



Land transformation changes people's values of ecosystem services in Las Vegas agrarian landscapes of Madrid Spain

Irene Pérez-Ramírez^{a,d}, Juan Miguel Requena-Mullor^b, Antonio J. Castro^b, Marina García-Llorente^{a,c,*}

^a Social-Ecological Systems Laboratory, Department of Ecology, Universidad Autónoma de Madrid, Madrid, Spain

^b Biology and Geology Department, Andalusian Center for the Assessment and Monitoring of Global Change (CAESCG), University of Almería, Almería, Spain

^c FRACTAL Collective, Madrid, Spain

^d CENSE - Center for Environmental and Sustainability Research & CHANGE - Global Change and Sustainability Institute, NOVA School of Science and Technology, NOVA University Lisbon, Campus de Caparica, 2829-516 Caparica, Portugal

ARTICLE INFO

Keywords:

Industrial expansion
Land abandonment
Land use change trajectory
Land use legacy
Las Vegas agrarian district of Madrid
Resilience
Social perceptions
Urban expansion

ABSTRACT

Agrarian landscapes play a vital role in securing ecosystem services to people. These environments in central rural Spain are threatened by urban and industrial expansion, as expansion has and continues to cause the exile of young people to cities and rural abandonment. Land transformation in these environments not only alters the diversity of the services the ecosystems provide to people but may also change the values people hold on these landscapes. Incorporating people's perceptions regarding trade-offs and synergies associated with land transformation is thus key for designing land use policies that mitigate these impacts. The general objective of this research is to explore whether the values that people attribute to land use and ecosystem service changes can inform land-related decision-making. To do so, we first 1) characterized and mapped major land use change trajectories that occurred for the 1990–2018 period, 2) assessed social perceptions regarding the impacts of land use change trajectories on ecosystem services, 3) explored the vulnerability level of ecosystem services, and 4) assessed the social importance of ecosystem services for the wellbeing of locals. From the results, we identified three major land use change trajectories, including agricultural abandonment, aggregate industry and agricultural intensification. The results identified that agricultural abandonment is generally perceived to negatively impact food from agriculture, soil fertility, and maintenance of the gene pool through local varieties. We also found that agricultural intensification is recognized as negatively impacting the gene pool through local varieties and soil fertility. Our findings indicate the need to study the impacts of land use changes beyond biophysical changes, and link them to changes in people's values. We finally argue that this research will be crucial for identifying socially resilient pathways of European agricultural landscapes.

1. Introduction

Landscape transformations resulting from human activities affect the supply of ecosystem services and generate land conflicts and trade-offs among private interests, local populations and conservation goals (Quintas-Soriano et al., 2016; Wester-Herber, 2004) that result in diverse landscape configurations at multiple spatial scales (Verburg et al., 2010). Agrarian landscapes play a crucial role in providing food and food sovereignty, water, and other ecosystem services that are crucial for shaping territorial resilience (Ramankutty et al., 2018). However, the transformation of lands into agrarian landscapes that has

occurred over the past few decades has generated enormous and unprecedented pressures (Khouri et al., 2014; Nyström et al., 2019). Despite this knowledge, global agricultural systems have become increasingly homogenized over the last fifty years (Khouri et al., 2014; Nyström et al., 2019). The industrial agricultural system has focused exclusively on the production efficiency and intensification of the agri-food system (Foley et al., 2011; Tilman et al., 2001), while the importance of the ecological and cultural components of food production has been forgotten (MA 2005). On the one hand, homogeneity in agricultural expansion has led to the complete degradation of ecosystems (Chaplin-Kramer et al., 2015) by affecting the structural diversity

* Corresponding author at: Social-Ecological Systems Laboratory, Department of Ecology, Universidad Autónoma de Madrid, Madrid, Spain.

E-mail address: marina.glllorente@uam.es (M. García-Llorente).

<https://doi.org/10.1016/j.landusepol.2023.106921>

Received 6 August 2021; Received in revised form 8 August 2023; Accepted 17 September 2023

Available online 30 September 2023

0264-8377/© 2023 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC license (<http://creativecommons.org/licenses/by-nc/4.0/>).

of agroecosystems and motivating biodiversity loss (of both cultivated and noncultivated lands; O'Rourke et al., 2011). Additionally, agricultural intensification, which involves the use of chemical inputs, has led to soil depletion, water pollution, and overexploitation, as well as to losses of pollinators or agrobiodiversity, among other fundamental aspects of agroecosystem resilience (Karp et al., 2012; Tsiafouli et al., 2015).

Agrarian landscapes in rural central Spain have been modified by urban growth in large cities, industrial expansion, and landscape simplification; these changes have caused and continue to cause the exile of young people to cities and the abandonment of rural settings. These land transformations have not only altered the variety of ecosystem services these lands provide to local people but have also significantly influenced the value that people hold on these landscapes. Examples of ecosystem services include provisioning services (e.g., food from agriculture, forests and genetic materials (Maes et al., 2011), regulating ecosystem services (e.g., climate regulation, water regulation, pollination, and soil fertility) and cultural ecosystem services (e.g., aesthetic value, cultural heritage, recreation, and sense of place; García Llorente et al., 2012; Carvalho-Ribeiro et al., 2016; Pérez-Ramírez et al., 2019). Managing the trade-offs between ecosystem services (Turkelboom et al., 2017; Carmen et al., 2018; Jax et al., 2018) is thus crucial to understanding changes in values associated with ecosystem service gains or losses (Castro et al., 2011; Huang et al., 2020). From 1990–2018, our region of study, the Las Vegas agrarian district of Madrid, underwent land use changes that drove its development. For example, during the 1980s and 1990s, the conversion of corrals and orchards into vacation homes was remarkable. Irregular urban developments were also promoted on rural lands. These developments reduced the biodiversity of the region and increased the inflation of agricultural lands. Unique hydraulic infrastructures that characterized the region were also removed. In the Tajo basin, the hydraulic system of this fertile plain was modernized, allowing the development of large areas of intensively irrigated crops. The vega of the Tajuña was maintained as a smallholding, though the irrigation system has been poorly conserved and water shortages occur in the driest years.

Understanding how land use changes translate into changes in people's valuation of landscapes is key for designing new land management policies that integrate the complex interactions between people and nature and for identifying the drivers, feedbacks, emergent properties, and thresholds of these complex interactions (Folke, 2006; Berkes, 2009; Bridgewater and Rotherham, 2019). This interest has been captured by a growing body of literature that has focused on inter- and transdisciplinary work in real-world contexts (Martín-López et al., 2019; García-Llorente et al., 2020; Riechers et al., 2021). Such research is essential for fostering knowledge exchanges and advancing the need for science-policy interfaces to address the complex relationship between cultural values and decisions about land practices. In this sense, assessments of social demands for ecosystem services (i.e., individual perceptions; Martín-López et al., 2012) can help with this goal, as such assessments may reflect on the potential trade-offs between ecosystem services and the derived conflicts between people's values.

Methodological approaches that include sociocultural values in the management of agricultural landscapes have not yet been formalized (Castro et al., 2013; Kelemen et al., 2016). Land use-based typologies have proven to be useful in enabling land use decisions at a regional scale. However, more research that references the ways in which different land use change trajectories can influence multiple ecosystem services and applies approaches to explore how land use changes influence people's values is needed. To date, the utilized landscape approaches ignore the fundamental role that the land use legacy plays in understanding ecosystem service provisions; i.e., historical human-induced land use changes can result in legacy processes that influence ecosystem functioning and structure, biodiversity, and ecosystem services (Requena-Mullor et al., 2018). Thus, the typologies of eco-regions based on land use changes are characterized by a great

diversity of change trajectories that depend on the local conditions, regional context, and external influences (Verburg et al., 2010). As the drivers of land changes may exert different influences depending on the context and timing, analyses of land use dynamics must be specific to each region and incorporate the different change trajectories that occur at the same point in time. Moreover, including the social dimension in the analyses is crucial for fostering public collaborative governance (Ansell and Gash, 2008). For this purpose, academia can improve institutional collaborations from interdisciplinary work by combining biophysical methods with social methods (Lang et al., 2012; Balázs et al., 2019; Pérez-Ramírez et al., 2019).

This study occurs in a historical moment when multiple social, economic and environmental drivers are influencing the agrarian landscapes of rural Spain. At this point, rural abandonment and the intensification of agriculture have generated social and ecological changes reflected in the relationship between people and their natural environment. Specifically, we aim to address the following question: can the diverse values that people attribute to land use changes and ecosystem services inform land-related decision-making? Here, using a highly vulnerable agricultural region in the agrarian landscapes of Madrid (Spain) as a case study, we present a spatial modeling approach that 1) characterizes major land use change trajectories for the 1990–2018 period, 2) explores the social perceptions regarding the impacts of land use change trajectories on ecosystem services, 3) identifies ecosystem service vulnerabilities, and 4) explores the social importance of ecosystem services for the local population.

2. Material and methods

2.1. Study area: Las Vegas agrarian district of Madrid

Las Vegas is an agrarian and rural district in the southeastern Madrid region (Spain). The Tajo River and its tributaries (Jarama and Tajuña) cross this landscape (Fig. 1). The region has several protected areas classified as Sites of Community Importance (SCI) and Special Protection Areas for Birds (SPAB). This place has a high faunistic, floristic and geomorphological interest. There is a great amount of endemic flora, which gives this area a unique value. Some examples include tamarisk species (*Tamarix* spp.), riparian forests (*Ulmus* spp., *Populus* spp. and *Salix* spp.), subshrubs composing gypsiferous communities, the traditional La Mancha holm oak community, in which holm oaks (*Quercus ilex*) are scattered together with small kermes oak (*Quercus coccifera*), and numerous examples of marshy environments (*Phragmites* spp. and *Typha* spp.). Thus, the region harbors habitats of European interest in good conservation conditions. In total, there are 19 types of natural habitats of community interest, 4 of which are of priority interest, occupying an area of 8505 ha, representing 16.69% of this territory. This Protected Area includes 21 Natura 2000 Network Species (9 mammal species, 1 amphibian, 2 reptiles, 5 inland fish, 2 invertebrates and 2 plants), with only one plant species, *Lythrum flexuosum*, being a priority.

This agrarian region faces water-scarcity periods, along with water pollution that threatens the sustainability of the water supply system and environmental needs (Sondermann et al., 2022). The economy in this region has traditionally been based on farming and related agrifood industries. Currently, municipalities are highly aged, with a high rate of the population over 60 years old (16% of the population was between 60 and 64 years old in 2021; these data were extracted from the Statistical Institute of the Community of Madrid). The region can be presented as a bedroom community. However, due to its distance to the city of Madrid (approx. 52 km), it is possible to distribute and sell horticultural products from the area in the Spanish capital as a hopeful look into agro-ecological initiatives that use short marketing channels, as was done traditionally (Aracove, 2015). This proximity to a large city makes the Las Vegas agrarian district particularly vulnerable to land use intensification (i.e., the exploitation of land for extractive purposes, the implementation of renewable energy parks, or land consolidation with

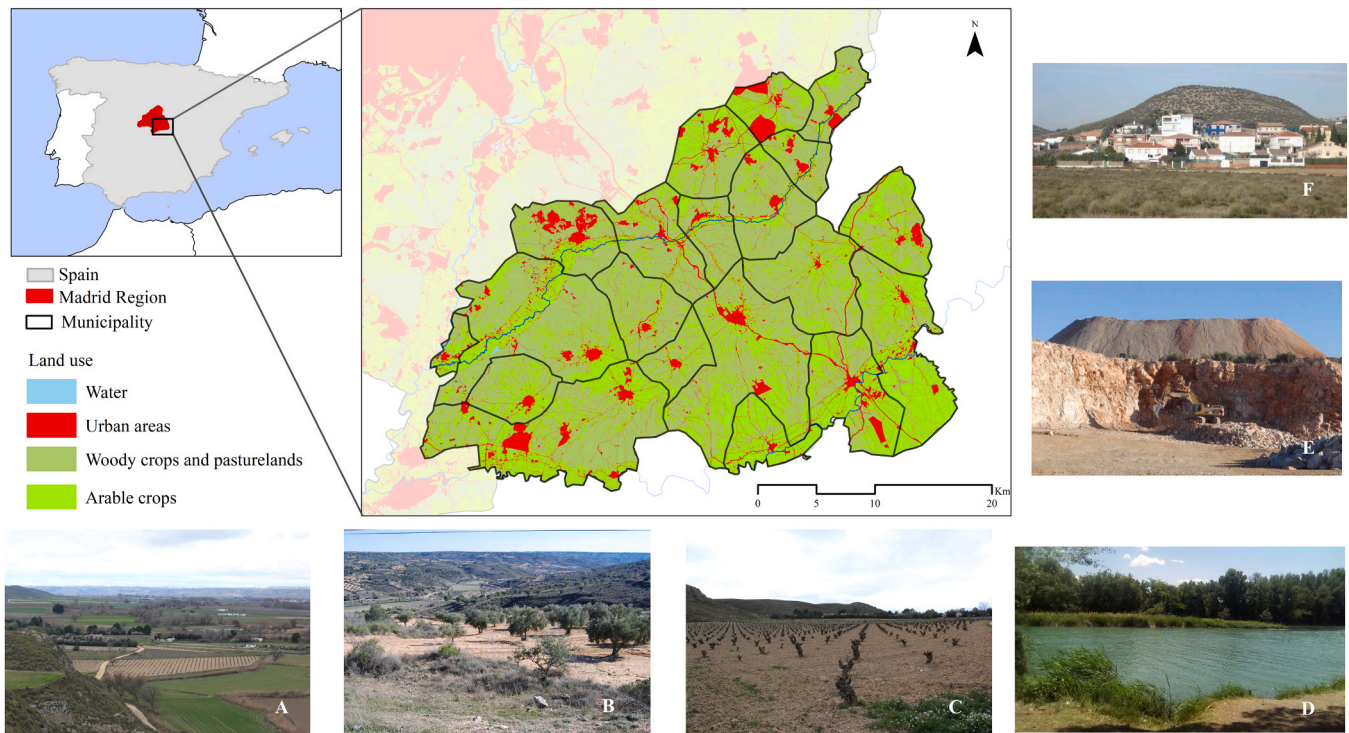


Fig. 1. Location of the study area, land use types in the Las Vegas agrarian district and main landscape units: A) moorland with crop mosaic; B) olive groves on the hills and banks of the Tajuña; C) vineyard cultivation on a moorland; D) natural riverbank vegetation area on the banks of the Tajo River; E) limestone extraction area; and F) urban development on a fertile plain.

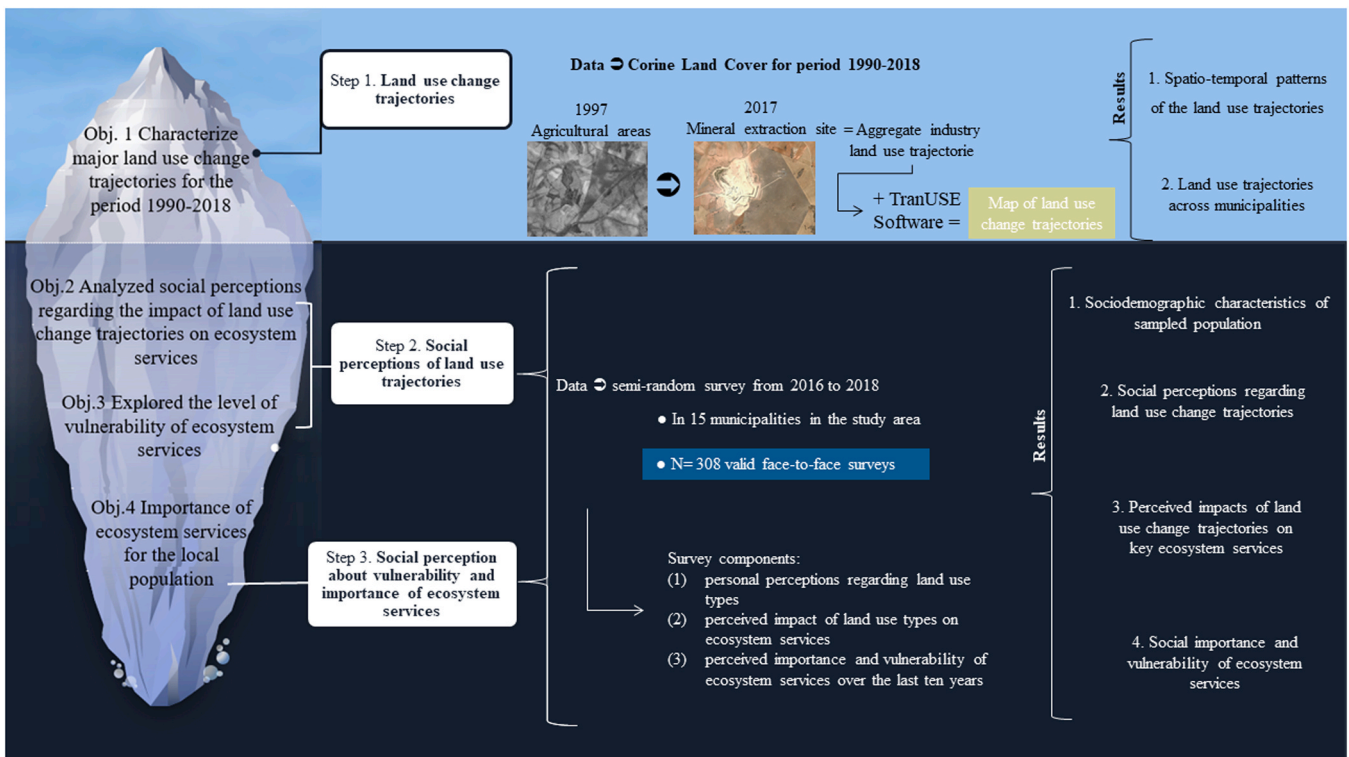


Fig. 2. Representation of the methodological framework followed in the research, including both spatial and social methodologies. The visible part of the iceberg shows the methodology used to evaluate the land use trajectories. The invisible part of the iceberg explains the methodology followed to conduct surveys of the local population.

the aim of agricultural intensification). Currently, the dominant land uses in this area include industries, intensive agriculture, and agricultural abandonment (Moreno, 1992).

2.2. Methodological approach

The methodological approach is interdisciplinary and is based on a mixture of methods that combine qualitative and quantitative research to gain an in-depth understanding of socioecological dynamics (Fig. 2). The approach includes three steps aligned with the specific objectives.

2.2.1. Step 1: land cover data and land use change trajectories

This step responds to objective 1 (i.e., it characterizes the major land use change trajectories during the 1990–2018 period). This objective aims to incorporate knowledge about land use legacies in our study region. We followed the approach proposed by Requena-Mullor et al. (2018) by defining a land use legacy as the effects of past land use on ecosystem processes that propagate until the present day.

For this purpose, we characterized and analyzed the land use trajectories in the study area (Fig. 2) using tranUSE software in three previously defined subbasins: the Tajuña subbasin, the Inner area, and the Tajo subbasin (Table 1). Here, land use trajectories are understood as the sequence of changes corresponding to a given sampling unit and time period (Lambin 1997). First, we selected the most dominant trajectories that occurred in the region and were identified in previous research (Rodríguez et al., 1987; Pérez-Ramírez et al., 2019). Second, we used the Corine Land Cover (CLC) database to define the trajectories

Table 1

Description of the three eco-regions, including the number of municipalities, brief description of the landscape types, number of inhabitants and average GDP in 2018 of each eco-region.

	Municipalities	Main landscape components	GDP	No. of inhabitants
Tajuña subbasin	Ambite	Plain area without automated irrigation.	16.3	28,672
	Carabaña			
	Chinchón			
	Morata de Tajuña	Particular small or medium cultural extension.		
	Orusco de Tajuña	Main crops, irrigated		
	Perales de Tajuña	cereals, self-consumption		
	Tielmes	orchards, small ecological		
	Titulcia	agriculture projects.		
	Valdilecha	Olive groves and vineyards in the dry area.		
	Villar del Olmo			
	Valdelaguna			
Inner area	Belmonte de Tajo	Cultivated land irrigated with aquifers without large extensions. Dry	17.0	13,709
	Brea de Tajo	crops, large extensions of olive groves, vines and <i>Cucurbitaceae</i> spp.		
	Valdaracete			
	Villaconejos			
	Villarejo de Salvanes			
Tajo subbasin	Colmenar de Oreja	Plain area with automated irrigation.	17.4	11,822
	Estremera	Particular great extensions of cultivated lands.		
	Fuentiduena de Tajo	Main crops, cereals, <i>Liliaceae</i> spp., <i>Cucurbitaceae</i> spp. and <i>Solanaceae</i> spp. in areas with extensive irrigation.		
	Villamanrique de Tajo	Olive groves and vineyards in the dry area.		

for the 1990–2018 period (<https://land.copernicus.eu/pan-european/corine-land-cover>). The CLC database has a thematic and geometric accuracy of 85% and has been widely used to detect and quantify land use changes at multiple spatiotemporal scales (Kucsicsa et al., 2019). CLC is a pan-European land coverage map for the entire EU territory (1:100,000 and a minimum mapping unit of 25 ha). The CLC inventory was initiated in 1985 (reference year 1990). The approximately three-decade time span covered by the CLC dataset allows us to track land use changes and define land use trajectories as a function of these changes.

Five land use trajectories were identified: agricultural abandonment, aggregate industry, agricultural intensification, soil restoration and protection, and urban growth (Table 2). Then, we imported the CLC data into TranUSE software. We used tranUSE software to spatially compute the five land use trajectories corresponding to the different municipalities. TranUSE is a free Java multiplatform software that allows spatial interpretations of land use/land cover changes from trajectories previously defined by the user (Requena-Mullor et al., 2014). The tranUSE algorithm compares land use/land cover types patch-by-patch between two dates and assigns the corresponding trajectory previously defined by the user (Requena-Mullor et al., 2014). Here, we used tranUSE to compare the 1990 and 2018 CLC layers, taking into account the defined trajectories. Through this method, we obtained a map of land use trajectories for the 1990–2018 period.

Then, the land use trajectory similarities among municipalities in the study area were analyzed by using Nonparametric Multidimensional Scaling (NMDS) through the ‘vegan’ R package (Oksanen et al., 2019). The municipalities of the Las Vegas agrarian district were arranged on a Cartesian axis according to the percentage of area occupied by each land use trajectory. We used the Mahalanobis distance to consider the potential correlations between the variables used in the ordination. A shorter distance between municipalities indicates a greater land use change similarity. In addition, we fitted municipalities’ gross national product to the ordination using penalized splines (Oksanen et al., 2019). We used Kruskal’s stress test (Kruskal, 1964) to check the goodness of fit of the NMDS. Kruskal’s stress test measures the agreement in the rank order of the interstate distances observed and those predicted from the similarities. According to Clarke’s (1993) guidelines for stress values, values lower than 0.3 indicate that the arrangement reached is better than one obtained randomly.

2.2.2. Steps 2 and 3: social perceptions of land use trajectories and ecosystem services

These two steps are focused on analyzing the social perceptions regarding land use trajectories and ecosystem services. The overall aims of these steps were to develop a consultative process with the local population that would allow analyzing social perceptions regarding the impacts of land use trajectories on ecosystem services (objective 2), to explore the vulnerability levels of ecosystem services (objective 3) and to determine the importance of ecosystem services to the local population (objective 4). These objectives were addressed by conducting a semirandom sampling strategy from 2016 to 2018. A total of $n = 308$ valid face-to-face semis-structured surveys were collected across 15 different sampling locations in the study area (22 municipalities).

The surveys included different sections. Step 2 was designed by obtaining the section-specific (1) personal perceptions regarding land use trajectories and (2) perceived impacts of land use trajectories on ecosystem services. We carried out the analysis of perceptions regarding land use trajectories by asking respondents whether they were for or against each land use type (Quintas-Soriano et al., 2016) and asking for a maximum of four ecosystem services, including two that were positively impacted by land use scenarios and two that were negatively impacted. Respondents had the option of not choosing any option (Quintas-Soriano et al., 2016; Sherren and Verstraten, 2013) to allow answers to be collected when respondents did not have a clear opinion, as we considered these responses to be equally important.

Table 2

Land use trajectories computed in the study area between 1990 and 2018.

			Example	
Land use trajectory	Land use in 1990	Land use in 2018	From	To
Agricultural abandonment	Agricultural areas	Forests and seminatural areas	Vineyards	Scrublands
Aggregate industry	Any land use type	Mineral extraction sites	Heterogeneous agricultural areas	Mineral extraction sites
Agricultural intensification	Complex cultivation patterns	Intensive crops	Annual crops associated with permanent crops	Permanently irrigated land
Land restoration and protection	Any land use type (except agricultural areas)	Forests and seminatural areas	Aggregate industry	Spaces with scarce vegetation
Urban growth	Any land use type	Urban areas	Agro-forestry areas	Urban green areas

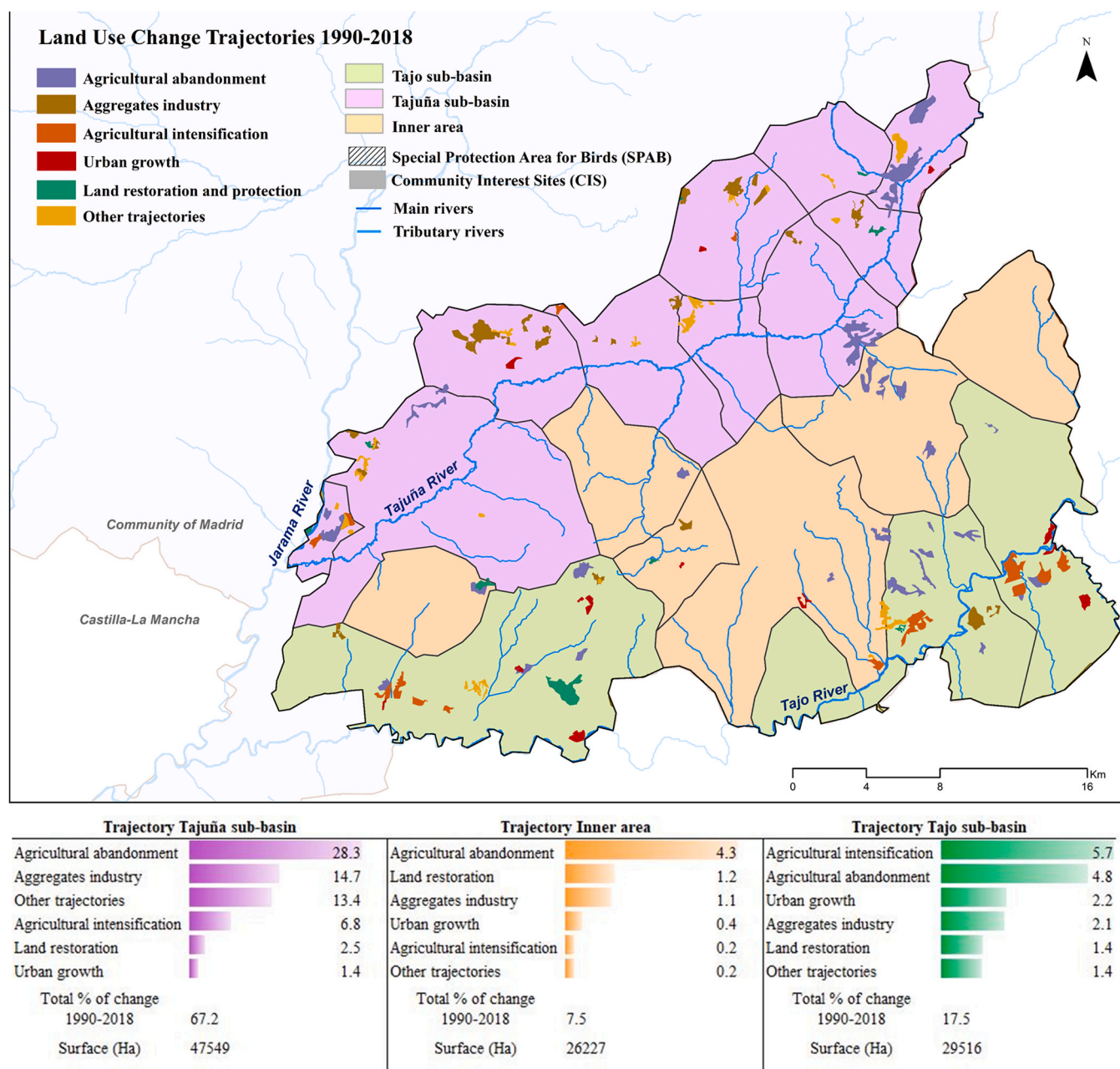


Fig. 3. Land use trajectories from 1990 to 2018 in the Las Vegas rural and agrarian district in the Madrid Region, Central Spain. Specific eco-regions of the Tajuñasubbasin (purple color), Inner area (orange color) and Tajo subbasin (green color), Special Protection Area for Birds (SPAB), Community Interest Sites (CIS) and main rivers are shown.

Step 3 was designed through Section (3), aiming to address the perceived importance and vulnerability (i.e., increasing, stable or decreasing trend) of ecosystem services over the last ten years. We asked if the respondents believed that the provision of selected ecosystem services had increased, decreased or remained the same (based on Castro et al., 2016; Quintas-Soriano et al., 2016). The list of ecosystem services was obtained from the classification scheme used in the proposed international classification of ecosystem services (CICES; www.cices.eu; Haines-Young and Potschin, 2013). Ecosystem services included food from agriculture, the gathering of wild foods, and mineral materials as provisioning ecosystem services; clean quality air, pollination, and soil fertility as regulating ecosystem services; and entertainment, leisure and tourism, peace, relaxation and spiritual enrichment as cultural ecosystem services. Panels with photographs were used to facilitate respondents' understanding of these ecosystem services. Surveys were conducted individually with each stakeholder in a quiet place that invited conversation and avoided the use of technical terms.

We performed all statistical analyses with the XLSTAT 2010 software package. To address the social perceptions regarding land use trajectories (objective 1), we used the percentages of responses regarding the most important land use types in the three eco-regions, and through the Kruskal–Wallis nonparametric statistical test, we explored the differences in perceptions regarding land use trajectories. In addition, the data were analyzed with a multiple correspondence analysis (ACM) of respondent motivations for or against land use trajectories with the percentages obtained for each region. To explore the perceived impacts of land use trajectories on ecosystem services (objective 2), we employed the percentage of perceived impacts of land use trajectories on ecosystem services across the three eco-regions. We used diagrams to compare the positive and negative impacts of each land use change trajectory type on the provision of ecosystem services. Finally, to perceive the vulnerability and social importance of ecosystem services (objectives 3 and 4), we used the percentage of social importance and perceived trends of ecosystem services over the last ten years. For this, we used a diagram adapted from the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).

3. Results

3.1. Spatiotemporal patterns of land use trajectories

The analysis carried out using tranUSE software yielded an overall low land transformation trend in the studied period. We found that the dominant land use trajectories that occurred between 1990 and 2000 were agricultural abandonment (37% of total surface), aggregate industry (21%), and agricultural intensification (15%); these were the dominant land use trajectories across the analyzed municipalities (Fig. 3). Agricultural abandonment was dominant in the Tajuña and the Inner area, while agricultural intensification was dominant in the Tajo subbasin (Fig. 3). Additionally, the other land use trajectories with lower incidence levels were urban development (7%) and land restoration and protection (7%).

In the Tajuña subbasin (Fig. 3), the most dominant land use trajectories were agricultural abandonment (28.3% of land change) and the expansion of aggregate industry (14.7%). The same land use trajectories were found in the adjacent lands. In the inner area, we observed the predominance of agricultural abandonment followed by land restoration and protection. Finally, in the Tajo subbasin, we observed agricultural intensification and abandonment as the most dominant land use trajectories.

3.2. Distribution of land use trajectories across municipalities of the Las Vegas agrarian district of Madrid

All municipalities were optimally arranged according to the percentages of the land surface occupied by the land use trajectories

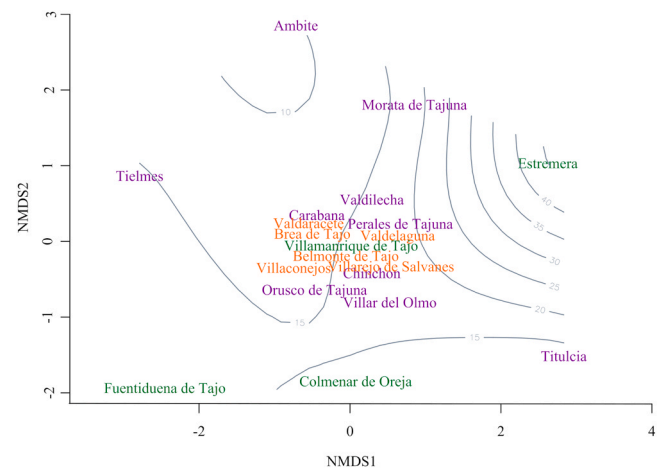


Fig. 4. Nonparametric multidimensional scaling (NMDS) results derived using Mahalanobis dissimilarity. Axes show the distance ranges between municipalities. The municipalities were arranged so that the distances between them were as close as possible to the observed differences between the percentages of the area occupied by the land use trajectories (see Table 2). A shorter distance between municipalities indicates greater similarity between them, whereas a longer distance corresponds to greater dissimilarity. The colors of the municipalities correspond to the subbasins (Tajuña subbasin: purple color, Inner area: orange color, and Tajo subbasin: green color). The gross national product was fitted to the ordination using contour lines with penalized splines ($R^2(\text{adj}) = 74\%$).

(Kruskal's stress $0.17 < 0.3$). The spatial configuration of the municipalities reached by the NMDS analysis (Fig. 4) suggested that although most of the municipalities shared similar land use trajectory percentages (the municipalities are grouped around the origin (0,0) in Fig. 4), seven municipalities belonging to the Tajuña and Tajo subbasins showed different land use change records. The land use trajectories that best characterized the municipalities from the Tajuña subbasin were agricultural intensification in Tielmes (3%), agricultural abandonment in Ambite (12.7%), aggregate industry in Morata de Tajuña (5.9%), and disparate land use trajectories in Titulcia (21.7%). Regarding the GDPs of these municipalities, Tielmes, Ambite and Titulcia showed similar average GDPs (10,000–15,000 €), while the GDP was higher in Morata de Tajuña (20,000 €; Fig. 4). In the Tajo subbasin, we found three municipalities with dissimilar land use trajectory percentages. In the village of Fuentidueña de Tajo, agricultural intensification and agricultural abandonment occupied 1.7% and 3.2% of the area, respectively. Among the multiple land use trajectories that occurred in Colmenar de Oreja, land restoration and protection were the most important, together having a percentage of 1.2%, while agricultural intensification occupied 3.1% in Estremera, the municipality with the highest GDP ($> 50,000$ €). Finally, the rest of the municipalities, including those in the Inner area, had similar land use trajectory percentages and average GDPs of 15,000–20,000 €.

3.3. Sociodemographic characteristics of the population of the Las Vegas agrarian district of Madrid

On average, most respondents had been living in the region for approximately 30 years. The mean age of the respondents was 43.4 years, and the respondents were equally distributed between males (57.8%) and females (42.2%; 95% CI: $\pm 5.5\%$). Most of the respondents had a professional or university-level education (52.4%; 95% CI: $\pm 5.6\%$), and only 28% (95% CI: $\pm 5.0\%$) were employed full-time. Their professional activities were related to commercial (14.3%; 95% CI: $\pm 4.0\%$), administrative and auxiliary services (11.7%; 95% CI: $\pm 3.6\%$) and the agricultural industry (11.0%; 95% CI: $\pm 3.5\%$). We found that all respondents presented an active interest in nature and its

conservation, and 52% (95% CI: $\pm 5.6\%$) of the respondents expressed a connection to the agricultural landscape since they owned or leased agricultural lands.

3.4. Social perceptions regarding land use trajectories

Most respondents were in favor of promoting land restoration and protection (86%; 95% CI: $\pm 4.3\%$), rejected agricultural abandonment (90%; 95% CI: $\pm 3.7\%$) and did not report a position in favor of the expansion of the aggregate industry (23%; 95% CI: $\pm 5.2\%$) or urban growth (21%; 95% CI: $\pm 5.1\%$; Fig. 5). With regard to respondents' overall attitudes toward land use changes that occurred in the three eco-regions, we found significant differences in terms of the aggregate industry (Kruskal–Wallis; $K=6.9$; p value < 0.03). Additionally, we found significant differences in terms of agricultural intensification (Kruskal–Wallis; $K=26.2$; p value < 0.0001 ; Fig. 5), which was particularly supported in the Tajo subbasin (74%; 95% CI: $\pm 5.5\%$).

The MCA identified five groups of respondents in terms of their attitudes toward land use trajectories (Fig. 6). One group clustered around a discourse against the expansion of the aggregate industry, urban growth, and agricultural intensification; this group lived mainly in the Tajuña subbasin (51.6% (95% CI: $\pm 6.2\%$); 44.4% (95% CI: $\pm 6.2\%$); and 41.3% (95% CI: $\pm 6.1\%$), respectively). Another group showed a positive attitude toward agricultural intensification, urban growth and aggregate industry and lived mainly in the Inner area (52.0% (95% CI: $\pm 6.2\%$); 46.2% (95% CI: $\pm 6.2\%$); and 40.4% (95% CI: $\pm 6.1\%$), respectively) and the Tajo subbasins (74% (95% CI: $\pm 5.5\%$); 42.0% (95% CI: $\pm 6.2\%$); and 39.1% (95% CI: $\pm 6.1\%$), respectively). Finally, we found a group that was in favor of promoting land restoration and protection areas and against agricultural abandonment. Respondents in the Tajuña subbasin showed a less clear positioning in favor or against the various land use trajectory types.

3.5. Impacts of land use trajectories on ecosystem services values

The results indicated that respondents clearly perceived agricultural abandonment as having a negative impact on food provision from

agriculture (66%; 95% CI: $\pm 5.7\%$), soil fertility (18%; 95% CI: $\pm 4.7\%$), and the maintenance of the gene pool through local varieties (7%; 95% CI: $\pm 3.1\%$); Fig. 7). In contrast, agricultural abandonment was perceived to have a positive impact on wild foods (11%; 95% CI: $\pm 3.8\%$), entertainment, leisure, and tourism (8%; 95% CI: $\pm 3.3\%$). Similarly, respondents recognized the negative impact that agricultural intensification may produce on the gene pool through local varieties (28%; 95% CI: $\pm 5.4\%$) and soil fertility (18%; 95% CI: $\pm 4.7\%$), whereas the responses regarding food from agriculture were positive (53%; 95% CI: $\pm 6.0\%$). Respondents found urban growth to produce a negative effect on clean and quality air (29%; 95% CI: $\pm 5.5\%$); tranquility, relaxation, and spiritual enrichment (23%; 95% CI: $\pm 5.1\%$); and food from agriculture (16%; 95% CI: $\pm 4.4\%$), but urban growth was perceived to have a positive impact on entertainment, leisure, and tourism (31%; 95% CI: $\pm 5.6\%$). Respondents found the aggregate industry to have a negative impact on soil fertility (31%; 95% CI: $\pm 5.6\%$) and clean and quality air (27%; 95% CI: $\pm 5.4\%$) and a positive impact on materials of mineral origin (43%; 95% CI: $\pm 6.0\%$). Finally, land restoration and protection areas were perceived to produce positive impacts on clean and quality air (32%; 95% CI: $\pm 5.6\%$), and entertainment, leisure and tourism were highlighted (31%; 95% CI: $\pm 5.6\%$).

3.6. Vulnerability and importance of ecosystem services for the local population

Overall, most respondents indicated that the provisions of regulating services (i.e., air quality, climate regulation, water regulation and erosion control) had undergone decreasing trends over the last decade, whereas cultural services (i.e., entertainment, tourism and scientific knowledge) and provisioning services were mostly identified as having positive trends. Safe drinking water, tranquility, relaxation, and spiritual enrichment were ecosystem services not associated with any positive or negative trend. However, we found that pollination, water retention and water purification were highly vulnerable ecosystem services.

Regarding the importance levels of ecosystem services to locals, we found that respondents considered clean and quality air (65.6%; 95% CI:

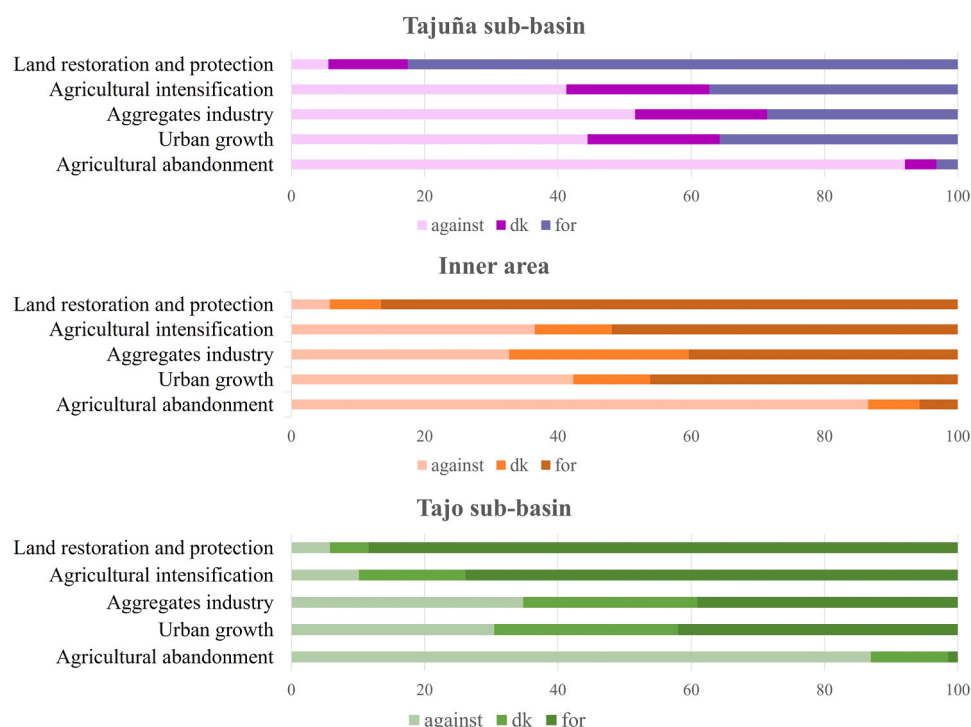


Fig. 5. Percentage of responses about perceptions of the most important land use types in the three eco-regions. dk: do not know/did not answer.

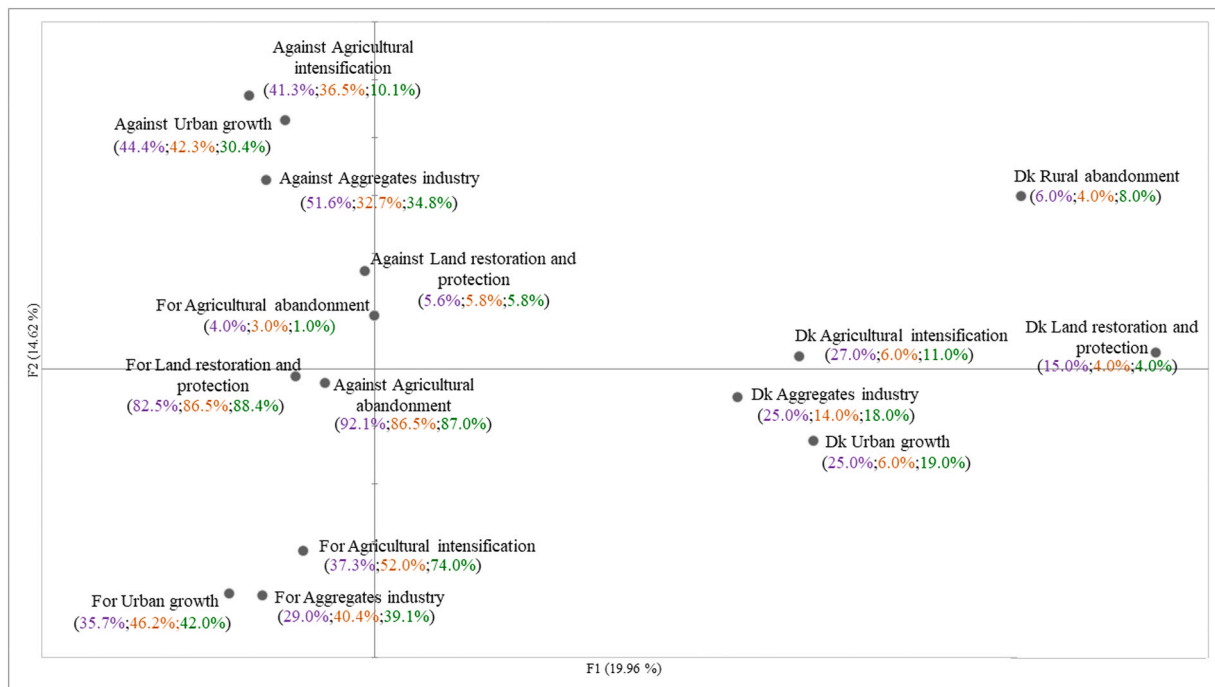


Fig. 6. Multiple correspondence analysis (ACM) results of respondent motivations for or against land use trajectories with the percentage obtained for each region: Tajunassubbasin (purple color), Inner area (orange color) and Tajo subbasin (green color).

$\pm 5.3\%$), food from agriculture (58.1%; 95% CI: $\pm 5.5\%$), and safe drinking water (53.2%; 95% CI: $\pm 5.6\%$) to be the most relevant ecosystem services for their wellbeing (Fig. 8). In contrast, materials of mineral origin received the lowest recognition (0.6%; 95% CI: $\pm 1\%$), followed by plant materials (2.0%; 95% CI: $\pm 1.6\%$; Fig. 8).

4. Discussion

The importance of land use trajectories as drivers of global change has been extensively studied worldwide as a way to understand the impacts of human activities on ecosystems and the ecosystem services they provide to people (Palomo et al., 2013; Turner y Gardner 2015; Burkhard et al., 2014). However, reports on how land use change translate into changes in people's values toward ecosystem services are lacking. This research offers a novel spatial modeling approach that simultaneously empirically characterizes major land use trajectories and assesses changes in the value people place for ecosystem services. Results clearly identify the most socially desired future for the Las Vegas agrarian district of Madrid (i.e., land restoration and protection and the rejection of agricultural abandonment), indicating the need to incorporate people's values toward landscapes to foster transformations toward more resilient agrarian landscapes in Spain.

Findings of this research must be considered under some limitations. Our spatial modelling approach to map land use trajectories involved the use of cartographic bases of the Corine Land Cover scale 1:100,000 and a minimum cartographic unit of 25 ha. Here we call out this step could incur generalization errors in the analyzed land use types. However, we considered it as the most appropriate spatial scale because other available cartographic databases, such as SIOSE (Spanish Land Occupation Information System), offer less extensive temporal data (temporal coverage of SIOSE 2005–2014; temporal coverage of Corine Land Cover 1990–2018). In any case, our results regarding the social perceptions by the public of ecosystem services easily recognized the land use trajectories identified with the Corine Land Cover scheme at the local scale, thus highlighting the convenience of combining both methodological approaches. Additionally, although the sampling instrument used here (i.e., face-to-face surveys) allowed us to capture a

convenient sample of locals (a total of 308 surveys), we recognize it was not sufficient to capture deep ideas underpinning the worldviews found around the interconnection between land use change and ecosystem services.

4.1. Land use trajectories in the rural agrarian landscape of Madrid

Over the past 50 years, Spain's countryside has lost 28% of its population due to the Green Revolution and the globalized market economy and is now known as "Empty Spain" (Taibo, 2021). Our findings identified agricultural abandonment and intensification as key land use trajectories that have occurred in recent decades. These land use trajectories summarize the agricultural intensification that took place in Spain in the 1960s, when agriculture was mechanized through the application of extensive external inputs (Gonzalez de Molina et al., 2020), making Spain one of the largest European agricultural producers. In turn, agricultural intensification promoted the modernization of irrigation (e.g., in the Tajo subbasin), which continues to be a key strategy for improving agricultural efficiency and adhering to the Ecological Transition Plan (European Commission 2021). However, despite the increase in agricultural production, the current model is placing unprecedented pressure on water quality and quantity resources (WWF, 2015). This suggests the urgent need to incorporate in the Ecological Transition Plan new agricultural models that reduce the use of fertilizers and pesticides and are compatible with the reduced availability of water flows (Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy). The globalized agri-food model has reduced agricultural employment in the countryside; this process has been another driver of "Empty Spain" (Taibo, 2021). This demographic transition exemplifies the movement of people from rural areas to overpopulated urban centers in search of labor, cultural and personal incentives. In Spain, this phenomenon has been occurring since the 1950s, and currently, 72% of the population lives in 1% of the territory. Thus, addressing the long-term viability of rural areas in the Las Vegas agrarian district of Madrid is essential for facilitating the transition to a more just and sustainable future (Yacamán

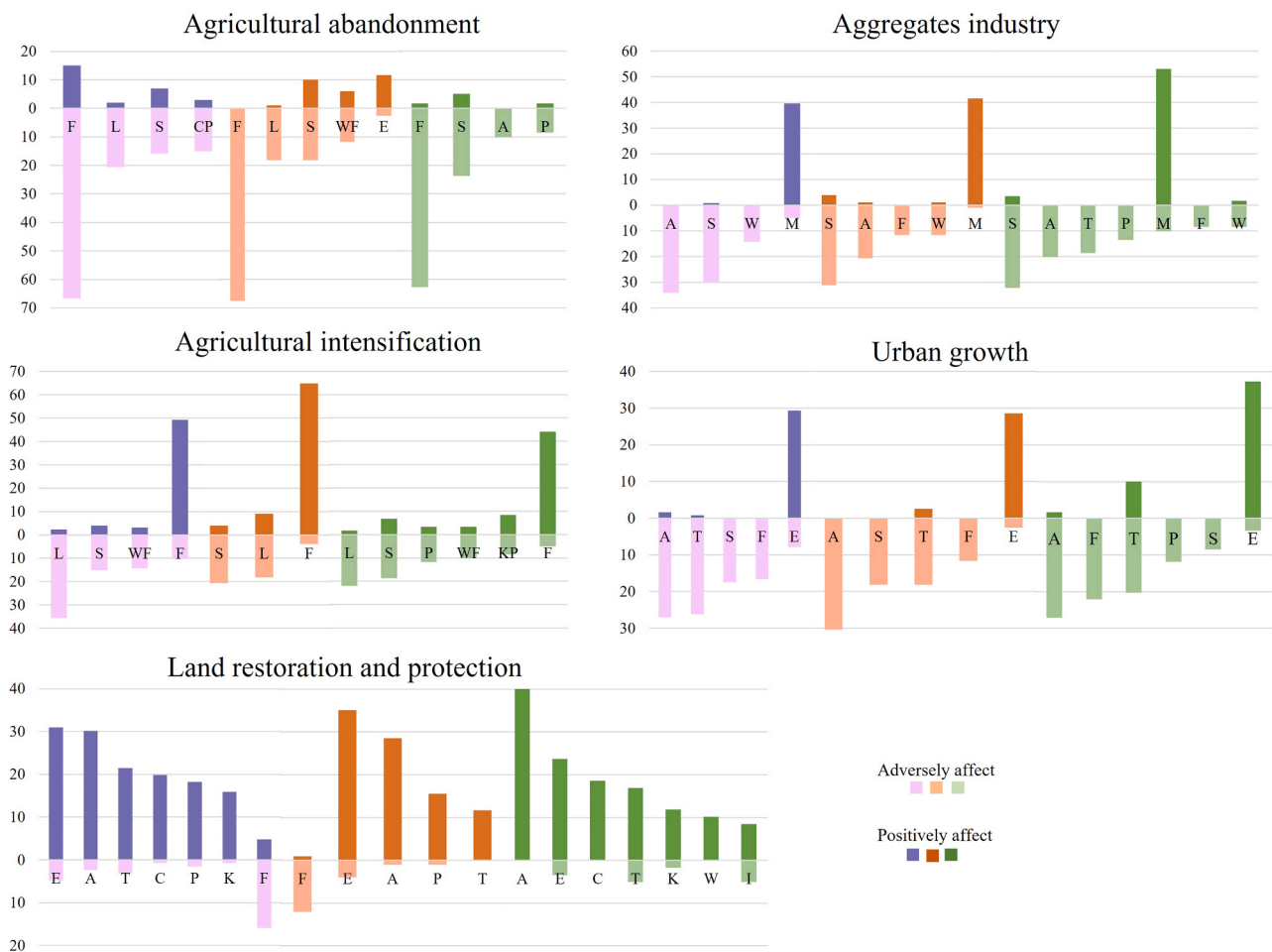


Fig. 7. Percentages of perceived impacts of land use trajectories on ecosystem services across three eco-regions in the Las Vegas agrarian and rural district: the Tajunassubbasin, Inner area, and Tajo subbasin. The Y-axis indicates the number of responses of positive (values above zero) and negative impacts (values below zero). The X-axis indicates the different ecosystem services, *Cultural Ecosystem Services*, including CP: Traditional cultural practices and knowledge rooted in the land; T: Tranquility, relaxation and spiritual enrichment; K: Scientific knowledge and opportunities for environmental education; I: Sense of place and cultural identity; and E: Entertainment, leisure and tourism, *Provisioning Ecosystem Services*, including F: Food from agriculture; WF: Wild foods; L: Local varieties and cultivated diversity; and M: Materials of mineral origin (aggregates, limestone, etc.), and *Regulating Ecosystem Services*, including S: Soil Fertility; A: Clean and quality air; P: Pollination; KP: Keeping pests under control; C: Maintenance of favorable climate; and W: Water retention and purification.

et al., 2020).

According to our results, agricultural abandonment is one of the most socially rejected land use trajectories and is clearly linked to losses of multiple ecosystem services, such as food production and soil fertility. Here, we suggest that reducing rural abandonment in rural Madrid can be achieved by promoting proximity agriculture, where production and demand both occur locally. It is essential to support small-scale production and self-sufficiency marketing channels to ensure the economic viability of small production initiatives (Palomo-Campesino et al., 2021).

Recent research has supported the concept that land transformations that simplify landscape configurations (e.g., agricultural intensification) reduce the level of human-nature connectedness (Pérez-Ramírez et al., 2021; Quintas-Soriano et al., 2022). Our results are consistent with these findings, as we showed that agricultural intensification is linked to a decrease in local varieties (Fig. 7). This result is consistent with the findings of Riechers et al. (2021), who observed that production intensification was linked to the losses of the sense of place and cultural heritage associated with agricultural production of traditional varieties.

Land restoration and protection were the land trajectories valued most positively by locals, with positive impacts on ecosystem services such as clean and quality air (i.e., the most important ES). Here, we argue that no existing model is capable of satisfying food security and

fostering the protection of nature. Our results support the idea proposed by the European Commission of new agri-environmental initiatives that preserve local biodiversity and promote sustainable land use (Pascual et al., 2017). The European Union rewards farmers for promoting measures that conserve natural resources and provide public goods that benefit local communities. Among these measures, areas of ecological interest (e.g., crop rotations with leguminous crops, winter soil cover and catch crops above conditionality, the use of crops/plant varieties that are highly resilient to climate change) may promote green spaces around agriculture, improve clean and quality air and increase the supply of sustainable and healthy foods (Titttonell et al., 2020). Overall, these agri-environmental measures are considered the most beneficial option because they can be adapted to local needs and support the public interest. Current proposals plan to cut the Pillar II budget by up to 27%; these proposals have been criticized for their lack of commitment to implementing an approach to move toward a climate change-resilient agriculture model.

A new agricultural model in the Las Vegas agrarian district of Madrid should preserve the three ecosystem services recognized as most important by locals (i.e., clean and quality air, food from agriculture and safe drinking water). This model must implement measures that improve the states of these ecosystem services, specifically in areas where the identified land use trajectories (i.e., agricultural intensification and

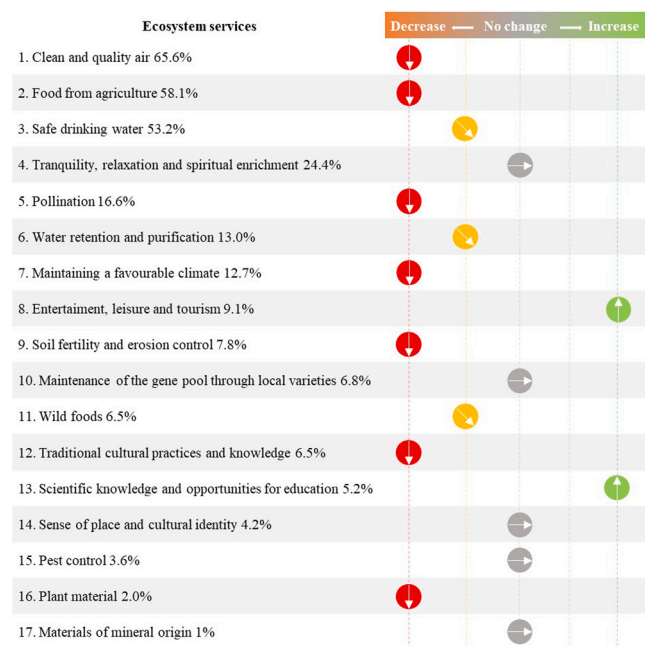


Fig. 8. Percentages of the social importance level and perceived ecosystem service trends over the last ten years. The red circles indicate that the ecosystem service trend decreased, green circles indicate that the ecosystem service trend increased and the gray circle indicates stability. Adaptation of IPBES.

abandonment) are predicted to continue to expand. On the other hand, the results also show that entertainment, leisure, tourism, scientific knowledge and opportunities for education are identified to have positive trends (Fig. 8). These ecosystem services can be used as vehicles to cocreate, share, and support these agri-environmental measures in the local population. To do so, it is essential to foster the active participation of the local population in the preservation and cocreation of knowledge regarding agrarian landscapes (Bots and Van Daalen, 2008; Sachet et al., 2021). Here we call the need to use complementary methodologies such as focus groups or in-depth surveys to better capture the social dynamics of agrarian landscapes.

As stated by a growing body of literature, the proposed spatial modeling approach combined the biophysical and sociocultural aspects of landscape dynamics that can be integrated into land policies (Quintas-Soriano et al., 2018; Martín-López et al., 2012). Our interdisciplinary approach was supported by Sala and Torchio (2019), who emphasized that landscape management must be undertaken in consideration of complex socioecological dynamics that are critical to cocreating opportunities for knowledge exchange at the science-policy interface. Similarly, Pandit et al. (2020) showed that ecological agricultural restoration must fully embrace the cultural, social, and political dimensions to be effective in the long term and move away from ecology-dominated perspectives. Our results exemplify the complexities in the ways people relate to agrarian landscapes and clarify the shortcomings of existing theoretical frameworks, such as land sharing and land sparing, to promote transformational pathways toward sustainability. Applying socioecological approaches such as landscape stewardship or participatory methodologies (e.g., photovoice or participatory mapping) can help to integrate people's values in sustainable transitions (Derr and Simons, 2020; Pérez-Ramírez et al., 2019; Bieling et al., 2020). We suggest future research must integrate the political and cultural context as key factors for shifting land transformation toward better and more just and sustainable futures.

5. Conclusions

A novel spatial modeling approach that empirically characterizes

land use trajectories and changes in perceptions for ecosystem services in central rural Spain is proposed. The insights gained in this research reveal the complex relationships that have arisen over time between land transformations and people's values regarding key ecosystem services in the agrarian landscapes of rural Madrid (Spain) (Lavorel et al., 2017). The land use trajectory with the highest responders' support was land restoration and protection, while the least supported one was agricultural abandonment. This result is aligned with pattern of land use trajectories observed in other rural European regions, which are characterized by the abandonment of traditional agricultural lands and agricultural intensification. Additionally, we found that local land transformations also influence the value that key ecosystem services hold for local people. Projected land use trajectories are expected to impact on the most valued ecosystem services by locals, including clean and quality air, food from agriculture and safe drinking water.

Our findings suggest the need to rely on methodological approaches that promote inclusive, intersectoral, and transdisciplinary methods to shed light on the complex coevolution between people and agrarian landscapes and to identify socially resilient pathways for European agricultural landscapes. We suggest that public participation in decision-making is fundamental to democratizing agrarian landscapes. Our spatial modeling transdisciplinary approach can inform land use planning in multiple ways, including better identification of the public's values, more community support for land use planning, a better-informed community about land planning issues and concerns, and an increase in trust between decision-making leadership and the farming community.

Formatting of funding sources

This work was supported by the 2019 call for grants for R&D projects for young researchers of the Universidad Autónoma de Madrid with the project SAVIA-Sembrando AlternatiVas de Innovación Agroecológica [SI1/PJI/2019-00444].

CRedit authorship contribution statement

Irene Pérez-Ramírez: Methodology, Investigation, Formal analysis, Data curation, Conceptualization, Writing - original draft. **Juan Miguel Requena-Mullor:** Writing - review & editing, Supervision, Methodology, Formal analysis, Data curation, Conceptualization. **Antonio J. Castro:** Writing - review & editing, Validation, Supervision, Methodology, Conceptualization. **Marina García-Llorente:** Writing - review & editing, Writing - original draft, Validation, Supervision, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization.

Declaration of Competing Interest

We state that the work submitted to Land Use Policy is original unpublished work, and is not being considered for publication elsewhere and that all authors agree with the content and to the submission. It is declared that there are no conflicts of interest and all authors have equal contributions.

Data Availability

Data will be made available on request.

Acknowledgements

We thank F. Xavier Picó, researcher at the Estación Biológica de Doñana (EBD-CSIC) for reviewing the article, which have enriched the manuscript. We would like to thank all the students of the Universidad Autónoma de Madrid who helped us to carry out the surveys. And a special thanks to all those who participated in this research and made it possible, thank you for your time and patience.

References

- Ansell, C., Gash, A., 2008. Collaborative governance in theory and practice. *J. Public Adm. Res. Theory* 18, 543–571. <https://doi.org/10.1093/jopart/mum032>.
- Balázsi, Á., Riechers, M., Hartel, T., Leventon, J., Fischer, J., 2019. The impacts of social-ecological system change on human-nature connectedness: a case study from Transylvania, Romania. *Land Use Pol.* 89, 104232 <https://doi.org/10.1016/j.landusepol.2019.104232>.
- Berkes, F., 2009. Evolution of co-management: role of knowledge generation, bridging organizations and social learning. *J. Environ. Manag.* 90, 1692–1702. <https://doi.org/10.1016/j.jenvman.2008.12.001>.
- Bieling, C., Eser, U., Plieninger, T., 2020. Towards a better understanding of values in sustainability transformations: ethical perspectives on landscape stewardship. *Ecosyst. People* 16, 188–196. <https://doi.org/10.1080/26395916.2020.1786165>.
- Bots, P., Van Daalen, E., 2008. Participatory model construction and model use in natural resource management: a framework for reflection. *Syst. Pract. Action Res.* 21 (6), 21. <https://doi.org/10.1007/s11213-008-9108-6>.
- Bridgewater, P., Rotherham, I.D., 2019. A critical perspective on the concept of biocultural diversity and its emerging role in nature and heritage conservation. *People Nat.* 1, 291–304. <https://doi.org/10.1002/pan3.10040>.
- Carmen, E., Watt, A., Carvalho, L., Dick, J., Fazey, I., Garcia Blanco, G., Grizzetti, B., Hauck, J., Izakovićová, Z., Kopperoinen, L., Lique, C., Odee, D., Steingrover, E., Young, J., 2018. Knowledge needs for the operationalisation of the concept of Ecosyst. Serv. *Ecosyst. Serv.* 29 <https://doi.org/10.1016/j.ecoser.2017.10.012>.
- Carvalho Ribeiro, S.M., Pinto-Correia, T., Paracchini, M.-L., 2016. Addressing the social landscape dimensions: the need for reconciling cross scale assessments for capturing Cultural Ecosyst. Serv. (CES). *Land Use Pol.* 53 <https://doi.org/10.1016/j.landusepol.2015.12.022>.
- Castro, A.J., Martín-López, B., García-Llorente, M., Aguilera, P.A., López, E., Cabello, J., 2011. Social preferences regarding the delivery of Ecosyst. Serv. in a semiarid Mediterranean region. *J. Arid. Environ.* 75, 1201–1208. <https://doi.org/10.1016/j.jaridenv.2011.05.013>.
- Castro, A.J., García-Llorente, M., Martín-López, B., Palomo, I., Iniesta-Arandia, I., 2013. Multidimensional approaches in ecosyst. Serv. Assessment, in: *Earth Observation of Ecosyst. Serv.* CRC Press.
- Castro, A.J., Vaughn, C.C., García-Llorente, M., Julian, J.P., Atkinson, C.L., 2016. Willingness to pay for ecosystem services among stakeholder groups in a south-central U.S. watershed with regional conflict. *J. Water Resour. Manag.* 142, 05016006 [https://doi.org/10.1061/\(ASCE\)WR.1943-5452.0000671](https://doi.org/10.1061/(ASCE)WR.1943-5452.0000671).
- Clarke, K.R., 1993. Non-parametric multivariate analyses of changes in community structure. *Austral Ecol.* 18, 117–143. <https://doi.org/10.1111/j.1442-9993.1993.tb00438.x>.
- Derr, V., Simons, J., 2020. A review of photovoice applications in environment, sustainability, and conservation contexts: is the method maintaining its emancipatory intents? *Environ. Educ. Res.* 26, 359–380. <https://doi.org/10.1080/13504622.2019.1693511>.
- European Commission, Directorate-General for Budget, 2021. The EU's 2021–2027 long-term budget and NextGenerationEU: facts and figures, <https://data.europa.eu/doi/10.2761/80859>.
- Folke, C., 2006. Resilience: The emergence of a perspective for social-ecological systems analyses. *Global Environmental Change, Resilience, Vulnerability, and Adaptation: A Cross-Cutting Theme of the International Human Dimensions Programme on Global Environmental Change* 16, 253–267. <https://doi.org/10.1016/j.gloenvcha.2006.04.002>.
- García Llorente, M., Martín-López, B., Iniesta-Arandia, I., López-Santiago, C., Aguilera, P., Montes, C., 2012. The role of multi-functionality in social preferences toward semi-arid rural landscapes: an ecosystem service approach. *Environ. Sci. Policy*. <https://doi.org/10.1016/j.envsci.2012.01.006>.
- García-Llorente, M., J. Castro, A., Quintas-Soriano, C., Oteros-Rozas, E., Iniesta-Arandia, I., González, J. A., García del Amo, D., Hernández-Arroyo, M., Casado-Arzuaga, I., Palomo, I., Gómez-Baggethun, E., Onaindia, M., Montes, C., Martín-López, B., 2020. Local perceptions of ecosyst. serv. across multiple ecosystem types in Spain. *Land* 9, 330. <https://doi.org/10.3390/land9090330>.
- Huang, Q., Yin, D., He, C., Yan, J., Liu, Z., Meng, S., Ren, Q., Zhao, R., Inostroza, L., 2020. Linking Ecosyst. Serv. and subjective well-being in rapidly urbanizing watersheds: Insights from a multilevel linear model. *Ecosyst. Serv.* 43 <https://doi.org/10.1016/j.ecoser.2020.101106>.
- Jax, K., Calestani, M., Chan, K.M., Eser, U., Keune, H., Muraca, B., O'Brien, L., Potthast, T., Voget-Kleschin, L., Wittmer, H., 2018. Caring for nature matters: a relational approach for understanding nature's contributions to human well-being. *Curr. Opin. Environ. Sustain.* 35, 22–29. <https://doi.org/10.1016/j.coesust.2018.10.009>.
- Kelemen, E., García-Llorente, M., Pataki, G., Martín-López, B., Gómez-Baggethun, E., 2016. In: Potschin, M., Jax, K. (Eds.), *Non-monetary techniques for the valuation of ecosystem service*. OpenNESS Ecosystem Services Reference Book. EC FP7 Grant Agreement no. 308428. Available via: www.openness-project.eu/library/reference-book.
- Khoury, C., Björkman, A., Dempewolf, H., et al., 2014. Increasing homogeneity in global food supplies and the implications for food security. *PNAS* 111 (11), 4001–4006. <https://doi.org/10.1073/pnas.1313490111>.
- Kruskal, J.B., 1964. Multidimensional scaling by optimizing goodness of fit to a nonmetric hypothesis. *Psychometrika* 29, 1–27. <https://doi.org/10.1007/BF02289565>.
- Kucsicsa, G., Popovici, E.-A., Bălteanu, D., Grigorescu, I., Dumitracu, M., Mitrică, B., 2019. Future land use/cover changes in Romania: regional simulations based on CLUE-S model and CORINE land cover database. *Landsc. Ecol. Eng.* 15, 75–90. <https://doi.org/10.1007/s11355-018-0362-1>.
- Lang, D.J., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., Swilling, M., Thomas, C.J., 2012. Transdisciplinary research in sustainability science: practice, principles, and challenges. *Sustain. Sci.* 7, 25–43. <https://doi.org/10.1007/s11625-011-0149-x>.
- Lavorel, S., Grigulis, K., Leitinger, G., Kohler, M., Schirpke, U., Tappeiner, U., 2017. Historical trajectories in land use pattern and grassland ecosystem services in two European alpine landscapes. *Reg. Environ. Chang.* 17, 2251–2264. <https://doi.org/10.1007/s10113-017-1207-4>.
- Maes, J., Paracchini, M.-L., Zulian, G., 2011. Towards an atlas of ecosystem services. *A Eur. Assess. Provis. Ecosyst. Serv.*
- Martín-López, B., Iniesta-Arandia, I., García-Llorente, M., Palomo, I., Casado-Arzuaga, I., Amo, D.G.D., Gómez-Baggethun, E., Oteros-Rozas, E., Palacios-Agundez, I., Willaarts, B., González, J.A., Santos-Martín, F., Onaindia, M., López-Santiago, C., Montes, C., 2012. Uncovering Ecosystem Service Bundles through Social Preferences. *PLOS ONE* 7, e38970. <https://doi.org/10.1371/journal.pone.0038970>.
- Martín-López, B., Felipe-Lucia, M.R., Bennett, E.M., Norström, A., Peterson, G., Plieninger, T., Hicks, C.C., Turkelboom, F., García-Llorente, M., Jacobs, S., Lavorel, S., Locatelli, B., 2019. A novel telecoupling framework to assess social relations across spatial scales for Ecosyst. Serv. research. *J. Environ. Manag.* 241, 251–263. <https://doi.org/10.1016/j.jenvman.2019.04.029>.
- Molina, M.G., de Fernández, D.S., Casado, G.G., Infante-Amate, J., Fernández, E.A., Traver, J.V., Ruiz, R.G., 2020. The Mediterranean way towards industrialization. *Environmental History*. In: *The Social Metabolism of Spanish Agriculture, 1900–2008*. Springer International Publishing. <https://doi.org/10.1007/978-3-030-20900-1>.
- Moreno, L.U., 1992. *Geografía agraria de la Comarca "Las Vegas"*. Doce Calles, Madrid, 420 pp. ISBN: 84-87111-26-2.
- Nyström, M., Jouffray, J.-B., Norström, A.V., et al., 2019. Anatomy and resilience of the global production ecosystem. *Nature* 575, 98–108. <https://doi.org/10.1038/s41586-019-1712-3>.
- Oksanen, J., Blanchet, F.G., Friendly, M., Kindt, R., Legendre, P., McGinn, D., Minchin, P.R., O'Hara, R.B., Simpson, G.L., Solymos, P., 2019. *vegan: Community Ecology Package*. 2019. R package version 2.5–6.
- Palomo-Campesino, S., García-Llorente, M., González, J.A., 2021. Characterizing agroecological and conventional farmers: uncovering their motivations, practices, and perspectives toward agriculture. *Agroecol. Sustain. Food Syst.* 0, 1–30. <https://doi.org/10.1080/21683565.2021.1933671>.
- Pandit, R., Parrotta, J.A., Chaudhary, A.K., Karlen, D.L., Vieira, D.L.M., Anker, Y., Chen, R., Morris, J., Harris, J., Ntshotsho, P., 2020. A framework to evaluate land degradation and restoration responses for improved planning and decision-making. *Ecosyst. People* 16, 1–18. <https://doi.org/10.1080/26395916.2019.1697756>.
- Pascual, U., Balvanera, P., Díaz, S., et al., 2017. Valuing nature's contributions to people: the IPBES approach. *Curr. Opin. Environ. Sustain.* 26–27, 7–16. <https://doi.org/10.1016/j.coesust.2016.12.006>.
- Pérez-Ramírez, I., García-Llorente, M., Benito, A., Castro, A.J., 2019. Exploring sense of place across cultivated lands through public participatory mapping. *Landsc. Ecol.* 34, 1675–1692. <https://doi.org/10.1007/s10980-019-00816-9>.
- Pérez-Ramírez, I., García-Llorente, M., Sabán de la Portilla, C., Benito, A., Castro, A.J., 2021. Participatory collective farming as a leverage point for fostering human-nature connectedness. *Ecosyst. People* 17, 222–234. <https://doi.org/10.1080/26395916.2021.1912185>.
- Quintas-Soriano, C., Castro, A.J., Castro, H., García-Llorente, M., 2016. Impacts of land use change on Ecosyst. Serv. and implications for human well-being in Spanish drylands. *Land Use Pol.* 54, 534–548. <https://doi.org/10.1016/j.landusepol.2016.03.011>.
- Quintas-Soriano, C., Brandt, J., Running, K., Baxter, C., Gibson, D., Narducci, J., Castro, A., 2018. Social-ecological systems influence ecosystem service perception: a Programme on Ecosystem Change and Society (PECS) analysis. *Ecol. Soc.* 23 <https://doi.org/10.5751/ES-10226-230303>.
- Quintas-Soriano, C., Buerkert, A., Plieninger, T., 2022. Effects of land abandonment on nature contributions to people and good quality of life components in the Mediterranean region: a review. *Land Use Pol.* 116, 106053 <https://doi.org/10.1016/j.landusepol.2022.106053>.
- Ramankutty, N., Mehrabi, Z., Waha, K., et al., 2018. Trends in global agricultural land use: implications for environmental health and food security. *Annu. Rev. Plant Biol.* 69, 789–815. <https://doi.org/10.1146/annurev-arplant-042817-040256>.
- Requena-Mullor, J.M., López, E., Castro, A.J., Cabello, J., Virgós, E., González-Miras, E., Castro, H., 2014. Modeling spatial distribution of European badger in arid landscapes: an ecosystem functioning approach. *Landsc. Ecol.* 29, 843–855. <https://doi.org/10.1007/s10980-014-0020-4>.
- Requena-Mullor, J.M., Quintas-Soriano, C., Brandt, J., Cabello, J., Castro, A.J., 2018. Modeling how land use legacy affects the provision of Ecosystem Service in Mediterranean southern Spain. *Environ. Res. Lett.* 13, 114008 <https://doi.org/10.1088/1748-9326/aae5e3>.
- Riechers, M., Martín-López, B., Fischer, J., 2021. Human-nature connectedness and other relational values are negatively affected by landscape simplification: insights from Lower Saxony, Germany. *Sustain. Sci.* (3) <https://doi.org/10.1007/s11625-021-00928-9>.
- Sachet, E., Mertz, O., Le Coq, J.F., et al., 2021. Agroecological transitions: a systematic review of research approaches and prospects for participatory action methods. *Front. Sustain. Food Syst.* 5 <https://doi.org/10.3389/fsufs.2021.709401>.
- Sala, J.E., Torchio, G., 2019. Moving towards public policy-ready science: philosophical insights on the social-ecological systems perspective for conservation science. *Ecosyst. People* 15, 232–246. <https://doi.org/10.1080/26395916.2019.1657502>.

- Sherren, K., Verstraten, C., 2013. What can photo-elicitation tell us about how maritime farmers perceive wetlands as climate changes? *Wetlands* 33, 65–81. <https://doi.org/10.1007/s13157-012-0352-2>.
- Sondermann, M.N., Proença de Oliveira, R., 2022. Using the WEI+ index to evaluate water scarcity at highly regulated river basins with conjunctive uses of surface and groundwater resources. *Sci. Total Environ.* 836, 155754 <https://doi.org/10.1016/j.scitotenv.2022.155754>.
- Taibo C. (2021) Iberia Vacuada. Despoblación, decrecimiento, colapso. La Catarata. ISBN 9788413521275 Pag.128.
- Tittonell, P., Piñeiro, G., Garibaldi, L.A., et al., 2020. Agroecology in large scale farming: a research agenda. *Front. Sustain. Food Syst.* 4 <https://doi.org/10.3389/fsufs.2020.584605>.
- Turkelboom, F., Leone, M., Jacobs, S., Kelemen, E., Garcia Llorente, M., Baró, F., Termansen, M., Barton, D., Berry, P., Stange, E., Thoonen, M., Kalóczkai, Á., Vadineanu, A., Castro, A.J., Czúcz, B., Röckmann, C., Wurbs, D., Odee, D., Preda, E., Rusch, V., 2017. When we cannot have it all: Ecosyst. Serv. trade-offs in the context of spatial planning. *Ecosyst. Serv.* 29 <https://doi.org/10.1016/j.ecoser.2017.10.011>.
- Verburg, P.H., van Berkel, D.B., van Doorn, A.M., van Eupen, M., van den Heiligenberg, H.A.R.M., 2010. Trajectories of land use change in Europe: a model-based exploration of rural futures. *Landsc. Ecol.* 25, 217–232. <https://doi.org/10.1007/s10980-009-9347-7>.
- Wester-Herber, M., 2004. Underlying concerns in land-use conflicts—the role of place-identity in risk perception. *Environ. Sci. Policy* 7, 109–116. <https://doi.org/10.1016/j.envsci.2003.12.001>.
- WWF, World Wild Fund for Nature, 2015. Modernización de regadíos. Un mal negocio para la naturaleza y la sociedad. Informe WWF/Adena.
- Yacamán, C., Ferrer, D., Mata, R., 2020. Green infrastructure planning in metropolitan regions to improve the connectivity of agricultural landscapes and food security. *Land* 9, 414. <https://doi.org/10.3390/land9110414>.