DAĞITIMI ÇİZELGESİNİN AYNISI
(BU ÇİZELGE ARAŞTIRMA ESNASINDA TOPLANAN TOHUM BİLGİLERİ İÇİNDİR)

APPENDIX B

CORRELATION TABLES FOR PLOT-LEVEL ESTIMATION

	Landrace	Farm Exp. (Years)	Edu.	Dep. Ratio	Total Farm Area (Hectares)	Frag.	Off-farm Property Holdings
Landrace	1.00						
Farm Experience (Years)	0.05 *	1.00					
Education (Years)	0.12 *	-0.32 *	1.00				
Dependency Ratio	-0.01	0.06 *	-0.06 *	1.00			
Total Farm Area (Hectares)	0.21 *	0.01	0.14 *	-0.01	1.00		
Fragmentation	0.20 *	0.03	0.12 *	0.09 *	-0.50 *	1.00	
Off-farm Property Holdings (1=yes, 0=no)	0.08 *	0.07 *	0.12 *	0.00	0.04	0.11 *	1.00
Number of Rooms in House	0.10 *	0.16 *	0.07 *	-0.09 *	0.13 *	-0.15 *	-0.09 *
Number of Buildings on Farm	0.11 *	-0.06 *	0.12 *	-0.04	0.22 *	-0.16 *	-0.01
Car Ownership (1=yes, 0=no)	-0.04	0.03	0.03	-0.13 *	0.16 *	-0.11 *	0.12 *
Cattle (Head)	0.07 *	-0.03	0.04	-0.15 *	0.12 *	-0.13 *	0.08 *
Sheep (Head)	0.01	0.07 *	0.06 *	-0.16 *	0.09 *	-0.12 *	0.10 *
Goats (Head)	-0.01	0.06 *	0.02	-0.02	-0.03	0.02	0.01
Cattle^2	0.09 *	0.04	-0.01	-0.14 *	0.10 *	-0.11 *	0.11 *
Sheep^2	-0.03	0.09 *	0.02	-0.12 *	0.06 *	-0.07 *	0.10 *
Goats^2	-0.01	0.08 *	-0.01	0.00	0.00	0.02	0.03
Medium Quality Land (1=yes, 0=no)	0.11 *	0.01	0.01	0.07 *	0.02	-0.06 *	0.10 *
Low Quality Land (1=yes, 0=no)	0.03	0.03	-0.05 *	-0.03	-0.03	0.12 *	-0.14 *
Extra Low Quality Land (1=yes, 0=no)	0.06 *	-0.01	-0.13 *	-0.03	-0.03	-0.01	-0.04
Irrigation (1=yes, 0=no)	0.12 *	-0.02	0.03	0.00	0.02	0.05 *	0.04
Distance to Mill (Kilometers)	0.17 *	-0.02	-0.06 *	-0.15 *	0.09 *	-0.04	-0.10 *
Knowledge of Recommended Varieties (1=yes, 0=no)	0.14 *	-0.12 *	0.09 *	0.07 *	0.05	-0.07 *	0.01
District Supply of Varieties (Number)	-0.02	0.19 *	-0.16 *	0.02	-0.22 *	0.22 *	0.07 *
Yield	-0.04	0.05 *	0.01	-0.02	0.11 *	-0.05 *	0.01
Drought Tolerance	0.03	-0.09 *	0.17 *	-0.05 *	0.00	-0.05	0.20 *
Cold Tolerance	0.04	-0.04	0.01	-0.02	0.06 *	0.01	-0.05 *
Disease Resistance	0.08 *	-0.03	-0.11 *	-0.06 *	0.04	-0.17 *	-0.22 *
Soil Adaptability	0.07 *	0.05 *	0.00	0.04	-0.09 *	0.09 *	0.14 *
Bread Quality	0.14 *	0.03	-0.09 *	0.13 *	0.18 *	0.20 *	0.08 *
Residue Quality	0.08 *	-0.07 *	0.00	0.07 *	-0.08 *	0.05	0.04
Sivas/Kayseri	-0.04	-0.09 *	0.08 *	0.05 *	0.44 *	-0.28 *	-0.04
Kutahya	0.12 *	0.12 *	-0.16 *	0.04	0.15 *	0.20 *	0.13 *
Malatya	0.13 *	0.03	0.01	-0.02	0.00	-0.16 *	-0.07 *
Kastamonu	0.01	-0.01	-0.01	0.01	-0.25 *	0.20 *	-0.09 *
Erzurum	0.24 *	-0.18 *	0.04	0.01	-0.19 *	0.20 *	0.03
Hilly	0.06 *	-0.07 *	0.09 *	0.02	0.18 *	-0.19 *	-0.01
Mountain	0.27 *	-0.02	-0.12 *	-0.09 *	-0.20 *	0.28 *	-0.07 *

	Number of Rooms in House	Number of Buildings on Farm	Car	Cattle (Head)	Sheep (Head)	Goats (Head)	Cattle^2
Number of Rooms in House	1.00						
Number of Buildings on Farm	0.23 *	1.00					
Car Ownership (1=yes, 0=no)	0.18 *	0.19 *	1.00				
Cattle (Head)	0.23 *	0.21 *	0.15 *	1.00			
Sheep (Head)	0.13 *	0.06 *	0.09 *	0.27 *	1.00		
Goats (Head)	0.04	-0.04	-0.06 *	0.02	0.28 *	1.00	
Cattle^2	0.16 *	0.11 *	0.15 *	0.87 *	0.45 *	-0.01	1.00
Sheep^2	0.08 *	0.05 *	0.11 *	0.44 *	0.84 *	0.15 *	0.71 *
Goats^2	0.03	-0.05 *	-0.04	0.01	0.15 *	0.91 *	-0.01
Medium Quality Land	-0.05 *	-0.01	-0.08 *	-0.06 *	0.02	0.01	-0.06 *
Low Quality Land	-0.04	-0.02	-0.03	-0.05 *	-0.05	-0.04	-0.04
Extra Low Quality Land	0.05	0.00	-0.03	0.00	-0.02	-0.01	-0.01
Irrigation (1=yes, 0=no)	0.00	-0.01	0.15 *	0.15 *	0.03	-0.02	0.14 *
Distance to Mill (Kilometers)	0.01	-0.02	0.02	0.04	0.11 *	0.12 *	0.06 *
Knowledge of Recommended Varieties (1=yes, 0=no)	-0.10 *	0.25 *	0.02	0.11 *	-0.09 *	-0.07 *	0.06 *
District Supply of Varieties	0.03	0.09 *	0.17 *	-0.06 *	-0.05 *	-0.03	-0.06 *
Yield	0.01	0.04	-0.08 *	0.01	0.01	0.02	0.01
Drought Tolerance	-0.09 *	0.14 *	0.03	0.01	0.12 *	0.11 *	0.03
Cold Tolerance	0.15 *	0.23 *	0.08 *	0.15 *	0.09 *	0.03	0.09 *
Disease Resistance	0.01	0.14 *	-0.09 *	-0.02	-0.13 *	-0.04	-0.03
Soil Adaptability	0.06 *	0.12 *	-0.13 *	-0.08 *	-0.01	-0.03	-0.04
Bread Quality	-0.08 *	-0.20 *	-0.06 *	-0.02	0.02	0.00	-0.03
Residue Quality	-0.04	-0.07 *	-0.07 *	0.03	0.02	0.00	0.01
Sivas/Kayseri	0.01	0.00	-0.10 *	0.02	0.01	-0.02	0.02
Kutahya	-0.05	0.07 *	0.10 *	-0.15 *	-0.05 *	-0.07 *	-0.11 *
Malatya	-0.13 *	-0.06 *	-0.05 *	-0.15 *	-0.08 *	-0.04	-0.08 *
Kastamonu	0.02	-0.06 *	-0.02	0.16 *	-0.14 *	-0.06 *	0.06 *
Erzurum	-0.07 *	-0.13 *	-0.15 *	0.08 *	-0.02	-0.03	0.03
Hilly	0.06 *	0.09 *	0.05 *	-0.02	0.03	0.00	-0.05 *
Mountain	-0.07 *	-0.09 *	-0.20 *	-0.04	0.01	0.08 *	-0.06 *

	Sheep^2	Goats^2	Medium Quality Land (1=yes, 0=no)	Low Quality Land (1=yes, 0=no)	Extra Low Quality Land (1=yes, 0=no)	Irrigation (1=yes, 0=no)
Sheep^2	1.00					
Goats^2	0.09 *	1.00				
Medium Quality Land	-0.04	0.02	1.00			
Low Quality Land (1=yes, 0=no)	-0.04	-0.03	-0.50 *	1.00		
Extra Low Quality Land	-0.01	-0.01	-0.10 *	-0.02	1.00	
Irrigation (1=yes, 0=no)	0.11 *	-0.02	-0.27 *	-0.09 *	-0.03	1.00
Distance to Mill (Kilometers)	0.09 *	0.10 *	-0.05 *	0.08 *	-0.02	-0.11 *
Knowledge of Recommended Varieties (1=yes, 0=no)	0.01	-0.04	0.02	0.02	0.07 *	-0.01
District Supply of Varieties	-0.02	-0.02	0.00	0.04	0.07 *	-0.12 *
Yield	0.02	0.02	0.04	-0.06 *	0.01	0.09 *
Drought Tolerance	0.13 *	0.08 *	0.05 *	-0.06 *	0.06 *	-0.14 *
Cold Tolerance	0.10 *	0.04	0.07 *	-0.03	0.08 *	-0.09 *
Disease Resistance	-0.08 *	-0.02	0.00	0.07 *	-0.02	0.06 *
Soil Adaptability	-0.03	-0.03	0.00	-0.05 *	-0.03	0.06 *
Bread Quality	-0.03	-0.02	0.03	0.02	-0.02	-0.01
Residue Quality	0.00	-0.01	-0.07 *	0.06 *	-0.01	0.03
Sivas/Kayseri	-0.02	0.01	0.04	-0.03	-0.03	-0.19 *
Kutahya	-0.04	-0.05 *	0.01	-0.01	0.06 *	-0.09 *
Malatya	-0.05 *	-0.03	0.08 *	-0.05	-0.02	-0.07 *
Kastamonu	-0.06 *	-0.04	-0.02	0.12 *	0.03	-0.09 *
Erzurum	-0.02	-0.03	-0.05 *	0.03	-0.02	0.26 *
Hilly	-0.02	-0.03	0.13 *	-0.03	0.07 *	-0.19 *
Mountain	-0.03	0.06 *	0.01	0.13 *	-0.04	-0.10 *

	Distance to Mill (km)	Knowledge of Recommended Varieties (1=yes, 0=no)	District Supply of Varieties (Number)	Yield	Drought	Cold	Disease
Distance to Mill (Kilometers)	1.00						
Knowledge of Recommended Varieties	-0.10 *	1.00					
District Supply of Varieties (Number)	-0.12 *	0.17 *	1.00				
Yield	-0.14 *	0.02	-0.07 *	1.00			
Drought Tolerance	0.02	-0.04	0.03	-0.03	1.00		
Cold Tolerance	0.12 *	0.20 *	0.04	-0.01	-0.07 *	1.00	
Disease Resistance	-0.04	0.21 *	0.07 *	0.10 *	-0.17 *	-0.01	1.00
Soil Adaptability	-0.01	-0.17 *	-0.13 *	-0.05	-0.07 *	-0.24 *	-0.18 *
Bread Quality	-0.10 *	-0.11 *	-0.07 *	-0.16 *	-0.21 *	-0.21 *	-0.34 *
Residue Quality	-0.07 *	-0.04	-0.01	-0.13 *	-0.06 *	-0.15 *	-0.15 *
Sivas/Kayseri	0.31 *	0.03	-0.47 *	0.08 *	0.06 *	0.15 *	-0.02
Kutahya	-0.27 *	0.09 *	0.72 *	0.01	0.03	-0.05	0.08 *
Malatya	-0.26 *	-0.09 *	-0.26 *	0.07 *	0.03	-0.15 *	0.04
Kastamonu	0.09 *	0.15 *	0.31 *	-0.08 *	0.02	0.18 *	-0.06 *
Erzurum	-0.20 *	-0.18 *	-0.51 *	0.01	-0.13 *	-0.07 *	-0.09 *
Hilly	0.00	0.01	0.05 *	0.03	0.03	0.11 *	-0.04
Mountain	0.14 *	-0.05 *	-0.07 *	-0.11 *	-0.02	0.07 *	-0.03

	Soil Adaptability	Bread Quality	Residue Quality	Sivas/Kayseri	Kutahya	Malatya	Kastamonu
Soil Adaptability	1.00						
Bread Quality	-0.06 *	1.00					
Residue Quality	0.00	0.17 *	1.00				
Sivas/Kayseri	-0.07 *	-0.17 *	-0.09 *	1.00			
Kutahya	-0.07 *	0.03	0.03	-0.26 *	1.00		
Malatya	0.01	0.04	-0.02	-0.15 *	-0.22 *	1.00	
Kastamonu	-0.08 *	-0.03	0.05 *	-0.17 *	-0.25 *	-0.15 *	1.00
Erzurum	0.21 *	0.26 *	0.16 *	-0.14 *	-0.20 *	-0.12 *	-0.13 *
Hilly	-0.13 *	0.01	0.01	0.04	0.06 *	0.08 *	0.03
Mountain	0.07 *	0.08 *	0.01	0.02	-0.07 *	-0.03	0.10 *

	Erzurum	Hilly	Mountain
Erzurum	1.00		
Hilly	-0.11	1.00	
Mountain	0.14	-0.49	1.00

APPENDIX C

CORRELATIONS FOR DIVERSITY OUTCOME ESTIMATION

	Berger-Parker Index	Shannon Index	Farm Experience (Years)	Edu.	Dep. Ratio	Total Farm Area (Hectares)	Frag.
Berger-Parker Index	1.00						
Shannon Index	0.92 *	1.00					
Farm Experience (Years)	-0.01	0.00	1.00				
Education (Years)	-0.06	-0.05	-0.32 *	1.00			
Dependency Ratio	-0.04	-0.06	0.07	-0.06	1.00		
Total Farm Area (Hectares)	0.07	0.09	0.02	0.09	-0.05	1.00	
Fragmentation	0.00	0.01	0.01	-0.09	0.09	-0.40 *	1.00
Off-farm Property Holdings (1=yes, 0=no)	0.02	0.01	0.11 *	0.12 *	-0.02	0.04	0.11 *
Number of Rooms in House	-0.04	-0.01	0.09	0.02	-0.06	0.10 *	-0.10 *
Number of Buildings on Farm	0.09	0.12 *	0.00	0.04	-0.13 *	0.18 *	-0.12 *
Car Ownership (1=yes, 0=no)	0.10 *	0.08	-0.04	0.09	-0.06	0.19 *	-0.12 *
Cattle (Head)	-0.01	-0.02	-0.03	-0.03	-0.16 *	0.16 *	-0.11 *
Sheep (Head)	-0.04	-0.03	0.04	0.04	-0.14 *	0.15 *	-0.10
Goats (Head)	-0.03	-0.03	0.12 *	-0.01	0.03	0.06	0.01
Cattle^2	-0.04	-0.06	0.02	-0.03	-0.15 *	0.17 *	-0.10 *
Sheep^2	-0.04	-0.04	0.08	0.01	-0.11 *	0.10 *	-0.06
Goats^2	-0.04	-0.04	0.12 *	-0.02	0.05	0.09	0.00
Percentage of Land that is Irrigated	-0.02	-0.04	-0.06	0.08	0.03	-0.07	0.08
Number of Named Land Qualities by Household	0.18 *	0.22 *	0.00	0.06	-0.07	0.06	0.08
Distance to Mill (Kilometers)	0.04	0.05	-0.02	-0.09	-0.15 *	0.17 *	-0.05
Knowledge of Recommended Varieties (1=yes, 0=no)	0.18 *	0.15 *	-0.03	0.04	-0.02	0.03	-0.06
District Supply of Varieties (Number)	0.36 *	0.39 *	0.19 *	-0.14 *	0.03	-0.11 *	0.13 *
Yield	0.04	0.03	0.04	0.02	-0.05	0.09	-0.03
Drought Tolerance	0.05	0.09	0.03	0.09	-0.05	-0.03	-0.06
Cold Tolerance	0.09	0.08	-0.01	-0.06	-0.04	0.05	0.02
Disease Resistance	0.06	0.05	-0.01	-0.11 *	-0.10 *	-0.04	-0.13 *
Soil Adaptability	-0.08	-0.10	0.07	0.00	0.07	-0.09	0.09
Bread Quality	-0.08	-0.11 *	-0.05	-0.01	0.12 *	-0.16 *	0.15 *
Residue Quality	-0.04	-0.03	-0.11 *	0.09	0.07	-0.05	0.03
Sivas/Kayseri	-0.07	-0.08	-0.06	0.02	-0.02	0.46 *	-0.22 *
Kutahya	0.22 *	0.26 *	0.12 *	-0.13 *	0.04	-0.08	0.10 *
Malatya	-0.09	-0.09	0.08	0.05	-0.03	-0.05	-0.17 *
Kastamonu	0.23 *	0.21 *	0.02	-0.04	0.04	-0.20 *	0.17 *
Erzurum	-0.19 *	-0.22 *	-0.22 *	0.08	0.05	-0.19 *	0.20 *
Hilly	-0.04	-0.03	-0.05	0.08	0.03	0.14 *	-0.14 *
Mountain	0.00	-0.03	0.01	-0.10 *	-0.04	-0.22 *	0.30 *

	Off-farm Property Holdings (1=yes, 0=no)	Number of Rooms in House	Number of Buildings on Farm	Car	Cattle (Head)	Sheep (Head)	Goats (Head)
Off-farm Property Holdings (1=yes, 0=no)	1.00						
Number of Rooms in House	-0.06	1.00					
Number of Buildings on Farm	-0.04	0.26 *	1.00				
Car Ownership (1=yes, 0=no)	0.10 *	0.13 *	0.18 *	1.00			
Cattle (Head)	0.04	0.16 *	0.23 *	0.18 *	1.00		
Sheep (Head)	0.08	0.12 *	0.11 *	0.08	0.21 *	1.00	
Goats (Head)	0.05	0.06	-0.02	-0.04	0.01	0.18 *	1.00
Cattle^2	0.08	0.13 *	0.16 *	0.19 *	0.88 *	0.36 *	-0.01
Sheep^2	0.09	0.09	0.11 *	0.12 *	0.37 *	0.85 *	0.12 *
Goats^2	0.07	0.04	-0.04	-0.04	0.00	0.07	0.95 *
Percentage of Land that is Irrigated	0.08	-0.01	0.05	0.16 *	0.09	0.00	-0.07
Number of Named Land Qualities by Household	0.15 *	0.03	0.06	0.12 *	0.11 *	0.05	-0.05
Distance to Mill (Kilometers)	-0.06	0.04	-0.02	0.05	0.05	0.14 *	0.10 *
Knowledge of Recommended Varieties (1=yes, 0=no)	0.04	-0.15 *	0.18 *	0.01	0.09	-0.05	-0.01
District Supply of Varieties (Number)	0.06	0.07	0.05	0.14 *	-0.04	-0.03	-0.01
Yield	0.06	0.00	0.08	0.02	0.00	0.00	0.01
Drought Tolerance	0.22 *	-0.09	0.12 *	0.08	0.01	0.10 *	0.09
Cold Tolerance	-0.07	0.13 *	0.18 *	0.01	0.13 *	0.10	0.03
Disease Resistance	-0.19 *	0.02	0.18 *	-0.09	-0.03	0.12 *	-0.03
Soil Adaptability	0.14 *	0.10 *	-0.07	-0.09	-0.10 *	0.03	-0.03
Bread Quality	0.00	-0.14 *	-0.23 *	-0.10 *	-0.01	-0.05	-0.04
Residue Quality	0.04	-0.08	-0.11 *	-0.04	0.02	0.03	0.01
Sivas/Kayseri	-0.05	-0.01	0.03	-0.05	0.05	0.07	0.04
Kutahya	0.10 *	0.00	0.08	0.03	-0.13 *	-0.03	-0.04
Malatya	-0.06	-0.10 *	-0.05	-0.05	-0.20 *	0.12 *	-0.06
Kastamonu	-0.03	0.03	-0.05	0.05	0.14 *	0.13 *	-0.05
Erzurum	0.03	-0.04	-0.07	-0.14 *	0.15 *	-0.01	-0.04
Hilly	-0.03	-0.01	0.04	0.03	-0.02	-0.01	-0.04
Mountain	-0.05	-0.02	-0.09	-0.19 *	-0.05	0.01	0.05

	Cattle^2	Sheep^2	Goats^2	Percentage of Land that is Irrigated	Number of Named Land Qualities by Household	Distance to Mill (km)
Cattle^2	1.00					
Sheep^2	0.61 *	1.00				
Goats^2	-0.02	0.06	1.00			
Percentage of Land that is Irrigated	0.10	0.08	-0.06	1.00		
Number of Named Land Qualities by Household	0.08	0.04	-0.04	0.02	1.00	
Distance to Mill (Kilometers)	0.06	0.09	0.07	-0.25 *	0.08	1.00
Knowledge of Recommended Varieties (1=yes, 0=no)	0.06	0.02	0.02	0.01	0.02	-0.04
District Supply of Varieties (Number)	-0.05	-0.01	-0.01	-0.22 *	0.22 *	0.01
Yield	0.00	0.02	0.02	0.13 *	-0.05	-0.14 *
Drought Tolerance	0.02	0.12 *	0.09	-0.07	0.07	-0.03
Cold Tolerance	0.07	0.10 *	0.02	-0.11 *	-0.09	0.15 *
Disease Resistance	-0.05	-0.08	-0.01	0.03	-0.13 *	-0.04
Soil Adaptability	-0.05	-0.01	-0.04	0.07	0.02	-0.04
Bread Quality	-0.02	-0.06	-0.05	0.00	0.06	-0.11 *
Residue Quality	0.01	0.00	-0.02	0.07	0.05	-0.08
Sivas/Kayseri	0.05	0.01	0.07	-0.30 *	-0.17 *	0.40 *
Kutahya	-0.09	-0.03	-0.04	-0.08	0.16 *	-0.20 *
Malatya	-0.10 *	-0.07	-0.04	0.04	-0.16 *	-0.32 *
Kastamonu	0.03	-0.06	-0.04	-0.13 *	0.04	0.07
Erzurum	0.06	0.00	-0.04	0.36 *	-0.05	-0.27 *
Hilly	-0.04	-0.03	-0.05	-0.12 *	0.00	0.03
Mountain	-0.06	-0.03	0.03	-0.17 *	-0.11 *	0.08

	Knowledge of Recommended Varieties	District Supply of Varieties (Number)	Yield	Drought Tolerance	Cold Tolerance
Knowledge of Recommended Varieties (1=yes, 0=no)	1.00				
District Supply of Varieties	0.16 *	1.00			
Yield	0.02	-0.08	1.00		
Drought Tolerance	0.00	0.03	-0.02	1.00	
Cold Tolerance	0.17 *	0.03	-0.01	-0.09	1.00
Disease Resistance	0.17 *	0.02	0.12 *	-0.16 *	0.04
Soil Adaptability	-0.17 *	-0.09	-0.06	-0.12 *	-0.22 *
Bread Quality	-0.11 *	-0.09	-0.12 *	-0.19 *	-0.29 *
Residue Quality	-0.05	0.00	-0.16 *	-0.10 *	-0.17 *
Sivas/Kayseri	0.02	-0.33 *	0.06	-0.01	0.20 *
Kutahya	0.07	0.66 *	0.03	0.03	-0.06
Malatya	-0.10 *	-0.29 *	0.10 *	0.15 *	-0.19 *
Kastamonu	0.19 *	0.43 *	-0.09	0.02	0.16 *
Erzurum	-0.13 *	-0.53 *	0.03	-0.16 *	-0.04
Hilly	0.06	0.08	0.06	0.02	0.10
Mountain	-0.09	-0.07	-0.12 *	-0.04	0.02

	Disease Resistance	Soil Adaptability	Bread Quality	Residue Quality	Sivas/Kayseri	Kutahya	Malatya
Disease Resistance	1.00						
Soil Adaptability	-0.21 *	1.00					
Bread Quality	-0.32 *	-0.05	1.00				
Residue Quality	-0.18 *	-0.01	0.23 *	1.00			
Sivas/Kayseri	-0.01	-0.13 *	-0.14 *	-0.11 *	1.00		
Kutahya	0.07	-0.03	0.00	0.06	-0.20 *	1.00	
Malatya	0.03	0.08	0.00	-0.03	-0.21 *	-0.21 *	1.00
Kastamonu	-0.08	-0.09	0.00	0.02	-0.18 *	-0.18 *	-0.19 *
Erzurum	-0.02	0.11 *	0.26 *	0.14 *	-0.20 *	-0.20 *	-0.21 *
Hilly	-0.06	-0.05	-0.02	0.02	0.09	0.06	0.07
Mountain	-0.01	0.06	0.12 *	0.00	0.00	-0.03	-0.03

	Kastamonu	Erzurum	Hilly	Mountain
Kastamonu	1.00			
Erzurum	-0.19 *	1.00		
Hilly	0.09	-0.15 *	1.00	
Mountain	-0.01	0.11 *	-0.52 *	1.00