DOES CROP DIVERSIFICATION PAY OFF?

AN EMPIRICAL STUDY IN HOMEGARDENS OF THE IBERIAN PENINSULA

Running title: Diversification and financial value of homegardens

Victoria Reyes-García[a*], Laura Calvet-Mir[b], Sara Vila[b,c], Laura Aceituno-Mata[b,d],

Teresa Garnatje[e], Juan José Lastra[c], Montserrat Parada[f],

Montserrat Rigat[f], Joan Vallès[f], Manuel Pardo-de-Santayana[d]

[a] Institució Catalana de Recerca i Estudis Avançats (ICREA) and Institut de Ciència i Tecnologia Ambientals, Universitat Autònoma de Barcelona, 08193 Bellaterra, Barcelona, Spain.
[b] Institut de Ciència i Tecnologia Ambientals, Universitat Autònoma de Barcelona, 08193 Bellatera, Barcelona, Spain.
[c] Departamento de Biología de Organismos y Sistemas, Universidad de Oviedo. Campus del Cristo, 33071 Oviedo, Spain.
[d] Departamento de Biología (Botánica), Universidad Autónoma de Madrid, C/ Darwin 2. Campus de Cantoblanco, 28049 Madrid, Spain.
[e] Institut Botànic de Barcelona (CSIC-ICUB), Passeig del Migdia s.n., Parc de Montjuïc, 08038 Barcelona, Catalonia, Spain.
[f] Laboratori de Botànica, Facultat de Farmàcia, Universitat de Barcelona, Av. Joan XXIII, s.n., 08028 Barcelona, Catalonia, Spain.

* *Corresponding author*:
Victoria Reyes-García
ICREA Professor
Institut de Ciència i Tecnologia Ambientals
Universitat Autònoma de Barcelona
08193 Bellaterra, Barcelona, Spain
Tel. + 34 (93) 586 8549
Fax: + 34 (93) 581 3331
E-mail: victoria.reyes@uab.cat

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Abstract: Because of its potential role in providing ecosystem services and private benefits (food security), the concern about the loss of agrobiodiversity has grown. We explore the links between agrobiodiversity and farm financial benefits in small-scale agroecosystems. We measured crop diversity in a subsistence-oriented agricultural production system: home gardens (n=250) in the Iberian Peninsula. We calculated the imputed market value of home gardens edible crops and estimated the association between agrobiodiversity and home gardens' gross financial value. Temperate home gardens harbour levels of agrobiodiversity comparable to those of tropical home gardens. Data suggest that an increase in crop diversity is associated with an increase in the gross financial value generated by home gardens. Our findings suggest that, in non-commercially oriented agricultural systems, there is a positive link between agrobiodiversity and financial benefits, highlighting the contribution of agrobiodiversity to the provision of private benefits.

Key words: agrobiodiversity; agroecosystems; ecosystem services, kitchen garden, Spain.

Introduction

The Convention on Biological Diversity (1992) defines agricultural biological diversity, or agrobiodiversity, as the variability among living organisms associated with the cultivation of crops and rearing of animals along with the ecological complexes of which they are part, such as soil microbes and fauna, weeds, herbivores, and carnivores in agroecosystems. Over the last years, the loss of agrobiodiversity has become a topic of increasing concern among researchers and policymakers for two main reasons. First, when considered at the landscape level, agrobiodiversity provides many ecosystem goods and services (Gollin and Smale 1999; Green et al. 2005; Pascual and Perrings

2007). For example, agrobiodiversity can play a critical role in the sustainability and conservation value of agricultural and wild ecosystems by providing important ecosystem services and functions. Research on the topic shows that more diverse agricultural landscapes contribute to *in situ* conservation of agricultural and wild genetic resources, recycling of nutrients, regulation of microclimate and local hydrological processes, suppression of undesirable organisms, and detoxification of noxious chemicals (Altieri 2004; Gliessman 1998; Jackson et al. 2007; Perfecto and Vandermeer 2008; Scales and Marsden 2008). Additional species in an ecosystem might also contribute to enhance pollination, integrated pest control, and rotational effects (Tscharntke et al. 2005).

Second, when considered at a small-scale level, agrobiodiversity has also been suggested to provide a variety of private goods, such as on-farm services and benefits that translate into higher levels of food security for households who depend on small-scale farming for subsistence (Altieri 2004; Frison et al. 2006; Thrupp 2000). Agrobiodiversity contributes to household security by ensuring the production of food for consumption, fiber, fuel, and income (Brush et al. 1995; Brush 2000; Reyes-García et al. 2008; Trinh et al. 2003; Watson and Eyzaguirre 2002). As a source of income, more diverse crop systems are more stable and subject to less variation than single crop systems, since different crops are unlikely to be affected to the same degree by adverse environmental shocks or fluctuations in prices (Bentley 1987; Morduch 1995; Perreault 2005; Zimmerer 1996). Thus, crop diversification has been explained as a rational decision by farmers aiming at diversifying their income sources in response to potential environmental and market-related shocks (Birol et al. 2006; Di Falco and Chavas 2009; Di Falco and Perrings 2005; Schläpfer et al. 2002; Smale and Aguirre 1998; Widawsky and Rozelle 1998). Furthermore, as a source of household consumption, crop diversification ensures the availability of micro-nutrients and vitamins, and therefore plays a critical role in the nutritional balance of human (Engels 2002) and animal (Rigat et al. 2009) diets.

Increased agrobiodiversity at the farm level also allows for an increase of household security and farm productivity because it often provides a variety of food and income sources that spread across the year, thus buffering households from seasonal harvest gaps (Aceituno-Mata 2010; Altieri 1999; Morduch 1995, 2002). In addition, staggered planting and harvesting allows farmers to reduce the costs for hiring labour, since this technique avoids peak-seasons, and can often be done predominantly using household labour. Last, there is also some evidence that more diverse crop systems might produce higher mean yields than single crop systems due to complementary and compensatory relations between crops (Tilman et al. 1996). More agrodiverse systems can make use of different species characteristics such as growth period, photosensitivity, and nutrient and water uptake, so that overall competition for resources is reduced and the resources available to each crop are more efficiently used both spatially and temporally (Bellon 1996). The potential for disease and insect tolerance gained through growing diverse crops can also lead to reduce crop pests (Altieri and Nicholls 2003; Tscharntke et al. 2005).

The evidence of the positive association between crop diversity and farm productivity comes from two strands of research. On the one side, agronomists have conducted experiments on research stations and farms (e.g. Tilman et al. 2006; Tscharntke et al. 2005). On the other side, applied economists have used survey data, either from cross-sectional (Di Falco and Chavas 2009) or panel (e.g. Di Falco et al. 2010; Smale et al. 1998; Widawsky and Rozelle 1998) studies. In this paper we contribute to this body of research by exploring the link between diversity in cropping systems and farm productivity using an innovative methodological approach. First, differently from research conducted by applied economists, we use observed, rather than self-reported, data on crop diversity. Second, contrarily to research conducted by agronomists, we measure crop diversity and abundance of edible crops from real (non-experimental) agricultural systems. Specifically, we measured crop abundance and diversity in a non-intensive, subsistence-oriented agricultural production system: temperate vegetable home gardens. We then calculated the market value imputed to edible crops present in home gardens to estimate the association between crop diversity and home garden productivity. Because of the reduced scale of our observation unit, the home garden, in this research we do not address the production of ecosystem goods and services that have previously been associated to agricultural landscapes (Green et al. 2005; Pascual and Perrings 2007), but centre the analysis on the private benefits of agrobiodiversity by looking at the relation the between diversity in cropping systems and farm productivity.

An important aspect of our study is the focus on temperate home gardens. Several studies have highlighted the high diversity of crop and wild species found in vegetable home gardens in tropical areas, suggesting that tropical home gardens constitute the agroecosystem with highest biodiversity (Swift and Anderson 1994), sometimes comparable to the diversity of natural ecosystems (Gajaseni and Gajaseni 1999; Scales and Marsden 2008). However, research on temperate home gardens is scarcer. Here we contribute to fill this regional gap.

The setting

We conducted research in three rural areas of the Iberian Peninsula: the Catalan Pyrenees, Central Asturias, and Sierra Norte de Madrid. The three areas of study are mountainous and therefore most agricultural activities were abandoned during the crisis of the Spanish rural agrarian society in the 1960s that led to the mechanization of farm activities in more productive areas and the abandonment of agriculture in marginal areas (Naredo 2004). Those changes, however, had an attenuated effect on home gardens, which persist nowadays as one of the most characteristic forms of agriculture in the three regions.

Previous work suggests that home gardens in the study areas are important in economic terms. Researchers have found that home gardens provide non-negligible financial gross income (Reyes-García et al. 2012). The average home garden in our sample produces fruits and vegetables worth 1 362 €/year. Since many tenders have more than one garden, the sum adds up to 1 691 €/year per tender, or the equivalent to three minimum monthly salaries in Spain. The gross value of vegetables (1 244 €/year/tender) is about three-fold the gross value of fruits (447€/year/tender). According to our data, about 60 % of the households in our sample consume most or all the products from their home gardens; around 55 % also give some products to family and friends, and only about 17 % of the people in the sample sell any product from the garden.

Previous work also shows that home gardens are also relevant in ecological terms as they harbor a large variety of species and varieties, both landraces and from commercial origin (Aceituno-Mata 2010; Calvet-Mir et al. 2011; Jesch 2009). For example, we have found 585 different taxa in home gardens in the area, most of them edible, but also used as spices, forage, ornamental, and medicinal plants (Reyes-García et al. 2010). Most gardeners kept a variety of landraces highly valued for their taste, smell, and gastronomic characteristics (Calvet-Mir et al. 2011).

Material and methods

A multidisciplinary team of social and natural scientists collected data during February-October 2008. Six researchers lived in the study sites during the period of data collection and used qualitative (i.e., participant observation, open-ended interviews) and quantitative (i.e., tender's survey, garden inventory) tools to collect data.

Definitions

We define home gardens as relatively small, cultivated plots devoted in whole or in part to the growing of vegetables, fruits, or herbs for household consumption (adapted from Kumar and Nair 2004). Following previous studies, we focus the analysis on *planned agrobiodiversity,* or the organisms directly incorporated into agroecosystems by farmers (Altieri 1999; Vandermeer and Perfecto 1995). However, we recognise that *planned agrobiodiversity* is only one aspect of biodiversity in agroecosystems, since home gardens may also be sites for conservation of wild plant diversity that can ultimately affect farmer's management (Agelet et al. 2000; Perrault-Archambault and Coomes 2008; Rigat et al. 2009, Vogl-Lukasser et al. 2010).

The sample

Data for this article comes from interviews with 201tenders managing 250 home gardens that were settled in 58 villages across three zones: 37 in the Catalan Pyrenees, 11 in Central Asturias, and 10 in the Sierra Norte de Madrid. In each area, we selected villages that were representative of the environmental and socioeconomic variability of the area. To capture variability between gardens in a village, we used a purposive sampling strategy including gardens grown using traditional and modern management methods. After we identified potential gardens for the study, we requested the voluntary participation of the primary garden tender, defined as the person who reportedly realized most of the work on the home garden and took most decisions about its management. Refusal to participate was low. In case of refusal, we substituted the initially selected garden for another in the same category.

Outcome variable: financial value of home gardens

To estimate the gross financial value of home gardens we followed four steps. First, we conducted a garden inventory including three visits to each garden. At the beginning of the sowing season, during our first visit, we requested the main gardener to accompany us to each of his/her home garden(s). We measured the dimensions of each garden (in m^2). We then asked the gardener to identify all the cultivated plants present in the home garden at the time of the visit. We recorded the local name and the main use (i.e., edible, medicinal, ornamental) of each plant species as reported by the gardener. We measured the cultivated surface of each crop present in the home garden, also in m^2. In the two subsequent visits we noted the presence and surface of crops not present during previous visits.

We determined the scientific names of the crops in the field or in the laboratory. We took pictures of all the species. We contrasted the pictures of those crops that we could not identify in the field with herbarium vouchers previously collected by the authors. We took vouchers of plants that could not be identified in the field or with the assistance of photos. Vouchers were identified and deposited in the herbarium of the Centre de Documentació de Biodiversitat Vegetal, Universitat de Barcelona (BCN), in the herbarium of the Departamento de Biología de Organismos y Sistemas, Universidad de Oviedo (FCO) or in the herbarium of the Real Jardín Botánico de Madrid, CSIC (MA). We identified crops at the species level and when possible at the subspecies or variety levels. We estimated crop productivity as the crop surface multiplied by the average productivity of the crop reported in the literature for the region (Agustí 2004; Carcelén-Fernández et al. 1988; Mainardi-Fazio 2006; Maroto-Borrego 1992; Navarro 2001).

Second, twice during field work, we visited three local markets in each of the study regions and recorded the unit price of fruits and vegetables found in sampled home gardens (2 times * 3 local markets * 3 areas= 18 prices/crop). Third, we calculated the gross financial value of each crop by multiplying the estimated productivity by the average retail price of the crop during the period of research. Finally, we defined the gross financial value of a home garden as the sum of the estimated value of all its edible crops with a market price.

Explanatory variables: richness and diversity indices

We followed an increasingly frequent approach in home garden research (Gajaseni and Gajaseni 1999; Kumar et al. 1994; Rico-Gray et al. 1990; Vogl et al. 2002; Wezel and Bender 2003) and computed indices of biological richness and diversity for all the gardens in our sample. We included edible and non-edible planted crops. Non-edible planted crops (i.e., medicinal, ornamental) were often found in field margins and hedgerows.

To calculate richness and diversity indices, during our visits to gardens we counted the number of individuals of each cultivated species present in the garden. When counting was not possible due to the small size of individual plants, we estimated the total amount of individuals by multiplying the total surface grown with a crop by the number of individuals in a small surface. We also estimated the number of individuals for species with vegetative reproduction. We used the taxonomic level of species to calculate three indices: 1) *Richness* defined as the total number of edible species in a home garden; 2) *Simpson's reciprocal index* or the degree that a community is dominated by one or a few very common species, using the reciprocal of the equation $C = \sum_{i=1}^{s} (p_i)^2$ where p_i is the proportion of individuals represented in each species in the sample (Major et al. 2005); and 3) *Shannon-Wiener diversity index* computed as $H = -\left[\sum_{i=1}^{s} (p_i)(\log p_i)\right]$ where p_i is the relative abundance (or proportion of occurrence) of the $_i^{th}$ species in a home garden (Gajaseni and Gajaseni 1999; Kehlenbeck and Maass 2005; Wezel and Bender 2003).

Richness, or the number of species on the home garden, is the simplest indicator of diversity, where a higher number of species is interpreted as higher richness. Thus, a garden with many different species is considered more diverse than one which grows only a few. The *Simpson* index captures skewness in the representation of species in the garden, i.e., high dominance means a few species are represented by many individuals, while other species are represented by only a few. This measure allows comparing gardens which grow the same number of species but which depend to various degrees on the relative contributions of each species to total production. Since we calculated the reciprocal of the *Simpson* index, higher values in our data should be interpreted as representing greater diversity. The *Shannon-Wiener's* index is a third more refined measure that captures the uniformity in the distribution of the number of individuals in each species, and thus it captures the relative abundance of each species according to the proportion it forms of the overall cropping pattern (Shaxson and Tauer 1992).

Control variables

Research has shown that individual (i.e., age, sex, education level) and household (i.e., household size) characteristics are primary drivers of plant agrobiodiversity in home gardens (Perrault-Archambault and Coomes 2008; Reyes-García et al. 2010). We collected information on those variables through a survey to the main garden manager lasting about 30 minutes. The survey included questions on individual attributes of the main gardener such as sex, age, education level, and years gardening. We also asked questions on household attributes, such as household size (or number of people living in the household at the moment of the interview), total number of gardens grown by the household, and estimated distance from the house to the garden.

Estimation strategy

We used multivariate analysis to estimate the association between the gross financial benefit of a home garden (the outcome variable) and its biological diversity (the explanatory variable). We modeled the association between financial benefits and diversity using the following expression:

[1]. $FB_{hv} = \alpha + \gamma D_{hv} + \lambda P_{ihv} + \zeta H_{hv} + \eta C_v + \varepsilon_{ihv}$

FB_{hv} stands for the gross financial benefit of edible crops in a home garden where *h* is the home garden and *v* the village. The expression D_{hv} is one of our three measures of species diversity on the same garden. We use P_{ihv} to stand for a vector of observed variables for the main home garden tender (e.g., age, sex, education), where *i* is the person. The term H_{hv} represents a vector of variables for the garden itself that affect its financial benefits and its richness (i.e., garden's area, distance to the house). C_v stands for a set of dummy variables to control for differences across the three areas of study that could directly affect a garden's financial benefit and crop diversity. Examples of such factors include regional prices and differences in geographical conditions. If species diversity reduces economic efficiency, we should see a negative association between a garden's financial benefit and its diversity, so γ should be negative.

To allow comparisons between home gardens of different size, we transformed both the financial value and our richness index to a per 100 m^2 basis (Kehlenbeck and Maass 2005). We took the logarithms of outcome and explanatory variables to stabilize variance and ease the interpretation of coefficients. We use the gross financial value because we could not collect reliable data on labour and physical inputs used in the production of edible crops. For all the calculations we used Stata for Windows, version 9.0 (StataCorp, College Station, Texas).

Results

Descriptive statistics

Table 1 contains definitions and summary statistics for the variables used in the regression analysis.

INSERT TABLE 1 ABOUT HERE

On average, edible crops in home gardens in our sample provide a gross financial value of 1 754 €/year, with a large variation between gardens (SD= 2 035). The minimum value found was of 52 €/year whereas the maximum value found was of 11 021 €/year. Home gardens in our sample had an average of 26.5 cultivated species (SD =15.9). One garden had only one species, whereas another garden had 70 different species. The average value for the Simpson reciprocal index was of 4.5 (SD=2.6) and the average value for the Shannon-Wiener diversity index was of 1.7 (SD=0.6). The three indexes had a normal distribution according to the results of a Shapiro-Wilk test.

The average age of the main home garden tender was 66.8 years, above the official retirement age of 65 years, with a range from 20 to 89 years. On average, informants had been gardening for 45 years. Sixty per cent of the reported main tenders in our sample were men. Sixty two per cent of the gardeners had only completed primary education and only about 13% had completed studies beyond secondary education. Home gardens in our sample had an average surface of 429 m^2 under cultivation (SD= 490) and were at a walking distance (mean=767 m) from the tender's house, although the variable house-to-garden distance showed a large variation (SD = 2 288).

Association between gross financial value and richness and diversity indices

Correlation coefficients of our measures of *gross financial value* and our richness and diversity indices were positive (data not shown). The correlation coefficients were relatively low (r ~ 0.4) but statistically significant (p<0.001).

When examining the association between the biological indexes and the gross financial value of a home garden through multivariate analysis, we also found that the three diversity indices bear a positive and statistically significant association with home garden's gross financial value (Table 2). For example, in column [a] we find that a 1% increase in the number of cultivated species in a garden (i.e., its richness) would increase its gross financial value in about 0.441% (p<0.001). That is, if we assume a linear relation between the variables, doubling the number of species in a garden (i.e., doubling its richness) would roughly be associated to an increase of 44% of the financial value of the home garden, or going from 1 754 €/year to about 2 512 €/year.

In column [b] we also see a positive and statistically significant association between the Simpson reciprocal index of species dominance and the gross financial value of a home garden. Specifically, a 1% increase in the Simpson reciprocal index would be associated to an increase of about 0.25% in the financial value of a home garden (p<0.001). Thus, doubling the Simpson reciprocal index would imply a 25% increase in the gross financial value of a home garden.

In column [c] we also see a positive and statistically significant association between the Shannon-Wiener diversity index and the gross financial value of home gardens. Specifically, a 1% increase in the Shannon-Wiener diversity index would be associated to an increase of about 0.29% in the financial value of a home garden ($p<0.001$). From the other variables used as controls in the regression models, only the number of gardens tended was consistently associated in a statistically significant way with the gross financial value. The association was, however, negative: the more gardens a tender owned, the lower the gross financial value of a given garden.

INSERT TABLE 2 ABOUT HERE

To test the robustness of our results, we ran several variations of the same model (Table 3). In row [2] we ran a similar regression model using the raw rather than the log transformed data. In row [3] we ran a model using absolute, rather than relative data, i.e., the total financial and biological values found in a home garden without transforming them to account for the garden's surface. In this model, we included the total area cultivated as a control. The model presented in row [4] resembles the model in row [3] except that the control included is the total area of the garden (including non cultivated surface). In the last model [5], we included a set of village dummies (in addition to the dummies for the study area). Results from the robustness analyses resemble results from the core model.

INSERT TABLE 3 ABOUT HERE

Discussion

We start the section addressing some methodological concerns before we discuss two interrelated findings.

Several methodological issues call for caution when considering results from research presented here. First, previous research has found that household assets

(Coomes and Ban 2004) and labor availability (Perrault-Archambault and Coomes 2008) influence the diversity of cultivated plants in home gardens. Informants' reluctance to talk about their economic status and the informal nature of home gardening in the area made it difficult for us to collect data on such variables, which are not included in our model. Failure to control for such variables in our model might bias results in unknown magnitude and direction.

A second methodological concern of this work relates to the measure of gardens' financial benefits as the gross financial value of edible crops, i.e., omitting labor and capital inputs used in production. Our own data suggest that the studied gardens have low capital, but high labor inputs. For example, 92.5% of the gardens in our sample mostly received organic fertilizers (ex., cow's manure), but 95.1% were weeded manually (Reyes-García et al. 2012). The omission of labor inputs in this labor-intensive agroecosystem opens the question of whether crop diversity and net benefits would follow the same association that crop diversity and gross benefits. Since most tenders of home garden in the sample were retired, when considering the importance of labor inputs in gardening, future research should assess the opportunity cost of labor for home garden tenders with different employment situations.

A last methodological concern of our results relates to the statistical model used. Recent ecological research suggests that, due to niche complementarity, increased plant species richness may have the largest effects on ecosystem processes at relatively low levels (Tilman et al. 2002), which implies that the association between species diversity and gardens financial benefit is probably not linear, as assumed in the regression model used. Future research should also address this topic.

Keeping those methodological issues in mind, we now turn the discussion to two interrelated substantive findings from our work related to the private benefits conferred by home gardens: their high agrobiodiversity and the positive association of agrobiodiversity and gross financial benefit.

Analyzing highly homogenized commercial agricultural systems, Perrings (2001) and Pascual and Perrings (2007) argued that farmer's decisions on what to grow are mediated by the institutional and economic environments, such as international agreements on agriculture and market prices of agricultural inputs and products. According to those authors, the current economic environment does not reward farmers with higher levels of crop genetic diversity (Perrings 2001), but rather favours a highly mechanized and homogenized agriculture through economic subsidies to farmers and the agricultural sector in general (Pearce 1999; Tilman et al. 2002). For example, if a farmer decides to grow a drought or disease resistant crop, that farmer will confer benefits to the rest of the society. However, since those benefits are not reflected in a higher price, the farmer does not have any incentive to grow that particular crop. Thus, in the commercial agricultural sector, the most profitable decision for the farmer would be to grow few commercial varieties, and not to invest in conservation of the varieties that are less favored by the market (Pascual and Perrings 2007).

Findings from this work indicate that the pattern is different in home gardens, as those agroecosystems harbour high levels of agrobiodiversity and -despite their small surface- have relatively important areas devoted to non-financially valuable crops. But why, in an otherwise highly homogenized agricultural landscape, farmers choose to diversify home gardens against the logic presented by Pascual and Perrings (2007)? We argue that, most likely, the answer to this question relates to the non-commercial character of home gardens' production. Because home gardens's agricultural production is mostly devoted to household consumption (Reyes-García et al. 2012), and not to the commercial sector, farmers decisions on what to grow might be less affected by the institutional and economic context. For example, our previous work highlights that cultural and social factors play an important role in farmers' decisions on what to grow in their home gardens (Calvet-Mir et al. 2012; Reyes-García et al. 2012). Specifically, we found that less than one third of the people in the sample argue that they keep a home garden because it provides economic benefits, whereas 74% of the respondents in our sample said that keeping a home garden was their pastime (Reyes-García et al. 2012). Similarly, research in the Catalan Pyrenees (Calvet-Mir et al. 2012) suggests that the main reasons to maintain local landraces are not economic. In particular people argued to conserve landraces because of taste and (perceived) nutritional value (37.5%), tradition and food security (25.0%), and ideological reasons, i.e., as an alternative to industrial agriculture (16.7%) (Calvet-Mir et al. 2012). The role of non-economic factors (i.e. aspects such as taste, psychological well-being, or marker of cultural identity) in determining farmers' decisions on what to grow in their home gardens deserves further research.

Despite the low importance that farmers seem to give to give to the financial benefits provided by home gardens, the second important finding of this work relates to the positive association between crop diversity and home gardens productivity. Specifically, we find that an increase in diversity of crop varieties in a home garden is associated with a not negligible increase in the gross financial value generated by the home garden. The result is robust to three standard diversity indices used (i.e., richness, Simpson, and Shannon-Wiener) and to the different variations in the econometric model. Furthermore, the result adds to the theoretical and empirical evidence provided by agronomists (Tilman et al. 2006; Tscharntke et al. 2005) and economists (Di Falco et al. 2010; Di Falco and Perrings 2003; Omer et al. 2007) on the relation between crop biodiversity and farm productivity. The finding suggests that, in addition to the cultural and social factors mentioned in the previous paragraphs, farmers who orient their agricultural production to household consumption, and are thus outside of the market incentives, might also have economic reasons to keep high levels of agricultural diversity. The finding is important because determining the costs and benefits associated to keeping additional species on farmer's fields might affect the design of strategies to protect on-farm conservation of agrobiodiversity.

Conclusion

In sum, our research indicates a) that home gardens have high levels of agrobiodiversity, and b) that the increase in diversity of crop varieties in a home garden is associated with an increase in the gross financial value generated by the home garden. Taken together those findings indicate that gardening is an adequate strategy to promote the maintenance of agrobiodiversity while ensuring food security.

Researchers have suggested two types of mechanisms to protect and promote biodiversity in agricultural systems. On the one side, and in response to the encouragement to signatory countries of the Biodiversity Convention and the International Treaty on Crop Genetic Resources to promote on-farm conservation of agrobiodiversity, some researchers have proposed market-based incentives to compensate farmers that maintain agrobiodiversity. Those incentives range from payments for ecosystem services, to direct compensation payments, or price premiums for local landraces (Krishna et al. 2010; Pascual and Perrings 2007). On the other side, and mostly focusing on tropical agroecosystems, other researchers have argued that because of their role on biodiversity conservation, tropical agroecosystems, rather than an antithesis of the natural world, deserve to be included in conservation strategies (Perfecto and Vandermeer 2008; Perfecto and Vandermeer 2010). The first type of incentives proposed to conserve on-farm agrobiodiversity are mostly oriented to commercial agricultural production, and are often difficult to translate to the non-commercial agricultural production. However, and given the high diversity found in temperate home gardens, including those agroecosystems in protective conservation strategies seems to be an adequate mechanism of protection.

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Table 1: Definition and descriptive statistics of variables used in the analyses

Variable	Definition	N	Mean	SD
Outcome				
Gross value	Gross financial value of edible crops in home gardens, in €/year	250	1754	2035
Explanatory, richness and diversity index				
Richness	Total number of species in a home garden	250	26.5	15.9
Simpson	Reciprocal of the Simpson's index of species dominance	250	4.5	2.6
Shannon-Wiener	Shannon-Wiener diversity index	250	1.7	0.6
Control				
Sown area	Total garden's surface, in m^2	250	429	490
Distance to the house	Estimated distance from the garden to the house, in m	250	767	2288
Age	Self reported age of the main garden tenders, in years	201	66.8	14.1
Years gardening	Self-reported number of years the informant has been gardening	201	45.2	23.3
Household size	Number of people living in the household at the moment of the interview	201	2.6	1.76
			%	
Male	Sex of the main tender, in percentage	201	60.2	
Education	No education	25	10.0	
	Primary	131	52.4	
	Secondary	61	24.4	
	Higher than secondary	33	13.2	

Table 2: OLS regressions of home garden's diversity indices against financial value (n=250)

	Garden's gross financial value, in logarithms		
	[a]	[b]	[c]
Richness (log)	.441*** (.063)	^	^
Simpson (log)	^	.249*** (.062)	^
Shannon-Wiener (log)	^	^	.287*** (.076)
Male	.182** (.087)	.153 (.098)	.157 (.100)
Age	-.002 (.005)	.001 (.006)	-.0006 (.006)
Years gardening	.006** (.002)	.004 (.003)	.005* (.002)
Education	.068 (.045)	.075 (.047)	.061 (.049)
Household size	.006 (.022)	.017 (.025)	.017 (.025)
Sown area	-.0002 (.0002)	-.0004** (.0001)	-.0003 (.0002)
Number of gardens	-.134* (.072)	-.210*** (.077)	-.193** (.082)
Distance to the house	<.0001 (<.0001)	<.0001 (<.0001)	<.0001 (<.0001)
R2	0.44	0.34	0.34

Regressions include clustering by subject and dummy variables for areas and a constant (not shown). Standard errors in parenthesis. *, **, and *** significant at ≤10%, ≤5%, and ≤1%.

Table 3: Robustness analyses

	Changes	Richness (log)	Simpson (log)	Shannon-Wiener (log)
[1]	Core model	.441*** (.063)	.249*** (.062)	.287*** (.076)
[2]	Raw data	.154** (.075)	.582** (.296)	2.27** (1.03)
[3]	Including control for total area	.441*** (.064)	.253*** (.062)	.292*** (.076)
[4]	Cluster area	.441*** (.022)	.249** (.039)	.287** (.053)
[5]	Including village dummies	.448*** (.004)	.285** (.045)	.332** (.072)

Regressions include clustering by subject and dummy variables for areas and a constant (not shown). *, **, and *** significant at ≤10%, ≤5%, and ≤1%.