Resilience of traditional knowledge systems:

The case of agricultural knowledge in home gardens of the Iberian Peninsula

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1. Introduction

Resilience has been defined as a system's ability to absorb change and endure while maintaining its essential structure, function, and feedbacks (Gunderson, 2003) and while remaining flexible in response to social and environmental changes (Redman and Kinzig, 2003). The concept of resilience has been mostly applied to analyze the capacity for renewal of ecological (Holling, 1973) or social-ecological (Folke, 2006) systems in the face of disturbance and change. A basic argument of the resilience approach is that, after each major social or environmental perturbation, the human-environment relation is altered, new knowledge develops, and a new balance is established (Berkes and Folke, 2002; Chapin et al., 2009). Therefore, the resilience of a social-ecological system largely depends on the capacity of the corpus of knowledge to learn by absorbing new information.

It is well acknowledged that in social-ecological systems with some basis of historical and intergenerational continuity in resource use management, people have developed knowledge of resource and ecosystem dynamics and associated management practices, or traditional ecological knowledge (Berkes et al., 2000). From the perspective of social-ecological systems, traditional ecological knowledge has been conceived as an evolving body of knowledge, practices and beliefs that develops over time from long-term observation and monitoring of the system functioning (Berkes et al., 2000), but also from learning with crises and mistakes (Berkes and Turner, 2006; Olsson and Folke, 2001). As other lay and local knowledge systems, traditional ecological knowledge is generally site specific in the sense that it is produced through economic and social interactions with the immediate environment and is dynamic and mutable (Kloppenburg, 1991). Therefore, traditional ecological knowledge contrasts with scientific knowledge, an "immutable mobile" (as coined by Latour, cited in Kloppenburg, 1991) mainly produced with the goal of being universal, transferable, mobile, and not tied to a singular place. But in contrast with other lay knowledge systems, the term "traditional ecological knowledge" emphasizes the historical continuity of such bodies of knowledge, not only their local embeddedness, a characteristic that seems to contribute to the long-term resilience of social-ecological systems by providing a pool of information and practices that improves societies' adaptive capacity to cope with recurrent environmental or social disturbances (Folke, 2004; Gómez-Baggethun et al., 2012; McIntosh et al., 2000).

Several researchers have emphasized that traditional knowledge systems should neither be considered static (Berkes et al., 2000; Gómez-Baggethun and Reyes-García, 2013), nor in isolation from other knowledge systems (Agrawal, 1995; Leonti, 2011; Leonti and Casu, 2013). Rather, traditional knowledge systems should be understood as being in constant change, in a dynamic process that encompasses a complex mix of knowledge replication, loss, addition, and transformation, in a type of process that anthropologists have noted to involve simultaneously "continuity and change" (Reenberg, et al., 2008). On the one side, traditional ecological knowledge draws from historical and intergenerational continuity in resource use management. On the other side, change in traditional knowledge systems can be triggered by multiple factors that include -but are not limited to- individuals' own learning and experimentation, adoption of new technologies, the production of new knowledge due to adaptation to new social or ecological conditions or the co-production of knowledge arising from the interactions with other knowledge systems, such as scientific knowledge.

In this research, we offer an exploration of the resilience of a traditional agricultural knowledge system. Specifically, we assess the ability of the traditional agricultural knowledge to continue to exist while absorbing changes, that is, its capacity to simultaneously evolve and persist in response to disturbance and change. After the presentation of the case study, we analyze the co-existence of agricultural information derived from two different knowledge systems: i) knowledge and use of landraces (representative of traditional agricultural knowledge) and ii) knowledge and use of commercial crop varieties (representative of modern agricultural knowledge). We then analyze the socio-demographic characteristics associated to the holders of those bodies of knowledge.

Our underlying hypothesis goes as follows. If the traditional agricultural knowledge system is not able to absorb change, then we should see either a) a displacement of traditional agricultural knowledge and practices by new knowledge, or b) the maintenance of the traditional agricultural knowledge, if people are not able or willing to incorporate new knowledge. In both cases, we would expect to observe a negative association between the two measures of agricultural knowledge and a concentration of one or the other type of knowledge in different segments of the population. If, on the contrary, the traditional agricultural system is capable of absorbing new information and adapting to change, then we should see that traditional and modern agricultural knowledge are not necessarily mutually exclusive. Our research is based on pockets of traditional agricultural knowledge held by gardeners in three different regions of the Iberian Peninsula.

2. Home gardens as pockets of social-ecological memory

As mentioned, traditional knowledge is an attribute of societies with historical and intergenerational continuity in resource use management. Although, by and large, traditional knowledge systems are mostly found in non-industrial societies, some traditional knowledge systems remain in rural areas of industrial societies (Aceituno-Mata, 2010; Beaufoy et al., 1994; Calvet-Mir et al., 2011; Emanuelsson, 2010; Negri, 2003). Barthel et al. (2010) call *pockets of social-ecological memory* those places that having captured, stored, and transmitted through time the knowledge and experience of managing a local ecosystem and its services, continue to maintain them alive despite drastic changes in the surrounding environments (see also Barthel and Isendahl, 2013; Barthel and Crumley, in press). For example, agricultural landscapes in Europe evolved through thousands of years of interactions between social and ecological systems, but changed drastically with the ubiquitous industrialization and mechanization of agriculture in the last century as well as with societal transformation more broadly (Emanuelsson, 2010). Despite this general change, some places still preserve locally evolved experiences of farming with historical continuity in management (Hernández-Morcillo et al., in press). Such pockets include agricultural systems in parts of Eastern Europe or in marginal lands such as areas with poor soils or areas in sloping terrains (Beaufoy et al., 1994; Emanuelsson, 2010; Eyzaguirre and Linares, 2004; Joffre et al., 1988; Negri, 2003). That is also the case of home gardens in mountain areas of the Iberian Peninsula.

Agriculture in Spain has been subject to deep transformations throughout history and especially since the 18th century (González de Molina and Sevilla-Guzmán, 1993), but many authors identify the 1960s as the tipping point when agriculture shifts most radically from a ‘traditional’ to a ‘modern’ (or industrial) agrarian mode of production based on the use of fossil fuels, chemicals, and machinery (Naredo, 2004). Changes in the long term agricultural tradition in the Iberian Peninsula were motivated by a new emphasis on exploitation efficiency in terms of physical and monetary yields and materialized in the simplification of agricultural systems, the introduction of new crops, and the mechanization of farm activities (Naredo, 2001), all of which have led to fundamental changes in traditional agricultural knowledge systems (see, e.g. Gómez-Baggethun et al., 2010). Spain's late entry in the European Union (EU), in 1986, and the adoption of the Common Agricultural Policy (started in 1957 in other parts of the EU) settled and reinforced transformations in agriculture and mainly in livestock activities (Lefebvre et al., 2012). At the landscape level, those changes generally resulted in the concentration of agricultural activities and the abandonment of traditional agricultural practices (Naredo, 2004; Beaufoy et al., 2012). At the social level, those changes generated a developmentalist mindset, which focused in commercial agriculture, downplayed subsistence agriculture and undervalued traditional knowledge and practices as old and useless (Entrena-Durán, 1998; Pardo-de-Santayana et al., 2010). Those changes fully affected the commercial agricultural sector and, to a lesser extent the agricultural production that remained devoted to self-consumption (Naredo, 2004), such as food production in home gardens, the focus of our study.

Our study was conducted in home gardens in three mountain areas of the Iberian Peninsula: the Catalan Pyrenees, Central Asturias, and Sierra Norte de Madrid (Figure 1). Specific descriptions of each study area can be found in previous work (Aceituno-Mata, 2010; Calvet-Mir et al., 2011; Reyes-García et al., 2012; Rigat et al., 2011). There are linguistic and cultural differences between the three areas, but an important commonality between them is the prevalence of slopes which make intensive and mechanized agriculture difficult. In the three areas, home gardens are still quite widespread and involve a significant number of people, both when considering their participation in gardening activities and the consumption of home gardens' products.

FIGURE 1

Home gardens are places of confluence of biological and cultural diversity, conceived for a small-scale and complementary food production. Previous research suggests that the studied home gardens provide a myriad of ecosystem services beyond food production, holding important ecological, socio-cultural and economic values (Calvet-Mir et al., 2012; Reyes-García et al., 2012). Compared to other agricultural sectors which have undergone drastic changes since the 1960s (Naredo, 2004), farming in home gardens continues to involve a high degree of manual labor and traditional management techniques. Thus, many gardeners in our study areas still use traditional tools like hoes, billhooks, and sickles; traditional irrigation systems like water canals, watering cans; and other traditional management practices such as manual weeding and pest removal. Moreover, home gardens still harbor landraces highly valued for their taste, smell, and gastronomic characteristics (Aceituno-Mata, 2010; Calvet-Mir et al., 2011).

However, research also suggests that home garden management has not remained static. Gardeners have responded to environmental, social, and economic changes in a myriad of ways. Some responses include experimentation with new technologies and practices. For example, although the overall degree of home garden's mechanization is low, in most of the studied gardens plowing is no longer done with mules, but with rotavators. Chemical pest control methods have also made their way into home gardens. Gardeners also experiment with new crop varieties and as a consequence seed saving seems increasingly restricted to a smaller number of crops (Calvet-Mir et al., 2011). Responses to change are also reflected in the household distribution of garden activities. For example, previous work suggests that social changes affecting patterns of employment in the region have led to changes in the gendered distribution of home garden tasks (Reyes-García et al., 2010).

In sum, agricultural knowledge related to the maintenance of home gardens presents an ideal case to study the resilience of a traditional agricultural knowledge system for at least two reasons. First, it presents a clear example of knowledge developed through historical and intergenerational continuity in resource use management. And second, it is embedded in a social-ecological system suffering rapid change.

3. Methods

3.1. Definitions

Since our aim is to analyze the level of co-existence of traditional and modern agricultural knowledge systems, the definition and operationalization of such knowledge systems is of paramount importance. We follow researchers who have analyzed the transformation of the Spanish agricultural sector (González de Molina and Sevilla-Guzmán, 1993; Naredo, 2004; Carpintero 2005) and differentiate between the 'traditional' and the 'modern' (or industrial) agrarian mode of production. By using the term 'traditional' agricultural knowledge, rather than 'local', we emphasize historical and intergenerational continuity in agricultural management. By using the term 'modern' agricultural knowledge, rather than 'scientific', we acknowledge that there is a large scientific agronomic literature, for example in agroecology, emphasizing the scientific base of many traditional practices (Altieri, 2004; Rist and Dahdouh-Guebas, 2006).

From the many aspects that could be considered an integral part of the agricultural knowledge system, we focus on knowledge and use of landraces (representative of traditional agricultural knowledge) and knowledge and use of commercial crop varieties (representative of modern agricultural knowledge). We define "landraces" as the annual and biennial crops that farmers have reproduced in the area of study for more than one generation (30 years). For crops with vegetative reproduction we use the criteria of two generations (60 years) (Calvet-Mir et al., 2011). We focus on annual and biennial crops excluding perennial trees, because we found that farmers are often unaware of the origin of trees in their fields. We set up the limit of 30 (or 60) years, as a minimum amount of time needed both to provide diachronic data to farmers growing a plant strain and to allow a plant strain to adapt to the local environmental conditions and management.

Traditional knowledge systems are integrated corpus of knowledge, practices, and beliefs that provide a holistic view of ecosystems (Toledo, 2002). We are aware that by restricting our analysis to knowledge and use of landraces, we do not capture the broader complexity of this holistic view. The approach, however, also has advantages. By focusing on one measurable aspect, we are able to compare the level of landrace knowledge with the level of commercial varieties knowledge. Furthermore, the approach allows for testing our ideas in a larger sample than wider or more in-depth approaches allow. Lastly, the approach also allows for the collection of cross-cultural comparative data, and therefore for a higher degree of generalization.

3.2. Sample

Our sampling strategy proceeded in two steps. We first selected a range of villages representing key features of the environmental and socioeconomic variability of the study areas. In a second phase, we identified all the active gardens in the selected villages. For each garden, we requested the voluntary participation of individuals involved in garden management to answer a survey. As the number of people undertaking gardening varied from household to household, in some households we interviewed one person and in other households we interviewed two persons. Our total sample includes 383 individuals, in 326 households, and 28 villages across the three study areas.

3.3. Data collection

A multidisciplinary team of social and natural scientists collected data during April 2008-October 2009 using ethnographic tools and a survey.

Ethnographic tools: Six researchers lived in one or another of the study sites participating in local life. The rest of the team, occasionally also collaborated in data collection. Participant observation allowed the understanding of the different activities and tasks around gardening by providing ample opportunities -other than during the formal interviews- to interact with gardeners and to discuss garden's progress and other issues such as cultural practices and their changes, products grown and their evolution, destination of these products, and economic implications of home gardening, among others. We also carried out semi-structured interviews with more than 90 elders (about 30 per study area) regarding traditional management of home gardens and changes on management techniques over the last decades. We selected people over 65 years of age, with a long history of living and cultivating a home garden in the study areas. Ethnographic information helped us to interpret quantitative results in a broader context.

Survey: Our survey had two sections. In the first section, we asked about socio-demographic characteristics of the person answering the survey (age, sex, maximum education level, years gardening, and length of residency in the village). The second section evaluated gardeners' knowledge of landraces and commercial varieties through a knowledge test. The test included 36 questions on six different crop varieties (36=6*6), of which three were landraces and three were commercial varieties. To increase variation in responses, we used our ethnographic information to select one well known, one relatively known, and one rare landrace in each site. We used the same criteria to select three commercial varieties. For each item we requested gardeners a) to identify the variety by showing them the seed (or other propagation material such as bulbs); b) to report whether they were growing this variety at the time of the interview, c) had grown it in previous years, d) or had it in storage; and e) to answer a question on the species management, and f) a question on species use. Questions on species management and use were constructed using ethnographic information collected among locally recognized experts. Because species and practices vary from one site to another, the knowledge tests were site-specific, although they all conformed to the same structure.

3.4. Data analysis

We used answers to the 18 questions on landraces to generate a score of *landrace knowledge* and answers to the 18 questions on commercial varieties to generate a score of *commercial varieties knowledge.* Specifically, we added a point to the respective score if the informant a) was able to identify the propagation material by providing the folk name of the strain, b) was growing it at the time of the interview, c) had grown the strain during previous years, d) or had the strain in storage, e) knew the specific management technique of the strain, and f) knew the characteristic use or preparation for that plant strain (6 questions*3 landraces=18 points). Answers to questions on landrace folk name, management, and use were considered as correct if they matched responses from 'local experts,' defined here as local inhabitants with long-term experience with traditional management of home gardens in the area (Davis and Wagner, 2003) and identified by residents during informal interviews. For commercial varieties, correct answers were extracted from agronomic literature (Maroto, 1992).

To assess the association between landraces and commercial varieties knowledge, we used both bivariate and multivariate analysis. We first ran a Spearman correlation of landraces against commercial varieties knowledge. We then ran a Poisson multivariate regression with *landrace knowledge* as outcome variable and *commercial varieties knowledge* as explanatory variable while controlling for confounding factors that research suggests might affect the distribution of traditional ecological knowledge (i.e., age, sex, years gardening, schooling, and years of residency).

To assess trends in the association between those two bodies of knowledge, we performed a hierarchical cluster analysis classifying interviewees according to their *landraces* and *commercial varieties* knowledge. We used the Ward's method as agglomerative technique. Then, we used Kruskal-Wallis and Chi-square tests to characterize the groups obtained with the hierarchical cluster analysis according to socio-cultural and demographic variables. For the statistical analysis we used STATA 11.1 for Windows (Stata Corporation, Texas, USA).

4. Results

4.1. Landraces and commercial varieties knowledge

Table 1 contains definitions and summary statistics of the variables used in the analyses. The average respondent obtained a similar score in landraces and commercial varieties knowledge, although variation was larger for landraces than for commercial varieties knowledge. Overall, from a range from 0 to 18, the landraces knowledge score had a mean of 7.71 (median= 8; mode= 10), and the commercial varieties knowledge score had a mean of 7.83 (median=8; mode=10).

TABLE 1

The survey sample included people between 17 and 100 years of age, but the average respondent was 66 years, above retirement age in Spain (65 years). Men accounted for 68% of survey respondents. About 51% of the interviewees had been or still were farmers at the moment of the survey. The average informant held a long experience in gardening (42.6 years), but there were large differences within the sample (SD=24 years). Twelve percent of people in the sample had no schooling and only 7% had a university degree. Only about 33% of our respondents conformed to what we named as "migrant", a category that included people who was not born in the study site, but rather who had migrated to it from a city, other rural areas, or other countries (Table 1).

4.2. Relation between landraces and commercial varieties knowledge

Bivariate analyses suggest that, overall, landraces and commercial varieties knowledge correlated in a positive and significant way ($p<0.001$) although the correlation coefficient was relatively low ($r = 0.40$). Figure 2 provides a visual representation of the association between landraces and commercial varieties knowledge.

FIGURE 2

Multivariate regressions of commercial varieties against landrace knowledge confirm the intuition of bivariate analysis: commercial varieties knowledge bears a positive and statistically significant association with landrace knowledge (Table 2). That is, when taking the sample as a whole and after we control for socio-economic characteristics of the informant, the higher the score of commercial varieties of a person, the higher his/her landrace knowledge.

Other traits presenting a positive association with landrace knowledge include being a woman, being a farmer, and the number of years the person has been gardening. Characteristics that present a negative and statistically significant association with landrace knowledge include higher levels of formal education and age, although for the variable age the magnitude of the coefficient is very small.

TABLE 2

Since our three study areas present important socio-cultural differences, we conducted the same analysis by study area (Table 2). The analysis by study areas confirms the statistically significant association between commercial varieties and landrace knowledge. In those analyses, all the variables previously commented maintain their sign in their association with landrace knowledge, although some loss their statistical significance. Thus, only two of the control variables included in our analyses maintain a statistically significant association with landrace knowledge across the three study areas: years of gardening and age.

4.3. Characterizing knowledge holders

The hierarchical cluster analysis based on answers to the questions on landraces and commercial varieties knowledge divided the sample in four distinct groups. Results of the Kruskal-Wallis and Chi-square tests analyzing differences between those groups suggest that there are statistically significant differences both regarding the landraces and commercial varieties knowledge (the grouping criteria in our cluster analysis) and also regarding the socio-demographic characteristics of group members.

The first group (Table 3, group A) is the largest (n=164) and includes informants with the highest levels of both landraces and commercial varieties knowledge. We name this group 'hybrid knowledge' group. Compared with the other two groups, people in the hybrid knowledge group is older and holds larger experience gardening. This group is mostly composed by informants who have been (or still are) farmers and who have spent most of their lives in the study areas. A last marked characteristic of the hybrid knowledge group is that, compared to the overall mean (Table 1), it concentrates a larger share of people with no schooling and a lower share of people with university degrees, although differences in education between groups are only statistically significant for people having primary education or university degree.

INSERT TABLE 3

The second group (Table 3, group B) includes informants (n=90) with relatively high levels of landrace knowledge (7.2) but relatively low levels of commercial varieties knowledge (4.7). We call this group 'traditional knowledge' group. Compared with informants in the hybrid knowledge group, fewer informants in the traditional knowledge group have farming experience, and fewer informants have lived most of their live in the study areas. It is also interesting to notice that the mean score in landrace knowledge is lower than in the hybrid group.

The third group (Table 3, group C) shows the opposite trends in knowledge: informants in this group show low landrace knowledge (3.6) and high commercial varieties knowledge (9.8). We call this group 'modern knowledge' group, but notice that the average score in modern knowledge is lower than for the 'hybrid knowledge' group. Compared to the other three groups, the average age of informants in the modern knowledge group is the lowest, as it is their gardening experience. This group also holds the largest share of migrant population from the four groups.

Our last group (Table 3, group D) is the smallest in number (n=40). This group includes informants with low levels of both landraces (1.9) and commercial varieties (2.7) knowledge. We call this group ‘limited knowledge’ group. Compared to the hybrid knowledge and traditional knowledge groups (but not in relation to the modern knowledge group), informants in the limited knowledge group had lower experience in gardening. This group is formed by a disproportionate number of men, in relation with the overall gender distribution of the sample. By the standards of the sampled population, people in the limited knowledge group also have higher levels of formal education.

5. **Discussion**

We organize the discussion around results corresponding to the two specific goals of this article: to analyze the co-existence of traditional and modern agricultural knowledge and to analyze the socio-demographic characteristics associated to those two bodies of knowledge. In the last section, we interpret those findings in the light of resilience theory.

5.1. The relation between landraces and commercial varieties knowledge

Our results show a positive association between traditional and modern agricultural knowledge, specifically landraces and modern varieties knowledge: overall and by study area those gardeners who are more knowledgeable about landraces are also more knowledgeable about commercial crop varieties. Several authors have previously documented similar trends regarding coexistence of traditional and modern agricultural knowledge and practice. For example, a consistent finding has been presented by Eyssartier et al. (2011) in a case study in Northwestern Patagonia, where local people maintained traditional practices on vegetable gardens but also adopted greenhouses, as those improved the conditions for certain crops. Likewise, though in a different domain of knowledge, Giovannini et al. (2011) document coexistence and complementarity of individual knowledge of medicinal plants and individual knowledge of pharmaceuticals among an indigenous population in Oaxaca, Mexico.

Our ethnographic information helps contextualize this finding. Gardeners mentioned that dietary changes and improvement in market accessibility have affected the composition of their gardens driving them to acquire new commercial varieties and develop associated knowledge. Before the 1960s, home gardens were essential for providing staple food for households. As a consequence high-carbohydrate-content crops like beans and potatoes were the most prevalent and diverse among home garden's crops (Aceituno-Mata, 2010). Dietary changes have resulted in a decrease in the volume of staple crops cultivated in gardens as well as in an increase in the diversity of cultivated vegetable species, including commercial varieties of species such as cauliflower, broccoli, spinach or radishes. Nevertheless, gardeners reported that they continue to grow landraces of their preferred staples, even if in a limited extent, as they prefer their taste in the preparation of traditional dishes. This combination keeps alive knowledge associated to both landraces and commercial varieties.

Gardeners have also acquired knowledge on commercial varieties for other reasons such as convenience or to complement the harvest provided by landraces. For example, in the Catalan Pyrenees some gardeners buy seedlings of tomatoes commercial varieties at the beginning of the planting season. Gardeners argue that those varieties are not as tasty as landraces, but that they are convenient. Since gardeners do not have the technical equipment (e.g., greenhouses) to start a seed bank during the winter, they depend on weather conditions to plant their own landraces. In this context, buying seedlings from commercial varieties comes handily, as those plants would ensure an early harvest. The incorporation of tomatoes commercial varieties -which, in addition are often more productive- allows them to have an earlier harvest, without necessarily renouncing to the tastier –but later- harvest provided by the tomatoes landraces. Similarly, gardeners in Sierra Norte de Madrid argue that in the past 50 years annual rainfall has decreased in this mountain area and that summers have become warmer and drier. The cucumber landrace cultivated in the area is adapted to cold summers but is very sensible to drought, becoming bitter under water stress. Consequently, in the last decades gardeners have started to cultivate a new commercial cucumber variety that does not become bitter under water stress. However, gardeners continue to cultivate the cucumber landrace, considered tastier. This adaptation strategy ensures a yield of non-bitter cucumber and, under good weather conditions, a yield of the tastier variety. The simultaneous use of landraces and commercial varieties fits well with the positive association found between knowledge of both agricultural systems.

In sum, our first finding suggests that gardeners in the sample neither seem to totally adhere to past management traditions by cultivating only landraces, nor seem to have completely abandoned them to fully substitute them with commercial varieties. Remember that the hybrid knowledge group, representing nearly half of the gardeners (Group A is 43% of the sample), are at the same time those who know more about landraces and modern varieties, simultaneously suggesting that both types of knowledge can complement one to each other. Landraces and commercial varieties knowledge seem to co-exist in a dynamic body of hybrid agricultural knowledge, representing an example of continuity and change (Reenberg, et al., 2008). It is possible that these characteristics are associated with gardeners' interests and inquisitive nature. Our field experience suggests that many gardeners experiment with new varieties or technologies while maintaining the landraces they like and the traditional technologies they are familiar with. Put it differently, for those who still maintain the activity of gardening, traditional knowledge persists but not in a frozen from. Rather, it is constantly evolving in response to changing environmental and socioeconomic conditions by incorporating new knowledge and adopting an increasingly hybrid character.

5.2. Trends in knowledge holders' groups

Despite these overall positive trends in traditional and modern agricultural knowledge, there are substantial differences in the bodies of knowledge held by different informants. Our analysis of groups of knowledge holders shows substantial complexity in the socio-cultural factors that define groups of knowledge holders, and it seems to contradict overall both the view expressed in standard research on the diffusion-of-innovation approach and the essentialist view of traditional systems of knowledge (see Gilles et al., 2013).

The literature on diffusion-of-innovations (a theory that seeks to explain how, why, and at what rate new ideas and technology spread through cultures) has explicitly analyzed the characteristics of people who adopt modern agricultural practices (Wejnert, 2002). This line of research is largely based on the assumptions that i) those who adopt modern agricultural practices will have a comparative economic advantage over those who do not adopt them (Saltiel et al., 1994) and that ii) adoption and non-adoption of modern practices are mutually exclusive, implying that everybody will eventually adopt the new practices on the risk to be out competed by others. Furthermore, according to Gilles et al. (2013), the idea that a person can adopt some innovations while maintaining a core body of traditional practices is often downplayed in the specialized literature. The bulk of this literature also suggests that later adopters of innovations are older, less educated, have less media exposure, more traditional values and live in more isolated communities than earlier adopters (see Wejnert, 2002 for a review).

While the diffusion-of-innovation approach conceives the disappearance of traditional agricultural practices as a natural consequence of agricultural modernization, the essentialist approach to traditional knowledge looks for the potential value of these practices, often assuming that place-based agricultural practices can be self-sustained and maintained in isolation from new systems of knowledge. This approach emphasizes the need to understand who conserves traditional knowledge and practices in the face of modern alternatives. Findings from this line of research indicate that farmers who cultivate landraces and maintain crop diversity tend to be older, have smaller farms, and less connection to markets than other farmers. This line of research has also negatively associated migration, market integration, and off-farm employment with landraces maintenance (Brush, 2004; Valdivia, 2004).

Findings from hierarchical cluster analysis of data provided by our informants contradict some of the basic assumptions underlying both of these views. According to our results of groups of knowledge holders, many informants –those in the hybrid knowledge group, the largest group in our analysis- hold high levels of both landrace and commercial varieties knowledge. This indicates that, as mentioned before, many of the informants have acquired substantial amounts of modern agricultural knowledge while maintaining the bulk of their traditional agricultural knowledge. Furthermore, the characteristics of the groups of knowledge holders identified do not seem to fit with the characteristics typically associated to either knowledge innovators or keepers of traditional knowledge. For example, around 30% of the informants in the hybrid and the traditional knowledge groups are migrants. Despite not being originative from the study areas, some migrants use landraces and have learned locally-developed garden management practices. Thus, the group of preservers of landraces is not restricted to old farmers who have lived their entire lives in the study areas, but it also includes migrant gardeners who see a diversity of values in those landraces and associated knowledge beyond merely economic or utilitarian practicalities.

In sum, results from our hierarchical cluster analysis challenge the idea that traditional and modern agricultural knowledge necessarily concentrate on different segments of the population.

5.3. Interpretation of research findings in the light of resilience theory

We started this work highlighting that the resilience of a social-ecological system depends to a large extent on the capacity of its corpus of knowledge to learn by absorbing new information in response to change, and by stressing the need to explore the capacity of traditional knowledge systems to absorb changes and continue to exist. There are three main caveats to our results. First, we are well aware that the analysis presented here only partially addresses the resilience of traditional knowledge systems. That is, we assess the ability of the traditional knowledge system to absorb changes and continue to exist, but our data do not allow us to test to what point the traditional knowledge system maintains its essential structure and function. Further research should address to what extent these traditional knowledge systems maintain or not their identity and functionality. Second, we are also aware that our measure provides only a reduced assessment of traditional knowledge systems. Our conclusion is drawn from the fact that informants seem to combine information from landraces and commercial varieties. But it might well be that innovations such as the use of new varieties are often quickly adopted because they can be more easily integrated into existing production systems, but the case might be different when analyzing practices that require deeper reorganizations of the production systems. Future research should analyze the co-existence of other aspects of modern and traditional knowledge systems. Third, our data pictures the situation on a point of time, from which we infer diachronic patterns.

Our findings, however, advance two important arguments about the potential of traditional knowledge systems to absorb change, and therefore to contribute to the overall resilience of a social-ecological system. First, according to resilience theory, integrating information from several knowledge systems would increase the resilience of the system by enlarging the range of available responses in the face of different disturbances or limiting factors (Gómez-Baggethun et al., 2012; Houde, 2007; Plummer and Armitage, 2007). Moreover, the resilience perspective holds that adaptive management to deal with complexity and uncertainty in social-ecological systems can benefit from the combination of diverse types of knowledge (Olsson et al., 2004). For example, co-management arrangements that allow the integration of different knowledge systems through collaboration between scientists and resource users can help build social and ecological resilience, as the complexity that arises from integrating different knowledge systems offers a chance to find innovate answers to old and new problems (Plummer and Armitage, 2007; Davidson-Hunt et al., in press). Gardener's explanations about the combination of landraces and commercial varieties and their associated knowledge in home gardens provide a good example of how the integration of information from two knowledge systems is perceived as beneficial by resource managers.

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Second, it is important to acknowledge that home gardens are quite distinctive agricultural systems in industrial Europe. Differently from most other agricultural systems, home gardens retain an important degree of autonomy and self-organizing capacity. This autonomy is given by the fact that home gardens are mainly devoted to household consumption and are often grown in leisure time, which make gardener less dependent on market dynamics and exogenous knowledge and technologies for decisions regarding home gardening. Gardeners' knowledge and management techniques should then be understood in a context in which maximizing productivity and profit is generally not the ultimate aim, which in turn implies that there are no economic penalties for failures in experimentation. Previous research claims that securing traditional knowledge's capacity to regenerate over time requires maintaining the autonomy and conditions that allow continuing developing, testing, and updating knowledge in the face of changing environmental and socioeconomic conditions (Gómez-Baggethun and Reyes-García, 2013).

6. Conclusion

Much has been written on how traditional knowledge systems may nurture resilience in ecological or social-ecological systems but far less is known on the resilience of traditional knowledge systems themselves. Our research on gardeners suggests that traditional knowledge systems can be dynamic and capable of incorporating new knowledge while at the same time maintaining the bulk of the accumulated body of knowledge in a process of continuity and change. Our results suggest that a) traditional knowledge is not a frozen and static corpus of knowledge and b) modern and traditional agricultural knowledge are not necessarily mutually exclusive. Both, the maintenance of some aspects of the traditional knowledge and the incorporation of some aspect of the modern knowledge seem to be core elements of gardeners' body of agricultural knowledge which is constantly evolving in response to changing environmental and socioeconomic conditions. Changes in traditional knowledge can be seen as a part of the general self-organizing process of this knowledge system.

The finding that traditional knowledge systems are dynamic and hybridize with other knowledge systems and technologies to face changing circumstances dovetails well with previous research (Agrawal, 1995; Berkes et al., 2000; Dove et al., 2007; Leonti, 2011; Gómez-Baggethun and Reyes-García, 2013; Leonti and Casu, 2013), but poses the question of whether the body of knowledge emerging from this dynamic process can indeed continue to be considered 'traditional'. We argue that this denomination is still valid in our case study, as our data show persistence of landraces knowledge and overlap between landraces and commercial varieties expertise. Our finding, however, should not conceal that under different circumstances hybridization may indeed led to the loss of traditional knowledge, if this is gradually replaced by modern knowledge (Gómez-Baggethun et al., in press). Further case studies on the interactions of traditional knowledge systems with other forms of knowledge, ideally using a diachronic perspective, could enrich the discussion on the resilience of traditional knowledge systems.

Figure captions

Figure 1. Location of the study areas

Figure 2. Traditional versus modern agricultural knowledge (n=380)

Table 1

Definition and summary statistics of variables used in regressions (n=383)

Variable	Definition	n	Mean	SD
Landraces knowledge	Responses to 6 questions on 3 landraces (3*6=18)	383	7.72	4.45
Commercial varieties knowledge	Responses to 6 questions on 3 commercial varieties (3*6=18)	383	7.83	3.85
Age	Age of the person, in years	383	66.1	13.79
Male	Dummy variable that captures the sex of the person interviewed, 1=male, 0=female	383	0.68	0.46
Farmer	Dummy variable that captures whether the person's main occupation is or has been farming.	383	0.51	0.50
Migrant	Dummy variable that captures whether the person comes from another region (=1) or whether she was born and has been resident of the study village for large periods (=0).	383	0.33	0.47
Years gardening	Number of years the person has been gardening	383	42.6	24.92
		N	%	
Schooling	No schooling	45	12.40	
	Primary school	176	48.48	
	Between primary school and university degree	117	32.23	
	University degree	25	6.89	

Table 2

Relation between traditional and modern agricultural knowledge (n=383).

	Total	*Asturias*	*Catalan Pyrenees*	*Sierra Norte de Madrid*
Commercial varieties knowledge	0.037	0.021	0.077	0.023
	(0.007)***	(0.011)**	(0.016)***	(0.012)**
Age	-0.006	-0.019	-0.006	-0.005
	(0.002)**	(0.009)**	(0.003)*	(0.003)*
Male	-0.137	-0.011	-0.142	-0.125
	(0.038)***	(0.062)	(0.070)**	(0.025)***
Farmer	0.130	0.183	0.200	0.021
	(0.064)**	(0.046)***	(0.080)**	(0.117)
Years gardening	0.008	0.019	0.007	0.008
	(0.002)***	(0.005)***	(0.002)***	(0.004)**
Migrant	-0.085	0.034	-0.072	-0.136
	(0.053)	(0.028)	(0.098)	(0.050)***
Schooling (reference category no education)				
Primary school	-0.068	0.153	0.029	-0.121
	(0.061)	(0.128)	(0.118)	(0.089)
Between primary and university	-0.227	0.087	-0.123	-0.275
	(0.083)***	(0.192)	(0.139)	(0.170)
University	-0.377	0.000	-0.047	-0.824
	(0.178)**	(0.000)	(0.180)	(0.588)
n	383	58	196	129

Note: For definition of variables see Table 1. Cells report regression coefficients with robust standard errors in parenthesis. * p<0.10; ** p<0.05, *** p<0.01. Regressions contain a set of dummy variables for the village of data collection and a constant (not shown).

Table 3

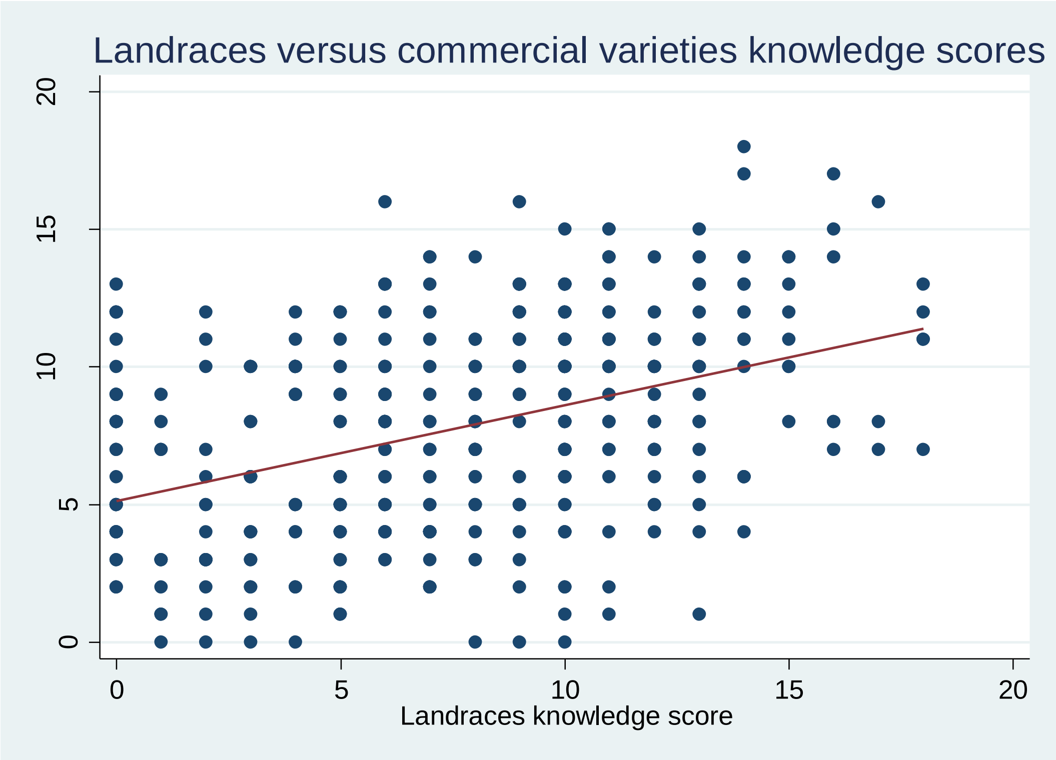
Characterization of respondents resulting from the hierarchical cluster analysis.

Variables		*$\chi 2$*	***p-value***	Group A	Group B	Group C	Group D
				Hybrid knowledge	Traditional knowledge	Modern knowledge	Limited knowledge
Landrace knowledge (average)		299.9	0.0001	11.7	7.2	3.6	1.9
Commercial varieties knowledge (average)		243.3	0.0001	10.2	4.7	9.8	2.7
Age (average)		12.4	0.006	66.2	65.6	58.8	64.6
Years gardening (average)		57.9	0.0001	50.7	45.5	25.2	36.4
Male (%)		13.6	0.004	63.4	62.2	68.7	89.7
Farmer (%)		31.9	0.0001	67.1	44.4	35.0	34.7
Migrant (%)		10.0	0.02	27.4	31.1	47.5	34.7
Schooling (%)	No schooling	5.2	0.16	14.8	7.7	10.2	6.3
	Primary school	10.0	0.02	48.7	62.2	38.8	41.8
	Between primary and university	2.0	0.57	30.8	24.4	34.7	31.6
	University	16.9	0.001	5.6	5.5	16.3	20.2
n				164	90	80	49

Figure 1


Central
Asturias
Vall
Fosca
Alt Ter
Catalan Pyrenees
Alt Empordà
Oviedo
Buitrago de
Lozoya
La Pobla
de Segur
Ripoll
Figueres
Barcelona
Madrid
Lisboa
Sierra Norte
de Madrid

Figure 2


Landraces versus commercial varieties knowledge scores
0
5
10
15
20
0
5
10
15
20
Landraces knowledge score

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