Managing Agricultural Biodiversity in a Transitional Economy: An Analysis of Hungarian Family Farms

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Abstract:

This paper summarises and explains agricultural biodiversity found on small-scale farms in Hungary, known traditionally as "home gardens." Survey data are used to investigate the revealed preferences of farm households for four components of agricultural biodiversity, including crop species diversity, agro-diversity, soil micro-organism diversity and crop genetic diversity. The reduced form, econometric model is based on the model of the agricultural household with missing markets, specified in different ways to reflect the definition of the dependent variable. Farm households who are most likely to sustain observed levels of agricultural biodiversity are described. The stratified sample design lends insights into the potential impact of economic transition on the prospects for conserving agricultural biodiversity. Findings can assist those who formulate agri-environmental policy in Hungary to design efficient programmes that incorporate agricultural biodiversity rich home garden management.

Key Words: agricultural biodiversity, farm household model, missing markets, Probit, Poisson, Negative Binomial, predictions

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1. Introduction

Much of the agricultural biodiversity remaining *in situ* today is found on the semi-subsistence farms of poorer countries and the small-scale farms and backyard gardens of more industrialised nations (Brookfield, 2001; Brookfield *et al.*, 2002; IPGRI 2003). The traditional small farms of Hungary are an example. Termed "home gardens," these privately-owned homestead fields persisted throughout the period of collectivised state farming and the subsequent transition to market-oriented, large-scale farming (Kovách, 1999; Swain, 2000; Meurs, 2001). Farmed by families with organic methods, many are rich in crop and livestock species, varieties and breeds, relative to the large-scale mechanised farms that now dominate the nation's cropland (Már, 2002; Bela *et al.*, 2003). Home gardens have contributed to food security in Hungarian society, supplying families with farm produce that contributes colour, flavour, and nutrients to the diets of both rural and urban people in time periods and locations when markets or state institutions did not (Wyzan, 1996; Seeth *et al*., 1998).

A nation with a transitional economy, Hungary recently joined the European Union (EU). The agri-environmental policies and programmes that promote multifunctional agriculture are now being developed to comply with the *acquis communautaire*, and these appear not to recognise the private and public values of agricultural biodiversity found in Hungarian home gardens. Policy oversight, coupled with the changing economic and market conditions in this country, may result in the demise of these family farms. Excluding home gardens from any agri-environmental programme that promotes multifunctional agriculture could in fact result in diversion of incentives, loss of agricultural biodiversity and economic inefficiencies.

This paper investigates the factors affecting observed levels of four main components of agricultural biodiversity in Hungarian home gardens, including crop species and variety diversity, crop genetic diversity, agro-diversity and soil micro-organism diversity. Observed levels of agricultural biodiversity on small farms in Hungary reflect the optimal choices of farm families living in communities with imperfect markets for production inputs and farm produce. Predictions based on the econometric model enable profiling of the households that are most likely to sustain current levels of agricultural biodiversity components since they reveal the greatest preference for them. Methods of this type can assist in designing targeted strategies for on farm conservation programmes that are cost-effective, efficient and equitable (Meng, 1997; Smale *et al.*, forthcoming).

The historical role and policy significance of these “repositories” of agricultural biological diversity is explained in the next section. Section 3 describes the survey design, survey sites, farm households and agricultural biodiversity components farm families manage in their home gardens. Section 4 presents the underlying conceptual approach that motivates the econometric models. Hypotheses and operational variables are then defined. Section 6 presents the results of the econometric analyses of the factors that explain variation in levels of four different components of agricultural biodiversity found on Hungarian small farms. Section 7 profiles the households and farms that are most likely to sustain these components of agricultural biodiversity. Conclusions for programme design are drawn in the final section.

2. Policy context

Hungarian agriculture today has a dual structure consisting of large-scale, mechanised farms alongside semi-subsistence, small-scale farms operated with traditional farming practices. Dualism has persisted in some form throughout Hungarian history, and most recently during the socialist period of collectivised agriculture from 1958 to 1989 (Szelényi, 1998; Kovách, 1999; Swain, 2000; Szép, 2000; Meurs, 2001). Even today semi-subsistence agricultural production is an important component of economic activity in Hungary[1].

Home gardens played an important role in food security during the socialist period when families were permitted to cultivate privately the small plots located adjacent to dwellings. Village level markets remain thin in many areas of rural Hungary for a combination of reasons. Historically, food market formation was discouraged. Risky food prices are common in transitional economies, as is uncertain and variable

[1] Of the about 10 million people populating Hungary today, it is estimated that nearly 2 million Hungarians produce agricultural goods for their own consumption and as a source of additional income (Már, 2002) on 800 000 home gardens of up to 1 ha (Simon, 2001). The 1996 Microcensus of the Hungarian Central Statistical Office (HCSO) reported that 33 % of people aged 14 and over were engaged in auxiliary agricultural work, although few relied on agriculture as a main occupation.

food quality (Seeth *et al.*, 1998)[2]. Transaction costs are high, including search and transport costs to the nearest food market. In addition, the increasing number of super and hypermarkets in the country since the transition to market economy has begun[3], is found to cause disappearance of existing few local shops and markets found in rural areas (WHO, 2000). Consequently rural households continue to rely on their home gardens for their food consumption for at least some of the goods they consume and to enhance the quality of their diet.

Though there is wide variation among them, production in home gardens was and still is accomplished with family labour, traditional farming practices, ancestral crop varieties and livestock races, and limited use of purchased inputs. These traditional home gardens not only serve as 'small repositories of agricultural biodiversity', but also contribute to Hungarian cultural heritage (Már, 2002). As a result of their ability to supply food security and safety to rural families, home garden production creates incentives for rural people to remain in the countryside, consequently they play an indirect part in conservation of rural settlements and lifestyles (Seeth *et al*., 1998; Juhász *et al*., 2000).

This stylised depiction of Hungarian home gardens is consistent with the notion of multifunctional agriculture, which views agriculture as providing a bundle of public goods in addition to private goods of food and fibre. Public goods supplied by agriculture include rural settlement and economic activity, food security, safety and quality, biodiversity, agricultural biodiversity, cultural heritage, amenity and recreational values (Romstad *et al.*, 2000; Lankoski, 2000). The concept of multifunctional agriculture is embraced by the EU's reformed Common Agricultural Policy (CAP) and is stated in the EU's 2078/92 agri-environmental regulation, according to which each EU member country is expected to encourage production of agricultural public goods through the development of a National Agri-Environmental Programme (NAEP).

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[2] Seeth *et al.* (1998) investigate the role of gardens in alleviation of rural poverty in Russia during the early stages of the economic transition process. They find that the households, who are engaged in subsistence agriculture in their garden plots, had higher levels of real income and food consumption, both of which were crucial to combat poverty during an era in which risk in food prices and household income were prevalent and real incomes declined dramatically.

[3] The number of hypermarkets in Hungary has grown from only 5 in 1996 to 63 in 2003 (HCSO, 2003).

Hungary's NAEP was accepted by the Ministry of Agriculture and Regional Development in 2000 and launched experimentally in 2002 (Juhász *et al.*, 2000). NAEP proposes that the intensity of agricultural production in a region should depend on its natural and human resource endowments. Several areas of Hungary with low agricultural productivity and high environmental value have been designated as environmentally sensitive areas (ESAs). NAEP seeks to protect these areas as habitats for endangered plant and animal species. Direct payments, training programmes and technical assistance are provided to the farmers who are willing to participate in agri-environmental schemes that promote the use of specified farming methods.

The Hungarian NAEP recognises that extensive agricultural methods are most suitable for conserving biodiversity of endangered wildlife and providing other agricultural public goods, but the role of home gardens in the programme has not yet been elucidated. Proposed EU agricultural policies designed for accession states also fail to recognise the possibility of provision of public goods through home garden production. Special Accession Programme for Agriculture and Rural Development (SAPARD), prepared for accession countries, considers the dual structure of agriculture that exists in several of these countries as inefficient. SAPARD proposes either a) subsidies for transformation of semi-subsistence small farms to commercial farms, or b) direct payments to land-holdings larger than 0.3 ha on the condition that the land is managed in a way compatible with protection of the environment, as suggested by the NAEP of the member country (Commission of the European Communities 2002).

The expected loss of these traditional home gardens has been cited by many experts as one of the costs of EU accession, economic transition and development (Vajda, 2003; Weingarten *et al.*, 2004). Risky food prices and quality, transaction costs and the low wages that led to dependency on home grown food are expected to decrease with greater market access (Birol, Kontoleon and Smale, *forthcoming*). EU accession could lead to improved rural infrastructure through SAPARD, along with rural development and the growth of employment opportunities outside agriculture (Weingarten *et al.*, 2004).

Previous studies have estimated the private value of home gardens that accrue to farmers with a stated preference approach of choice experiment (Birol, Smale and

Gyovai, 2004). The relationship between farmers' demand for agricultural biodiversity in home gardens and the development level of the communities in which the farm families reside has also been investigated with a choice experiment (Birol, Kontoleon and Smale, *forthcoming*). This study aims to characterise the settlements and farm households where publicly valuable agricultural biodiversity are most likely to reside by use of revealed preference, namely a farm household survey data. Though the benefits of home gardens accrue first to the farmers that cultivate them, they are national, intergenerational and potentially global in nature. Excluding home gardens from any agri-environmental programme that supports multifunctional agriculture could in fact result in diversion of incentives, loss of agricultural biodiversity, and economic inefficiencies.

3. Data collection

The survey design consisted of two stages. In the first stage, three sites were selected. The sites are located in the ESAs identified by the NAEP, where the Institute of Agrobotany had already identified high levels of agricultural biodiversity (in terms of crop genetic diversity) during collection missions. Secondary data from the Hungarian Central Statistics Office (HCSO) and NAEP were used to purposively select areas with contrasting levels of market development and varying agro-ecologies associated with different farming systems and land-use intensity.

In the second stage of the sample design, all settlements within the selected sites were sorted based on population sizes and an initial sample of 1800 households was chosen randomly from a complete list of all households compiled from telephone books. An initial screening survey was sent to the total random sample of 1800 households to identify all those who are engaged in home garden management. The initial sample size of 1800 households was chosen since a minimum final sample of 100 households per ESA was thought necessary for data analysis, and the response rate to a mail survey was expected to be low, the team decided to include 600 households per site. The initial response rate to the screening survey was low at 13% therefore the sample of farm households with home gardens was augmented through visits to households from the random household list with assistance from key informants in each settlement. Since all the households in the ESAs engaged in home garden production the final sample contained its randomness. A total of 323 farm households were interviewed in August 2002 for the farm household survey. Since the sample is random, findings of this study are statistically representative of the sites and can be generalised to home gardens in other ESAs in rural Hungary to the extent that they share characteristics in common

3.1. Survey site description

The three study sites (Dévaványa, Orség-Vend and Szatmár-Bereg) are depicted in Figure 1.

[Figure 1]

Twenty-two settlements across three ESAs were included in the study. Secondary data for settlement characteristics were drawn from the HCSO National Census (2001) and Statistical Yearbook (2001), and are presented in Table 1.

[Table 1]

Dévaványa, located on the Hungarian Great Plain, is closest to the economic centre of the country of the three sites. Soil and climatic conditions of this region are well suited to intensive agricultural production. Populations, areas, and population density are relatively high. Labour migration is not a major problem in Dévaványa, although the number of inhabitants is stagnating. The unemployment rate in Dévaványa (12.4%) is slightly higher than the Hungarian average. NAEP aims to conserve the rich wildlife of this ESA. Dévaványa is statistically different from the other two ESAs in most indicators of urbanisation and market integration, including: presence of a train station; distance to the nearest market (both in km and minutes); number of primary and secondary schools; food markets; and the number of shops and enterprises.

The two isolated ESAs are more similar. Located in the southwest, Orség-Vend has a heterogeneous agricultural landscape with poor soil conditions that render intensive agricultural production methods impossible. Settlements are very small in area and most are far from towns. Population sizes are small. Of the three, Orség-Vend is the least urbanised with fewest shops and enterprises. The population is declining and ageing, though the unemployment rate of this region is lowest in the country at 4.8%. Orség-Vend supports the lowest dependency ratio. NAEP encourages extensive production methods to conserve the picturesque landscape, natural and semi-natural habitats in this ESA, which also serve as a tourist attraction.

Szatmár-Bereg is situated in the northeast, far from the economic centre of the country. Settlements in this ESA are also small. The declining, ageing population reflects a lack of public investments in infrastructure and employment generation. Roads are of poor quality and the regional unemployment rate is the highest in the country (19%). Szatmár-Bereg also has a significantly higher ratio of inactive to total population than either of the others. NAEP seeks to promote nature conservation in Szatmár-Bereg by establishing a national park (National Labour Centre, 2000; Juhász *et al.*, 2000; Gyovai, 2002).

3.2.Household and farm description

The characteristics of the 323 farm families that took part in the farm household survey are presented in Table 2. The average family size is 3 persons and children are few in all sites, with orségi households having larger families and more children than those in Dévaványa. Households in Orség-Vend have significantly higher levels of income than those in Dévaványa and Szatmár-Bereg, but the difference between Dévaványa and Szatmár-Bereg is insignificant. The number of family members employed off-farm is higher in Orség-Vend than in Szatmár-Bereg but similar between Orség-Vend and Dévaványa. On average, households in Dévaványa and Orség-Vend spend approximately the same percentage of their income on food and but this percentage is statistically higher than in Szatmár-Bereg.

Home garden decision-makers are elderly, and their average ages do not differ statistically among the three regions. Dévaványa has statistically more experienced and educated home garden decision-makers compared to Szatmár-Bereg. Orség-Vend has the smallest percentage of decision-makers that have less than eight years of education across the three ESAs. A large proportion of them is retired, though the percentage is statistically lower in Dévaványa. Percentage of home garden decision-makers with off farm employment is higher in Dévaványa than Szatmár-Bereg. A higher percentage of Orségi households own cars compared to the other two regions.

[TABLE 2]

The likelihood that a farm household cultivates a field in addition to a home garden is greater in Orség-Vend than in either of the other ESAs, though the areas of land owned and cultivated, and cultivated that is also owned are less. The smallest home gardens and the largest total areas owned and cultivated are in Dévaványa, the most favoured ESA in terms of either soils or infrastructure. In terms of home garden characteristics, home gardens with least irrigation and best soil quality are in Szatmár-Bereg. Orségi home gardens have more irrigation than those in Dévaványa, however they also have the worst soil quality across regions.

The descriptive statistics for market characteristics differ significantly across regions. Households in Szatmár-Bereg region are statistically more integrated into markets as home garden output sellers, compared to the other two regions, which do not differ statistically. Distance to the nearest food market is non-existent for Dévaványa region, since each of the settlements studied in this survey has settlement level markets, whereas households in Orség-Vend have statistically the largest distances to the nearest food markets.

[TABLE 3]

Agricultural biodiversity in home gardens is depicted in terms of four components of the home garden. The four key components or "entry points" to agricultural biodiversity in home gardens were identified in focus groups and informal interviews, interviews with key informants and agricultural scientists. The four key components of agricultural biodiversity in Hungarian home gardens include: 1) crop species and variety diversity, 2) crop genetic diversity, 3) agro-diversity[4], and 4) soil microorganism diversity.

Crop species and variety diversity, or inter and infra-species crop biodiversity, is one of the most crucial components of agricultural biodiversity (FAO, 1999). Crop genetic diversity is measured by presence of a landrace in the home garden, where a landrace is a variety of a crop that has been passed down through generations. Landraces are variable populations that are adapted to local growing conditions and consumption preferences (Smale, 2001b) and have been the source of almost all the modern crop

[4] Only management of large animals (i.e. pig, cattle, horse and donkey) is taken into consideration here, since small animals do not require much labour time or land area.

varieties developed and diffused among farmers around the world (Evenson and Gollin, 2003). Hungarian landraces grown in the home gardens are found to be rich in crop genetic diversity (Már, 2002; 2004, personal communication). The traditional method of integrated crop and livestock management results in agro-diversity, or diversity in agricultural management practices (Brookfield and Stocking, 1999), in the home gardens. Organic production method is a crude measure for soil microorganism diversity in this paper, based on the findings of several experiments, which demonstrated the relationship between organic production methods and soil-organism activity, soil fertility and greater diversity of soil microorganisms (e.g. Lupwayi *et al.*, 1997; Mäder *et al.*, 2002).

Table 4 reports the components of agricultural biodiversity found on home gardens in each ESA. The average levels of crop species and variety diversity maintained by farm families in their home gardens are significantly higher for Orség-Vend than in the other two sites. In Dévaványa, the percent of households growing landraces is statistically significantly half of that found in the other two. Use of organic methods is similarly represented in Dévaványa and Orség-Vend, but probably for different reasons (Birol, Gyovai and Smale, 2004). Only 8% of farmers in Szatmár-Bereg apply organic practices, which is significantly lower than in the other regions. Across the three sites, roughly 50-60 percent of households tend livestock along with crops in their homestead plots across the three sites, with no statistically significant differences.

[TABLE 4]

4. Theoretical model

The behavioural model employed to explain the farm households' production and consumption decisions is based on the semi-subsistence model of the farm household with missing markets (Singh, Squire and Strauss, 1986; de Janvry, Fafchamps and Sadoulet, 1991; Taylor and Adelman, 2003).

Though motivated by the situation of developing country farmers, the model is appropriate for analysing the case of home garden production in Hungary. Due to a combination of historical, institutional and geographical factors, "home gardens" are essentially small-scale farms managed with family labour and oriented toward the satisfaction of food needs. Though farm families occasionally participate in market sales of home garden produce in some locations, profit maximisation does not guide their production decisions (Swain, 2000). Even where local markets are more plentiful, as in Dévaványa, heterogeneity of produce quality often induces families to find a “corner” solution where they produce and consume their own output (Singh, Squire and Strauss, 1986; Van Dusen and Taylor, 2003).

The model depicts a farm family that maximises its utility over consumption of market purchased goods, C_m, leisure, C_l, and home garden outputs, C_k, subscripted k for *kert*, Hungarian for home garden (1). The utility is maximised subject to budget, time, and production technology constraints, (2), (3) and (4) respectively. Household utility is influenced by Ω_{HH}, denoting a vector of household characteristics of the farm household that condition consumption preferences and choices. The utility function is assumed to be quasi-concave with positive partial derivatives. The prices of all market purchased goods, inputs and wages are exogenous, and production is assumed to be riskless.

$$U = U(C_k, C_m, C_l; \Omega_{HH}) \tag{1}$$

$$Y = wT + E - wH - p_V V \tag{2}$$

$$G(Q, H, V; \Omega_K) = 0 \tag{3}$$

$$H + L_o + C_l \equiv T \tag{4}$$

where (2), full income is composed of value of stock of total time owned by the household (*T*), exogenous income (*E*), which is non-wage, non-household production income such as direct assistance or pensions, less the values of household management input used in the home garden production (H), and other variable inputs required for production of home garden outputs (V). For cultivation of home garden plots, household management input (*H*) is a necessary and also sufficient input, since these small farms are typically managed by family labour alone. Field production decisions are treated as predetermined or exogenous to home garden decisions, affecting them through E in full income. Time allocated to field crop production is included in the ‘off home garden employment’ variable, treating wages as exogenous and fixed for both field employment and off farm employment.

The farm household faces a production constraint for production technology in the home garden (3), depicting the relationship between farm inputs (H, V) and all outputs (Q) by an implicit production function $(G,)$ that is quasi-convex, increasing in outputs and decreasing in inputs. The vector Ω_K represents the fixed agro-ecological features of the home garden, such as soil quality. The household also faces a time constraint (4), and cannot allocate more time to home garden cultivation (H), off home garden employment (L_O, including employment either in other forms of agricultural production, such as field production or in off farm employment) and leisure (C_l), than the total time available to the household.

The farm household is driven toward the goal of self-sufficiency in home garden production because of thin, unreliable or missing markets. This phenomenon brings about an additional constraint that induces the household to equate home garden output demand and supply, resulting in an endogenous, shadow price for home garden outputs. Consumption and production decisions cannot be separated.

$$Q_k = C_k(\Omega_M) \tag{5}$$

Q_k and C_k denote the quantity demanded and supplied of home garden produce, and Ω_M is a vector of exogenous characteristics related to availability and access to markets. This equality condition implicitly defines the shadow price for home garden produce, which guides production decisions. The endogenous shadow price is household-specific, depending on the household characteristics that affect access to markets and consumption demand, such as wealth, education, age, household composition. Agro-ecological features of the home garden such as soil quality or irrigation enter the equation through their affect on supply. Fixed factors related to market transactions costs and observed market prices also influence the shadow prices of home garden outputs. The shadow price, r, can be expressed as a function of all exogenous prices and household, agro-ecological and market characteristics:

$$r = r^*(p_m, p_v, w; \Omega_{HH}, \Omega_K, \Omega_M) \tag{6}$$

The solution to the household maximisation with missing markets for home garden produce results in a set of optimal choices:

$$Q_k = Q_k^*(r, p_v, w; \Omega_K) \quad (7)$$

$$H = H^*(r, p_v w; \Omega_K) \quad (8)$$

$$V = V^*(r, p_v, w; \Omega_K) \quad (9)$$

$$C_i = C_i^*(r, p_m, w, Y; \Omega_{HH}) \qquad i = k, m, l \quad (10)$$

Equation (7) is the optimal supply of home garden outputs; (8) is the optimal demand of household labour in the home garden production; (9) is the optimal demand for all other inputs to small farm production; and (10) is the optimal demand for each commodity.

Substituting the solution for the shadow price into home garden output production and consumption solutions, optimal production of home garden outputs is seen to be a function of all exogenous variables:

$$Q_k = Q_k^*(p_m, p_v, w; \Omega_{HH}, \Omega_K, \Omega_M) \quad (11)$$

Following Van Dusen and Taylor (2003) the level of agricultural biodiversity maintained on the home gardens, which is a direct outcome of the production and consumption choices of the farm household, is a function of all prices, and characteristics of the households, markets, and of the home garden plots

$$ABD = ABD(Q_K^*(p_m, p_v, w; \Omega_{HH}, \Omega_K, \Omega_M)) \quad (12)$$

5. Dependent and explanatory variables

Dependent variables are those summarised in Table 4 for four agrobiodiversity components. Crop species and variety diversity (richness) is a count, easier to interpret with such small home garden areas than the Margalef index. The other components of agricultural biodiversity are zero-one variables. Explanatory variables used in the analysis of the survey data are divided into three sets according to the vectors denoted in the theoretical model: household, home garden, and market characteristics. Variable definitions and hypothesised effects based on economic principles and findings reported in the literature are shown in Table 5.

[TABLE 5]

Age in this model proxies also for experience and education level because of strong statistical correlations. Age of the home garden decision-maker is positively correlated with their experience, and negatively correlated with their education. We hypothesise that age is positively related to crop biological diversity (Brush, Taylor and Bellon, 1992; Meng, 1997, Van Dusen, 2000). This is especially true in Hungary, where older farmers who were raised on family farms before the period of collectivisation are known to be those with ancestral seed varieties and traditional practices. Age probably also relates positively to traditional methods of integrated crop and livestock management without the use of chemical inputs. The quadratic term for age is included since older farmers may prefer not to maintain certain practices if they require heavy investments of labour. The number of household members that participate in home garden production represents the relevant family labour stock, and its effect is hypothesised to be positive for crop (Benin *et al.,* 2003; Gauchan, 2004) and agro-diversity. However, the effect of this variable is ambiguous for soil micro-organism diversity as larger families might prefer to use chemicals to ensure sufficient output.

Car ownership and the total area of owned, cultivated fields account for the wealth and social status of the household. Car ownership also indicates increased market access, which could be negatively correlated with the need to maintain agricultural biodiversity in home gardens. The effect of car ownership on choice of organic production methods is however ambiguous, given the luxury good nature of organically produced goods in some regions (Birol, Smale and Gyovai, 2004). Total area of owned, cultivated fields indicates the extent to which the household is dedicated to agriculture. More 'agricultural' households may have less or more agricultural biodiversity on farms, depending on the complementarity or substitutability of inputs and outputs between the home garden and field production.

Wealth indicators are also thought to influence attitudes toward output variability or market uncertainty. Risk aversion, and hence agricultural biodiversity found on farms, is hypothesised to decrease in wealth (Meng, 1997; Van Dusen, 2000). Though farm production is inherently uncertain because of the time lag between input choices and harvest, there is little reason to expect high degrees of output variability in home garden production in Hungary. Market sources of risk are substantial, however.

Farm physical characteristics and micro-ecologies clearly affect the numbers and types of crops and varieties grown on farms (Brush, Taylor and Bellon, 1992; Meng, 1997; Meng, Taylor and Brush, 1998; Van Dusen, 2000; Van Dusen and Taylor, 2003; Gauchan, 2004). Favourable agricultural production conditions in terms of more irrigation and good soil quality might affect agricultural biodiversity positively, by increasing the productivity of labour input, or negatively, by inducing specialisation in production of fewer species for market sales, especially in larger home gardens. Farmers might also choose to engage in agricultural biodiversity rich production to increase the productivity of an agroecosystem that is not very productive otherwise, as discussed in Van Dusen (2000) and Di Falco and Perrings (2002). The effect of irrigation and good quality soil on agro-diversity is however hypothesised to be negative, since farmers with good crop production conditions might not choose to tend livestock. Larger home gardens may have less agricultural biodiversity as families may choose to take advantage of economies of scale and specialise; on the other hand larger size may imply more space to undertake more activities that result in higher levels of agricultural biodiversity. Farm families with more extensive home gardens would are less likely to undertake organic production methods because of the cost of this labour intensive method.

Market characteristics indicate the extent to which the farm households are integrated into markets as sellers (the household specific value of home garden crop output sales variable), and the transaction costs the farm households face in market participation (the settlement specific distance to the nearest food market variable). Previous studies demonstrate that the more integrated into markets, the less agricultural biodiversity farmers will maintain on the home gardens (Brush, Taylor and Bellon, 1992; Meng, 1997; Van Dusen, 2000; Smale *et al.*, 2001a; Gauchan, 2004; Winters *et al*., 2004; Birol, Kontoleon and Smale, *forthcoming*). Households with large volume of sales on markets are expected to prefer less crop diversity in their home gardens, specialising in production. Demand for agro-diversity and crop diversity is expected to rise with greater distances from the nearest markets. When food markets are far away, farmers might prefer to ensure home garden produce levels by applying chemicals.

6. Econometric results

6.1. Crop species and variety diversity in Hungarian home gardens

The regression explaining crop species and variety diversity in home gardens is estimated with a Poisson regression because the dependent variable is a non-negative integer (Hellerstein and Mendelsohn, 1993). Statistical tests for both pooled and separate regressions for the three study sites revealed over-dispersion (Cameron and Trivedi, 1990). Consequently, the regressions were then estimated with a Negative Binomial model, an extension of the Poisson regression model, which allows the distribution of the variance to differ from the distribution of the sample mean (Greene, 1997).

The results of the Negative Binomial model for crop species and variety diversity are reported in Table 6. The hypothesis that parameters are constant across regions was rejected with a log likelihood ratio test at 0.5%, and separate regressions were estimated for each. Joint hypothesis tests on sets of estimated coefficients are consistent with the maintained hypothesis that production and consumption decisions cannot be separated for home garden production in any region except Dévaványa. In that region with greater market development and urbanisation, only the percent of area that is irrigated, a farm characteristic, positively affects crop species and variety diversity. In each other region and all regions taken together, the level of crop species and variety diversity, a metric calculated over optimal product choices (that in turn imply planting decisions), is affected jointly by household and market characteristics as well as farm characteristics.

Greater variation in factors across sites may explain why more of them are statistically significant in the pooled than in the separate regressions. Statistical tests of individual parameters confirm that older decision-makers maintain more crop species and varieties, but less so as they age. The stock of family participants in home garden production also contributes. The more extensive the home garden, the higher is the number of crop species and varieties grown, as expected. The most statistically significant variable whose effect also has the largest magnitude is the households' distance to the nearest food market. Transactions costs induce farmers to rely on the home garden and grow a wider range of foodstuffs.

Differences emerge among tests of individual hypotheses in the more isolated regions, Orség-Vend and Szatmár-Bereg. In Orség-Vend car ownership is positively associated with the family's decision to cultivate more crop species and varieties in their garden. In other words, orségi households that are better off cultivate more species and varieties than their poorer counterparts[5]. Good soil quality also has a favourable effect on crop species and varieties richness. Effects of these two significant factors are similar in magnitude. In Orség-Vend inter and infra crop species diversity also increases in the size of the home garden, although the effect is rather small. In Szatmár-Bereg, the sign of the most significant (and largest) factor, distance to the nearest food market, is negative. Home gardens in the more distant villages of Szatmár-Bereg are larger in size. Families cultivating these small farms tend to specialise in fewer species and varieties, especially of fruit trees, for sales to the large fruit juice industry in this region. Similarly, the coefficient on the value of sales of home garden output is negative, though not statistically significant. The size of the total farm area that is cultivated and owned also affects crop species and variety count negatively and significantly. Families who farm larger fields and sell their produce are more likely to have access to food markets and hence to substitutes for home garden outputs. Cultivated area owned is also wealth indicator, revealing that in Szatmár-Bereg ESA, households that are wealthier are more likely to cultivate fewer species and varieties of crops in their home gardens, consistent with the risk aversion hypothesis. Irrigation in the home garden contributes positively to crop species and variety richness.

[TABLE 6]

6.2. Crop genetic diversity in Hungarian home gardens

Univariate Probit regressions for landrace cultivation in the home garden are reported in Table 7. Log-likelihood ratio tests again confirm the non-separability of consumption and production decisions in each region and the dependence of parameters on region. In general, household characteristics (age, labour supply, wealth) and distances to market play an overwhelming role in the decision to plant landraces in the home garden. Stocks of family labour have both large and statistically significant effects. The importance of age and experience is particularly pronounced in Dévaványa, where it is the only significant variable. Clearly, in this more urbanised and economically developed region,

[5] A reason for this finding could be similar to that found by Szép (2000), who investigated time allocation patterns of Hungarian home garden producer households and found "rational" labour supply behaviour with backward bending labour supply curve. That is, as wages of the home garden decision-makers and

the older farmers who were raised as children on farms with landraces before the collectivisation period are those that retain them. Orségi families who are more agriculturally based, with larger fields and more family labour engaged on the farm, are more likely to cultivate landraces. In this less favourable agro-ecology, the irrigated share of the home garden relates negatively to the prospects that a landrace is grown. Coupled with the negative sign on the soil quality variable, these findings imply landraces in this region on found in less favoured environmental niches. Poorer families in Szatmár-Bereg, without cars and the market access they provide, are more likely to cultivate landraces. The size of the home garden counteracts this effect. More area increases the likelihood that landraces are grown, alongside other varieties.

[TABLE 7]

6.3.Agro-diversity in Hungarian home gardens

The dichotomous choices of whether or not to raise crops and livestock in the home garden is modelled with a univariate Probit model, the results of which are reported in Table 8. Log likelihood ratio tests suggest that production decisions are not separable from consumption decisions in any of the regions (including Dévaványa) and that regression parameters depend on region. For all regions taken together, household characteristics as a set are highly significant determinants of the decision to integrate crops and livestock, distance to market has a weaker effect, and farm characteristics are of no importance. Older, and hence more experienced and traditional decision-makers are more likely to undertake both crop and livestock production in their home gardens. The effect of age declines with this labour-intensive mode of production, offset by the positive effect of the number of family members involved. The labour requirements of livestock production are reflected in the prominent magnitudes of the coefficients on the number of family members involved in home garden production. To make space for larger animals and contribute feed and fodder, larger home field areas cultivated and owned are also associated with higher prospects of integrating crops and livestock in the home garden. Distance to the nearest food market has a less significant effect, but reflects

participants increase, they choose to engage less in employment outside of home gardens, preferring to use that time for leisure activities—which include the cultivation of species-rich home gardens.

farm family demand for self-sufficiency in consumption of pork and salami, crucial in the Hungarian diet.

In Dévaványa, where markets are prevalent, distance to the nearest market is of no consequence in the decision for integrated crop and livestock production in the home garden, though age again plays a major role. Denser settlements mean that home garden sizes are significant in the decision to raise livestock in addition to crops. In Orség-Vend, the age of the decision-maker and stocks of family labour working in the home garden are also important, though garden and field areas are not in its less populated, more dispersed settlements. Owning a car, which provides access to shops in town and indicates wealth, has a large negative effect on the probability that a household raises livestock in the home garden. Distance to market is somewhat less important. The same is true in Szatmár-Bereg. There, larger areas are negative associated with livestock production because Szatmári households with larger home gardens tend to specialise in crop (especially fruit trees, as explained above) production for market sales. The negative effect of value of produce sales reinforces this finding, though the coefficient is not statistically significant.

[TABLE 8]

6.4. Soil microorganism diversity in Hungarian home gardens

The univariate Probit regressions for determinants of the decision to use organic production methods area statistically significant only for the pooled regression. These results are reported in Table 9. Econometric results are weaker statistically because of the smaller percentages of farmers engaged in organic production relative to other components of agrobiodiversity, though they are consistent with hypotheses based on economic theory. In contrast with the other components of agricultural biodiversity, higher numbers of family participants in home garden production imply that the household is less likely to employ organic methods. Since the stock of home garden labour is highly correlated with family size, this finding suggests that larger families may be reluctant to expose themselves to the yield risks associated with avoiding chemical inputs. Since organic techniques also require labour to substitute for chemicals in pest and disease control, larger home garden areas reduce the likelihood that they are used.

Though the effects are statistically weak, good soil quality is positively associated with organic farming since it substitutes for fertilisers.

[TABLE 9]

7. Designing conservation programmes

The predictions from the models estimated above enable us to identify the types of families that are most likely to sustain the four components of agrobiodiversity investigated in the traditional home gardens of Hungary. Profiles can be used to design targeted, least cost incentive mechanisms to support conservation as part of national agri-environmental programme. Revealed choices indicate the value farmers assign to these components, given the constraints they face.

Overall, the predicted and actual levels of crop species diversity are lowest in Dévaványa, as is the percentage of households choosing to grow landraces. Only one household is predicted to grow landraces in this urbanised ESA. The opportunity costs of maintaining crop biological diversity are clearly lower in the more remote Orség-Vend and Szatmár-Bereg. The likelihood of integrated crop and livestock production in home gardens is high and similar across the regions.

Farm families that are most likely to manage crop species diversity rich home gardens in each ESA are reported in Table 10, and compared to the other farm families in the sample. In Dévaványa, farm families with high probabilities of maintaining levels of crop species and variety diversity levels above the regional average have more home garden production participants, lower income levels and food expenditure and cultivate smaller total areas of fields than other households. They have more irrigation in their home gardens but are less likely to have good quality soil in their home gardens.

In Orség-Vend farm families with high probabilities of maintaining levels of crop species and variety diversity levels above the regional average own and cultivate smaller fields but have larger home gardens and sell more of their home garden output compared to other farm families in the sample. They have higher income levels and wealth, in terms of car ownership compared to the other households. In Szatmár-Bereg, families with high probabilities of maintaining levels of crop species and variety diversity above the again own much smaller total areas and are less as likely to own cars, but are slightly closer to markets. These households have more irrigation and are likely to have better quality soil in their home gardens.

[TABLE 10]

Farm families that are most likely to cultivate landraces are predicted and their profiles are reported in Table 11. In Dévaványa ESA only one farm family had a high predicted probability (over 75%) of growing landraces, reflecting that landrace cultivation in this ESA is not a sustainable home garden activity. In Orség-Vend those with high probabilities of growing landraces have older and less educated home garden decision-makers, smaller dependency ratios and less exogenous income compared to those farm families that are not likely to cultivate landraces. These farm families have much larger owned and cultivated field areas than other families, and sell more home garden produce per m^2 of home garden.

In both regions, farm families that are predicted to cultivate landraces are located farther from markets. In Orség-Vend they have smaller home gardens than other households, while the opposite is true in Szatmár-Bereg. Szatmári farm households that have high predicted probabilities of growing landraces have more family members participating in home garden production, and are less likely to own cars and home gardens with good quality soil compared to other households in that region.

[TABLE 11]

Finally, farm families that are most likely to manage livestock in their home gardens are reported in Table 12. Across regions, larger farm households are more likely to undertake mixed crop and livestock production. In Dévaványa and Szatmár-Bereg regions, those that own and cultivate larger fields are more likely to manage livestock alongside crops, reflecting the complementarity between feed production in the field and livestock production in the home garden. Dévaványai farm families with high predicted probabilities of agro-diversity are also more likely to own cars, have home gardens with good quality soil and be more integrated into markets as sellers of home garden produce.

In Orség-Vend and Szatmár-Bereg regions, younger home garden decision-makers are predicted to be managers of both crops and livestock. In Orség-Vend and Dévaványa, farm families with larger home gardens are more likely to raise animals in their home gardens, contrary to Szatmár-Bereg, where orchards are cultivated in larger

home gardens. Both orségi and szatmári farm families that are more likely to engage in livestock production have higher dependency ratios and number of household members that are employed off farm. Orségi households that are predicted to manage agro-diversity in their home gardens are located further away from the markets, and hence are more dependent on their own production of livestock for the families' meat consumption.
[TABLE 12]

8. Conclusions and Policy Implications

One of the main results of the analysis is uniqueness of each region studied in terms of levels of agricultural biodiversity found in the home gardens of farm families as well as the factors that explain their variation. In each statistical analysis conducted, the hypotheses that population parameters of interest are constant across regions was rejected. Hence, any agri-environmental policy or programme that aims to support the management of current levels of agricultural biodiversity in rural Hungary will need to recognise the diversity of traditional small farms and their context.

Findings are also consistent with the maintained hypothesis that for all regions, the choices of farm families concerning the outputs they produce in home gardens, as reflected in the components of agricultural biodiversity measured here, cannot be separated from their consumption decisions. According to the model of the agricultural household that motivates our approach, market imperfections in Hungary's transitional economy continue to induce farmers to produce for their own food requirements. Furthermore, any policy or programme that affects the wealth, education or labour participation of family members, as well as the formation of food markets within settlements, will influence the choices and observed levels of crop species richness, landrace cultivation, and integrated crop and livestock production through the households' internal equilibria.

Across regions, one of the most significant determinants of revealed preferences for maintaining agricultural biodiversity on Hungarian home gardens is age of the home garden decision-maker. Since outmigration of younger generation is a common phenomenon in the more isolated regions, this finding implies that crop species and genetic diversity levels, though relatively rich in these locations, is in jeopardy. Policies and programmes such as SAPARD and NAEP are now in place to encourage economic activities in the rural areas and retain settlement populations in the countryside. (SAPARD (Weingarten *et al.*, 2004) and NAEP (Juhasz *et al.*, 2000)). If managing Hungary's agricultural biodiversity is of policy importance, these programmes must ensure the transfer of knowledge and skills to future generation of small-scale farmers in the buffer zones of targeted environmentally-sensitive locations. Such rural development policies and programmes, however, could also cause the time allocated to home garden production to decrease as farm families choose more remunerative activities.

Prospects for niche markets or geographical denomination of origin might therefore be considered as part of the market integration that Hungary will experience with EU membership (Fischler, 2004; Birol, Smale and Gyovai, 2004). Numerous recent studies point to the rising demand of high-income, EU consumers for goods produced with organic methods or heirloom varieties of crop and animal species (e.g. Kontoleon, 2003).

Clearly, home garden production has an important role in promoting multifunctional agriculture through the NAEP's extensive agricultural production schemes. NAEP, as explained in section 2, is based on voluntary farmer contracts. Findings reported in this paper can be a starting point for identifying locations and farmers to include in contracting schemes to support the sustainable management of agricultural biodiversity in home gardens. This paper has described the type of farm households and locations that are likely to cost least in payments and whose inclusion in contracting schemes should be most effective.

References

Bela, G., G. Pataki, M. Smale and M. Hajdú. 2003. " Conserving Genetic Resources on Smallholder Farms in Hungary: Institutional Analysis". Paper presented at the BIOECON International Conference on 'Economic Analysis of Policies for Biodiversity Conservation', Venice, Italy, August 28-29, 2003

Benin, S. M. Smale, B. Gebremedhin, J. Pender, and S. Ehui. 2003. The determinants of cereal crop diversity on farms in the Ethiopian highlands. EPTD Discussion Paper No. 105. Washington D.C.: IFPRI.

Birol, E., M. Smale and A. Gyovai. 2004. "Agri-Environmental Policies in a Transitional Economy: The Value of Agricultural Biodiversity in Hungarian Home Gardens", EPTD Discussion Paper No. 117. Washington D.C.: IFPRI.

Birol, E., A. Kontoleon and M. Smale. forthcoming. "Farmer demand for agricultural biodiversity in Hungary's transition economy: A choice experiment approach", in Smale, M. (Ed.) *Valuing Crop Biodiversity on Farms during Economic Change*, CAB International, Wallingford, UK

Brookfield, H. and Stocking, M. 1999. Agrodiversity: definition, description and design. *Global Environmental Change* 9: 77-80.

Brookfield, H. 2001. *Exploring Agrodiversity*. Columbia University Press, New York.

Brookfield, H., Padoch, C., Parsons, H. and M. Stocking. 2002. *Cultivating Biodiversity: Understanding, Analysing and Using Agricultural Diversity*. The United Nations University. ITDG Publishing, London

Brush, S., E. Taylor, and M. Bellon. 1992. 'Technology Adoption and Biological Diversity in Andean Potato Agriculture', *Journal of Development Economics* **39** (2), 365-387.

Cameron, A. and P. Trivedi. 1990. "Regression Based Tests for overdispersion in the Poisson Regression Model" *Journal of Econometrics*, 46 pp. 347-364.

Commission of the European Communities. 2002.Enlargement and Agriculture: Successfully Integrating the New Member States into the CAP. Issues Paper. Brussels, 30.1.2002 SEC (2002) 95 Final.
http://europa.eu.int/comm/enlargement/docs/financialpackage/sec2002-95_en.pdf

De Janvry, A., Fafchamps, M., and E. Sadoulet. 1991. 'The Peasant Household Behaviour with Missing Markets: Some Paradoxes Explained.' *The Economic Journal.* 101:1400-1417.

Di Falco S. and C. Perrings. 2002. 'Cooperative Production and Intraspecies Crop Genetic Diversity: The case of Durum Wheat in Southern Italy.' Paper presented at the first BIOECON Workshop on Property Right Mechanisms for Biodiversity Conservation. International Plant Genetic Resources Institute (IPGRI) 30-31 May 2002, Rome, Italy.

Evenson, R.E. and D. Gollin (Eds.). 2003. *Crop Variety Improvement and Its Effect on Productivity: The Impact of International Agricultural Research*, Wallingford, UK: CAB International.

FAO. 1999. Multifunctional Character of Agriculture and Land: Conference Background Paper No. 1, Maastricht Sept 1999 Size

Gauchan, D. 2004. Conserving Crop Genetic Resources On Farm: The Case of Rice in Nepal. PhD Thesis. University of Birmingham, UK.

Greene, W.H. 1997. *Econometric Analysis,* 3rd Edition, Prentice Hall.

Gyovai, Á., G. M. Csizmadia and L. Holly. 2004. "Cultivated plant diversity in Environmentally Sensitive Areas". Poster presentation at the Hungarian Academy of Science, Budapest, 18-19 February, 2004.

Hellerstein, D. and R. Mendelsohn. 1993. "A theoretical foundation for count data models", *American Journal of Agricultural Economics* 75, 604-611.

IPGRI. 2003. Home Gardens and the *In Situ* Conservation of Plant Genetic Resources. http://www.ipgri.cgiar.org/system/page.asp?frame=publications/indexpub.htm

Juhász, I, J. Ángyán, I. Fesus, L. Podmaniczky, F. Tar and A. Madarassy. 2000. National Agri-Environment Programme: For the Support of Environmentally Friendly Agricultural Production Methods Ensuring the Protection of the Nature and the Preservation of the Landscape. Ministry of Agriculture and Rural Development, Agri-environmental Studies, Budapest 1999.

Kovách, I. 1999. "Hungary: Cooperative Farms and Household plots". In *Many Shades of Red: State Policy and Collective Agriculture*. Mieke Meurs (Ed.) Boulder: Rowman and Littlefield.

Lankoski, J. (Ed.). 2000. *Multifunctional character of agriculture*. Agricultural Economics Research Institute, Finland. Research Reports 241.

Lupwayi, N., W. Rick and G. Clayton. 1997. "Zillions of Lives Underground". APGC Newsletter, Fall 1997. http://www.pulse.ab.ca/newsletter/97fall/zillion.html

Mäder, P., A. Fliessbach, D. Dubois, L. Gunst, P. Fried, and U. Niggli, 2002: Soil fertility and biodiversity in organic farming. *Science*, 296: 1694-1697

Már, I. 2002. "Safeguarding agricultural biodiversity On Farms in Hungary" in Smale, M. I. Már and D.I. Jarvis (Eds) The Economics of Conserving Agricultural Biodiversity On Farm: Research methods developed from IPGRI's Global Project 'Strengthening the Scientific Basis of In Situ Conservation of Agricultural Biodiversity'. International Plant Genetic Resources Institute, Rome, Italy.

Meng, E.C. 1997. Land Allocation Decisions and In Situ Conservation of Crop Genetic Resources: The Case of Wheat Landraces in Turkey. Ph.D. Dissertation, University of California Davis.

Meng, E.C, J.E. Taylor, and S.B. Brush. 1998. "Implications for the Conservation of Wheat Landraces in Turkey from a Household Model of Varietal Choice", in Smale, M (Eds). 1998. *Farmers, Gene Banks and Crop Breeding: Economic Analyses of Diversity in Wheat, Maize and Rice*. Boston: Kluwer Academic Press and CIMMYT.

Romstad, E., A. Vatn, P.K. Rørstad and V. Søyland. 2000. *Multifunctional Agriculture: Implications for Policy Design.* Agricultural University of Norway, Department of Economics and Social Sciences, Report No. 21.

Seeth, H.T., S. Chachnov, A. Surinov and J. von Braun. 1998. "Russian Poverty: Muddling Through Economic Transition with Garden Plots". *World Development.* Vol. 26. No. 9, pp. 1611-1623

Simon, Á. 2001. *Agricultural Background For the On Farm Project.* Institute for Agrobotany, Tápiószele, Hungary.

Singh, I., Squire, L. and J. Strauss. 1986. *Agricultural Household Models*. Baltimore: The Johns Hopkins University Press

Smale, M., Bellon, R.M. and J.A. Aguirre Gomez. 2001a. 'Maize Diversity, Variety Attributes, and Farmers' Choices in Southeastern Guanajuato, Mexico.' *Economic Development and Cultural Change*. Volume 50, Number 1, October 2001.

Smale, M. 2001b. "Economic incentives for conserving crop genetic diversity on farms: issues and evidence". In G.H. Peters and P. Pingali (Eds) *Tomorrow's Agriculture: Incentives, Institutions, Infrastructure and Innovations*. Proceedings of the 24th International Conference of Agricultural Economists. Ashgate, Oxford.

Swain, N. 2000. "Post-Socialist Rural Economy and Society in the CEECs: the Socio-Economic Contest for SAPARD and EU Enlargement", Paper presented at the International Conference: European Rural Policy at the Crossroads, 29 June –1 July 2000, The Arkleton Centre for Rural Development Research, King's College, University of Aberdeen, Scotland

Szelényi, I (Ed.). 1998. *Privatising the Land:* Rural Political Economy in Post-communist Societies Routledge, 1998.

Szép, K. 2000. "The Chance of Agricultural Work in the Competition for Time: Case of Household Plots in Hungary". *Society and Economy in Central and Eastern Europe*, Volume XXII Number 4.

Taylor, E. and I. Adelman. 2003. 'Agricultural Household Models: Genesis, Evolution and Extensions.' Forthcoming in the *Review of the Economics of the Household*. Vol 1, No. 1 (2003).

Vajda. L. 2003. *The view from Central and Eastern Europe.* Agricultural outlook forum 2003, USDA. http://www.usda.gov/oce/waob/oc2003/speeches/vajda.pdf. Washington, DC: USDA.

Van Dusen, M.E. 2000. *In situ Conservation of Crop Genetic Resources in the Mexican Milpa System.* Ph.D. Dissertation, University of California Davis.

Van Dusen, E. and Taylor, J. E. 2003. "Missing markets and crop genetic resources: evidence from Mexico". A manuscript. University of California, Berkeley, USA.

Weingarten *et al.* 2004. The future of rural areas in the CEE new member states. Network of Independent Agricultural Experts in the CEE Candidate Countries.
http://europa.eu.int/comm/agriculture/publi/reports/ccrurdev/text_en.pdf

WHO. 2000. "The Impact of Food and Nutrition on Public Health: The case for a Food and Nutrition Policy and an Action Plan for the European Region of WHO, 2000-2005 http://www.hospitalitywales.demon.co.uk/nyfaweb/fap4fnp/fap_26.htm, and the Draft Urban Food and Nutrition Action Plan http://www.hospitalitywales.demon.co.uk/nyfaweb/urban/urb_02.htm

Wyzan, M. 1996. "Increased inequality, poverty accompany economic transition", *Transition*, Vol. 2, No. 20.

Figure 1. Location of the Study Sites

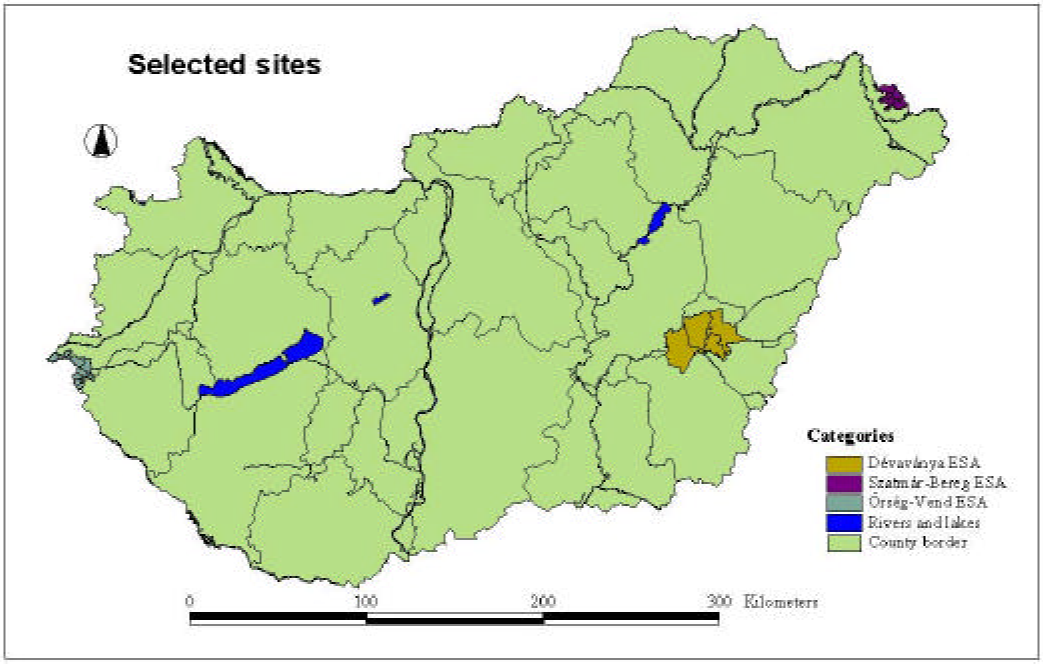

Table 1. Settlement and ESA Level Characteristics

Characteristics	Dévaványa, N=5	Orség-Vend, N=11	Szatmár-Bereg, N=6
	Mean		
Presence of train station	0.8	0.18	0
Distance to nearest food market (km)	0	19.85	18.35
Distance to nearest food market (minutes)	0	20.36	17.83
Number of primary schools	2.4	0.36	0.83
Number of secondary schools	1	0	0
Number of food markets	1	0	0
Population	9928.6	373.36	659
Area (km^2)	21964.6	1636.18	2407
Population density	0.45	0.20	0.28
Regional unemployment rate (%)	12.4	4.8	19.0
Inactive ratio (person on pensions or maternity leave/population)	0.37	0.40	0.48
Dependency ratio (inactive, children, housewives, students/population)	0.28	0.22	0.27
Number of shops	140.8	4.18	9.67
Number of enterprises	491.2	21.55	22.83
Regional road network (km)	6118.6	8678	3593
Regional area of total road network (km^2)	5621.2	5936	3337

Source: Hungarian Central Statistical Office Census (2001), Statistical Yearbooks for counties of Békés, Jász-Nagykun-Szolnok, Vas and Szabolcs-Szatmár-Bereg (2001) and Hungarian Ministry of Transport and Water, Road Department Main Data on Roads (2001). Road data is reported at the regional level.

Table 2. Characteristics of households and home garden decision-makers by region

Variable	Definition	Dévaványa N=104	Orség-Vend N=109	Szatmár-Bereg N=110
		Mean (s.e.)		
Family size**	Number of family members	2.7 (1.2)	3.1 (1.6)	2.8 (1.5)
Home garden participants**	Number of family members that work in home garden	2.1 (1)	2.5 (1.3)	2.4 (1.3)
Children*	Number of family members =< 12 years	0.3 (0.7)	0.5 (0.8)	0.4 (0.8)
Off farm employment**	Number of family members employed off farm	0.8 (1)	1 (1.1)	(0.7) (1)
Income***	Average monthly income from off-farm employment, pensions, rents, gifts or other benefits	747778.2 (25413.2)	92341.5 (19986.3)	71685.6 (40740.4)
Food expenditure***	Stated % of income spent on food consumption	39.2 (15.1)	39.7 (16.8)	32.8 (11.8)
Age	Average age of home garden decision-makers	58.5 (13.1)	57.8 (12.4)	56.6 (15)
Experience*	Average years farming experience of home garden decision-makers	42.8 (17.6)	40.7 (17.1)	38.4 (19.6)
Education*	Years of formal education the home garden decision-makers have received	10 (2.8)	9.9 (2.7)	9.3 (3.3)
		Percent		
Off farm*	Decision-makers with off farm employment	39.4	33.9	30
Retired	Retired decision-makers	66.3	72.5	72.7
Less than minimum education**	Decision-makers with less than 8 years of education	13.5	4.6	21.3
Car ***	The household owns a car	41.7	64.2	44.6

Source: Hungarian Home Garden Diversity Household Survey, Hungarian On Farm Conservation of Agricultural Biodiversity Project, 2002. (*) T-tests and Pearson Chi square tests show significant differences among at least one pair of ESAs at 10% significance level; (**) at 5% significance level, and (***) at 1% significance level.

Table 3. Home garden, field and market characteristics of the households by region

Variable	Definition	Dévaványa N=104	Orség-Vend N=109	Szatmár-Bereg N=110
		Mean (s.e.)		
Home garden area**	in m^2	560.9 (683)	1624.6 (2872.1)	2649.2 (3041.9)
Total field land owned***	in m^2	86215.7 (319476.5)	24561.3 (36780.2)	40300.9 (62608.4)
Total field land cultivated***	in m^2	83709.1 (321854)	21657.7 (43372)	61323 (103984)
Total field land cultivated and owned ***	Total land cultivated by the household that is also owned by the household in m^2	78956.2 (320233.3)	16962 (31441.5)	42753.7 (64057.4)
Irrigation**	Percentage of home garden land irrigated	36.1 (45.5)	46 (40.4)	16.6 (28.2)
Sales**	Value of total home garden output sold in market prices in Hungarian Forint per m^2 of home garden	5.5 (29.6)	6.6 (49.7)	33 (103.3)
Distance***	Distance of the settlement in which th household is located to the nearest market in km	0 (0)	19.9 (6.8)	18.4 (3.2)
		Percentage		
Household cultivates a field**	Household cultivates a field along with the home garden	42.3	59.6	44.5
Good soil**	Home garden soil is of good quality	16.8	9.2	31.2

Source: Hungarian Home Garden Diversity Household Survey, Hungarian On Farm Conservation of Agricultural Biodiversity Project, 2002. (*) T-tests and Pearson Chi square tests show significant differences among at least one pair of ESAs at 10% significance level; (**) at 5% significance level, and (***) at 1% significance level.

Table 4. Agricultural biodiversity found on Hungarian home gardens in study sites

Component of agricultural biodiversity	Definition	Dévaványa N=104	Orség-Vend N=109	Szatmár-Bereg N=110
		Mean (s.e.)		
Crop species and variety diversity***	Number of crop species and varieties cultivated in the home garden (richness)	17 (8.9)	28.1 (12.5)	18.6 (7.5)
		Percentage		
Crop genetic diversity***	Household cultivates a landrace in the home garden =1, 0 else	27	52	52
Agro-diversity	Household keeps large livestock in the home garden =1, 0 else	51	62	55
Soil micro-organism diversity *	Household employs organic production method in the home garden (i.e. does not use any chemicals including fertilisers, pesticides, insecticides, herbicides, fungicides and soil disinfectants) = 1, 0 else	16	17	8

Source: Hungarian Home Garden Diversity Household Survey, Hungarian On Farm Conservation of Agricultural Biodiversity Project, 2002.

(*) T-tests and Pearson Chi square tests show significant differences among at least one pair of ESAs at 10% significance level; (**) at 5% significance level, and (***) at 1% significance level.

Table 5. Definition of explanatory variables and hypothesised effects on components of agricultural biodiversity

Characteristics	Definition	Crop species diversity	Landrace cultivation	Agro-diversity	Organic Production
Household characteristics					
AGE	the age of the main home garden decision maker	+	+	+	+
AGE2	AGE squared	-	-	-	-
HGPAR	number of household members that participate in home garden cultivation	+	+	+	+,-
TOTFOC	total area of cultivated fields (in m^2) that are also owned by the household	+,-	+,-	+,-	+,-
CAR	household owns a car =1, 0 else	-	-	-	+,-
Farm characteristics					
HGAREA	size of the home garden (in m^2)	+,-	+,-	+,-	-
IRRPER	percentage of the home garden area irrigated	+,-	+,-	-	+,-
GOODSOIL	home garden soil is of good quality=1, 0 else	+,-	+,-	-	+,-
Market characteristics					
SALEM2	value of the sales of the home garden crop output (HF) in preceding period, per square meter of the home garden	+,-	-	-	-
DISTKM	the distance of the household, in kilometres, to the nearest food market (settlement level characteristic)	+	+	+	+,-

Table 5. Determinants of crop species and variety diversity in Hungarian home gardens

	Dévaványa	Orség-Vend	Szatmár-Bereg
	Marginal effects		
Constant	30.1**	2***	57.4***
AGE	0.51	0.023	0.32
AGE2	-0.005	-0.0001	-0.003
HGPAR	1.24	0.05	0.2
TOTFOC	-0.000003	0.0000008	-0.00001
CAR	-0.008	0.3***	-4.06**
HGAREA	0.0009	0.00002*	0.0003
IRRPER	0.03*	-0.0013	0.07**
GOODSOIL	0.0002	0.3*	0.004
SALEM2	-0.04	0.0006	-0.005
DISTKM	-	0.005	-0.7***
Sample size	104	109	110
Iterations completed	15	16	18
Log likelihood	-358.36	-409.16	-370.98
Chi squared	161.55	194.17	64.12
D.o.f	1	1	1
Significance level	0.00	0.00	0.00
a	0.17***	0.12***	0.09***
	(0.03)	(0.03)	(0.02)
Test $\Omega_{HH} = 0$ (d.o.f = 5)			
Likelihood ratio test	34.9	19.2***	6.8
Probability	0.57	0.998	0.76
Test $\Omega_{M} = 0$ (d.o.f.=1 for Dévaványa 2 for others)			
Likelihood ratio test	2.04	11.9***	9.6***
Probability	0.847	0.45	0.992
Test $\Omega_{HH} = \Omega_{M} = 0$ (d.o.f = 7 for all except Dévaványa d.o.f. = 6)			
Likelihood ratio test	7.12	22.4***	15.1**
Probability	0.992	0.999	0.999

Source: Hungarian Home Garden Diversity Household Survey, Hungarian On-Farm Conservation of Agricultural Biodiversity Project, 2002. * significant at less than 10%, ** significant at less than 5%, *** significant at less than 1% with one-tailed or two-tailed tests as shown on Table 4; regression is Negative Binomial; marginal effects are computed at mean values.

Table 7. Determinants of landrace cultivation in Hungarian home gardens

	Dévaványa	Orség-Vend	Szatmár-Bereg
	Marginal effects		
Constant	-0.07	-0.15	-0.3
AGE	0.0024***	0.005	0.003
AGE2	-0.00002***	-0.00004	$-0.1x10^{-4}$
HGPAR	-0.001	0.01**	0.04***
TOTFOC	$-0.3x10^{-7}$	$0.1x10^{-5}$**	$0.1x10^{-7}$
CAR	0.2	-0.01	-0.1***
HGAREA	$-0.5x10^{-6}$	$-0.3x10^{-5}$	$0.6x10^{-5}$***
IRRPER	$-0.8x10^{-5}$	-0.0003*	$0.5x10^{-3}$
GOODSOIL	$-0.4x10^{-5}$	-0.01	-0.018
SALEM2	$0.6x10^{-4}$	0.02	$0.13x10^{-4}$
DISTKM	-	-0.0007	0.005
Sample size	104	109	110
Log likelihood	-49.71	-63.65	-64.70
Chi squared	21.74	23.57	22.78
D.o.f	9	10	10
Significance level	0.0097	0.0088	0.01
Correct predictions	73%	65%	71%
r^2	0.74	0.996	0.49
Test $\Omega_{HH} = 0$ (d.o.f = 5)			
Likelihood ratio test	17.3***	11.7**	17.3***
Probability	0.996	0.960	0.996
Test $\Omega_M = 0$ (d.o.f.=1 for Dévaványa 2 for others)			
Likelihood ratio test	2.2	9.6***	1.2
Probability	0.860	0.992	0.458
Test $\Omega_{HH} = \Omega_M = 0$ (d.o.f = 7 for all except Dévaványa d.o.f. = 6)			
Likelihood ratio test	20.4***	20.9***	20.6***
Probability	0.999	0.999	0.999

Source: Hungarian Home Garden Diversity Household Survey, Hungarian On Farm Conservation of Agricultural Biodiversity Project, 2002. * significant at less than 10%, ** significant at less than 5%, *** significant at less than 1% with one-tailed or two-tailed tests as shown on Table 4; regression is Probit; marginal effects are computed at mean values.

Table 8. Determinants of agro-diversity in Hungarian Home Gardens

	Dévaványa	Orség-Vend	Szatmár-Bereg
	Marginal effects		
Constant	-0.005**	-1.7*	-0.7×10^{-3}
AGE	0.2×10^{-3}***	0.05*	0.4×10^{-4}
AGE2	-0.2×10^{-5}***	-0.5×10^{-3}*	-0.6×10^{-6}
HGPAR	-0.5×10^{-4}	0.16***	0.3×10^{-3}**
TOTFOC	0.7×10^{-7}*	0.3×10^{-5}*	0.6×10^{-8}**
CAR	0.2×10^{-5}	-0.3**	-0.9×10^{-3}***
HGAREA	0.4×10^{-6}**	0.2×10^{-4}	-0.2×10^{-6}***
IRRPER	0.1×10^{-5}	0.001	-0.6×10^{-3}
GOODSOIL	-0.3×10^{-5}	-0.14	0.4×10^{-3}*
SALEM2	0.6×10^{-5}	-0.003	-0.1×10^{-5}
DISTKM	-	0.017*	0.3×10^{-4}
Sample size	104	109	110
Log likelihood	-47.04	-58.06	-61.04
Chi squared	50.05	28.22	29.49
D.o.f	9	10	10
Significance level	0.00	0.0017	0.001
Correct predictions	78%	74%	72%
r^2	0.998	0.56	0.56
Separability test $\Omega_{HH} = 0$ (d.o.f = 5)			
Likelihood ratio test	41.1***	22.7***	20.3***
Probability	0.999	0.999	0.999
Separability test $\Omega_M = 0$ (d.o.f.=1 for Dévaványa 2 for others)			
Likelihood ratio test	2.5	5.4*	1
Probability	0.860	0.93	0.39
Separability test $\Omega_{HH} = \Omega_M = 0$ (d.o.f = 7 for all except Dévaványa d.o.f. = 6)			
Likelihood ratio test	42.1***	27.1***	22.5***
Probability	0.999	0.999	0.999

Source: Hungarian Home Garden Diversity Household Survey, Hungarian On Farm Conservation of Agricultural Biodiversity Project, 2002. * significant at less than 10%, ** significant at less than 5%, *** significant at less than 1%* with one-tailed or two-tailed tests as shown on Table 4; regression is Probit; The marginal effects are computed at mean values.

Table 9. Determinants of Organic Production in Hungarian Home Gardens

	All Regions
	Marginal effects
Constant	-0.13
AGE	0.0024
AGE2	-0.00001
HGPAR	-0.024***
TOTFOC	-0.2×10^{-7}
CAR	0.0002
HGAREA	-0.00002**
IRRPER	-0.0002
GOODSOIL	0.003
SALEM2	0.8×10^{-5}
DISTKM	0.0009
Sample size	323
Log likelihood	-117.71
Chi squared	25.40
D.o.f	10
Significance level	0.0046
Correct predictions	86%
r^2	0.48
Separability test $\Omega_{HH} = 0$ (d.o.f = 5)	
Likelihood ratio test	13.5**
Probability	0.981
Separability test $\Omega_M = 0$ (d.o.f.=2)	
Likelihood ratio test	1.1
Probability	0.420
Separability test $\Omega_{HH} = \Omega_M = 0$ (d.o.f = 7)	
Likelihood ratio test	14.4*
Probability	0.987

Source: Hungarian Home Garden Diversity Household Survey, Hungarian On Farm Conservation of Agricultural Biodiversity Project, 2002. * significant at less than 10%, ** significant at less than 5%, *** significant at less than 1%* with one-tailed or two-tailed tests as shown on Table 4; regression is Probit; The marginal effects are computed at mean values.

Table 9. Comparison of households with above- and below-average predicted levels of crop species and variety diversity [1]

Characteristics	Dévaványa N=104		Orség-Vend N=109		Szatmár-Bereg N=110	
	Above Mean	Below Mean	Above Mean	Below Mean	Above Mean	Below Mean
No. of predictions	20	84	22	87	27	83
Age	58.6	59.4	58.7	57.6	55.2	56.9
Education	10.2	10	10.4	9.8	9	9.5
Home garden participation	2.6***	1.9	2.9	2.5	2.5	2.4
Dependency ratio	0.06	0.07	0.09	0.1	0.08	0.1
No. off farm employment	0.7	0.9	1.3	1	0.65	0.68
Income	66082.1***	77079.2	94818.2**	91276.5	75117	70664.9
Food expenditure (HUF)	27442.2*	30217.2	38792.1**	34754.4	24059.7	22471.3
Field owned and cultivated (m^2)	5972.9*	39935.9	6508**	11027.1	14098.5**	20653.9
Car	40%	39%	86%§§§	58%	30%§§§	47%
Home garden area (m^2)	529.1	582.2	2106.9**	1502.7	2277.2*	2770.3
Irrigation	76.9***	26.4	43.5	46.6	31.5***	12.2
Good quality soil	10%§§	19%	9%	9%	41%§§	28%
Sales per m^2 home garden in HUF	4.3	5.7	22.9**	2.4	26.5**	35.1
Distance to the nearest food market	0	0	20.1	21	17.1***	18.8

Source: Hungarian Home Garden Diversity Household Survey, Hungarian On Farm Conservation of Agricultural Biodiversity Project, 2002.

[1] Predicted with probability above 5%; Regional means of crop species and variety diversity for Dévaványa, Orség-Vend and Szatmár-Bereg are reported in Table 3. Pairwise t-tests show significant differences at less than ***1% significance level, **5% significance level and *10% significance level; Pearson Chi square tests show significant differences at less than §§§ 0.5% significant level, and §§ 1% significant level

Table 11. Comparison of households with high predicted probability of growing landraces and all other households[1]

	Orség-Vend N=109		Szatmár-Bereg N=110	
	High Probability	Others	High Probability	Others
No. of predictions	20	89	23	87
Age	63.8***	56.5	56.6	56.5
Education	8.7***	10.2	9	9.5
Home garden participation	2.8	2.5	3.4***	2.2
Dependency ratio	0.04***	0.12	0.1	0.09
No. off farm employment	1	1.04	0.87	0.6
Income	84161.8*	93750.8	82084.8	69027.6
Food expenditure (HUF)	35956.9	35517.8	25533.7	22168.1
Field owned and cultivated (m^2)	37374.1***	3989.3	21912.3	18286.8
Car	65%	63%	21.7%§§§	48.3%
Home garden area (m^2)	896.5**	1788.3	3684.5**	2375.5
Irrigation	48.4	45.5	12.4	18.2
Good quality soil	5%§	10.1%	21.7%§§§	33.7%
Sales per m^2 home garden in HUF	35.7***	0.01	34.6	32.6
Distance to the nearest food market	23.1**	20.2	19.4**	18.1

Source: Hungarian Home Garden Diversity Household Survey, Hungarian On Farm Conservation of Agricultural Biodiversity Project, 2002.

[1] High probability is 75% or more; Pairwise t-tests show significant differences at less than ***1% significance level, **5% significance level and *10%significantce level; Pearson Chi square tests show significant differences at less than §§§ 0.5% significant level, §§ 1% significant level; § 5% significance level.

Table 12. Comparison of households with high predicted probability of engaging in integrated management of livestock and crops and all other households[1]

	Dévaványa N=104		Orség-Vend N=109		Szatmár-Bereg N=110	
	High Probability	Others	High Probability	Others	High Probability	Others
No. of predictions	24	80	39	70	32	78
Age	55.8	59.3	54***	60	46.8***	60.5
Education	11*	9.7	9.6	10.1	10.1*	9.06
Home garden participation	2.5***	1.9	3.7***	1.9	3.3***	2
Dependency ratio	0.04	0.07	0.19***	0.05	0.15**	0.08
No. off farm employment	1.06	0.75	1.6***	0.74	0.97**	0.55
Income	76362.5	74544.9	100916.3*	87018.8	81110.9	67920.5
Food expenditure (HUF)	26900.9	30522.1	40623	32894.9	26020.5	21520.3
Field owned and cultivated (m^2)	142127.4***	787.7	13735	8098.1	39414.2***	10688.2
Car	66.7%§§§	30.4%	61.5%	64.3%	46.9%	41%
Home garden area (m^2)	974.3***	450.2	2249.7**	1276.4	1609.7***	3075.7
Irrigation	36.9	35.8	45.2	46.5	18.4	16.4
Good quality soil	20.8%§§	15.6%	12.8%§§	7.1%	37.5%	28.6%
Sales per m^2 home garden in HUF	16.3***	2.2	0.6	9.9	15.4	40.2
Distance to the nearest food market	0	0	22.1*	20	18.7	18.2

Source: Hungarian Home Garden Diversity Household Survey, Hungarian On Farm Conservation of Agricultural Biodiversity Project, 2002.

[1]High probability is 75% or more; Pairwise t-tests show significant differences at less than ***1% significance level, **5% significance level and *10%significance level

Pearson Chi square tests show significant differences at less than §§§ 0.5% significance level, and §§ 1% significance level