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# Similar patterns, different processes: Persistence and change in path-dependent land systems

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ABSTRACT

Large-scale land use changes can lead to a fundamental reorganisation of the land and corresponding socio-ecological regime. These regime shifts are notably hard to detect, predict or model, often arising from unprecedented changes in technology, markets or policies. In a remote rural region in Portugal, we tracked the land use history in three parishes between 1899 and 2018, capturing multiple disruptive socioeconomic and political circumstances, to assess whether a regime shift was triggered. We used a causal historical approach that included the spatio-temporal mapping of LULC changes and a socioecological event timeline to track policy changes and other important events or circumstances. We used these, and other available (historic) literature, to contextualise local information provided in oral history interviews (OHI) that revealed land managers' decision-making during the last 70 years. We found that during the *Estado Novo* dictatorship, productivism-based policies had a strong influence on the observed land use intensification, yet OHI revealed that the high level of self-sufficiency agriculture made alternative trajectories unlikely if not impossible. After the 1974 revolution, recalibration took place in the form of a rural exodus and associated land reorganisation, including tenure and production systems. Overall, semi-natural areas, which usually depend on grazing or pastoralism, strongly diminished, while natural and plantation forests expanded. Arable land areas remained relatively stable across the entire study period. Our study shows that land systems that have undergone disruptive changes in the past may continue to evolve discontinuously afterwards, without causing a socioecological regime shift or breaking path dependence.

## 1. Introduction

Changes in land systems are the result of decisions by humans to engage with land in a different way. In turn, land system changes reflect and cause changes in the associated socioecological structures and outcomes on the (local) environment as a whole (Levers et al., 2018; Müller et al., 2014; Verburg et al., 2015). Landscape regime shifts occur when socioecological processes, their feedback loops and other interactions, transform or break down, leading to a restructuring of both the biophysical and social expressions of the landscape (Meyfroidt, 2016; Müller et al., 2014). Rural landscapes across Europe have undergone several management regime shifts since the 18th century: from traditional to intensified landscapes after the industrial revolution, and to post-modern landscapes after World War II (Antrop, 2005; Jepsen et al., 2015; Lowenthal, 1997). These processes occurred at varying spatiotemporal rhythms across the continent (Jepsen et al., 2015), influenced by diverse socioeconomic and -political contexts (Lambin et al., 2001; Müller et al., 2009) or catastrophic events (Antrop, 2005). For instance, in many countries of the former communist bloc in Europe, the period of collective agriculture resulted in land reform and land use intensification, which was followed by widespread agricultural abandonment in the post-socialist period (e.g. Kuemmerle et al., 2008; Munteanu et al., 2017; Prishchepov et al., 2013). Land tenure reform has also been linked to increased deforestation in several tropical countries, regardless of whether the reform is part of a democratic or autocratic transition process (e.g. Ango et al., 2020; Ferreira and Vincent, 2010;

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Kuusela and Amacher, 2016). Aside from transformational changes, landscapes may demonstrate strong path-dependence and legacy effects as they evolve (Tappeiner et al., 2021; van Vliet et al., 2015; Zariņa, 2013). Past human uses can have a long-lasting impact on the landscape, its ecology (Bürgi et al., 2017) and its identity (Antrop, 2005; Dossche et al., 2016) while self-reinforcing processes may produce lock-in scenarios that inhibit evolutionary change – positive or negative (Allison and Hobbs, 2004; Strambach and Halkier, 2013). This situation is particularly found in many remote and mountainous areas, where traces of traditional agricultural landscapes with high cultural and biodiversity values persist, both despite and thanks to the European Union's Common Agricultural Policy (CAP) (Donald et al., 2002; Lomba et al., 2020; Plieninger and Bieling, 2013). Such multifunctional mosaics are under increasing pressure due to challenging farming circumstances and other socioeconomic strains, as the ecosystem services provided by these landscapes and practises remain insufficiently valorised (Lomba et al., 2020). When traditional management processes disappear, polarised landscape trajectories may emerge instead, with intensified agriculture on suitable land areas, while formerly multifunctional areas are left unmanaged or abandoned, leading to the breakdown of their associated ecological communities (Levers et al., 2026; Plieninger et al., 2014). In Mediterranean and similar systems, climate change effects such as prolonged droughts or heat waves accompany the naturalisation/rewilding processes following abandonment, leading to an increase in unmanaged biomass which in turn elevates risks for severe wildfires (Azevedo et al., 2011; Sequeira et al., 2019; Sil et al., 2019). Eventually, a socioecological system may lose its identity and range of capital values so quickly and profoundly that it can be defined as a collapse (Cumming and Peterson, 2017). Simultaneously, recent European policies imagine novel land uses in these depopulated rural landscapes by embracing ecosystem restoration and rewilding (e.g. EU Nature Restoration Law Reg 2024/1991), expanding renewable energy production such as wind and solar (Madsen et al., 2025) and the potential mining of critical minerals needed for the energy transition (Deberdt et al., 2025).

Developing effective land management responses in such changing rural landscapes is complicated because they affect the whole embedded socioecological system (Vaz and Soto, 2020). In addition, systems may present time-lagged responses to triggers, changes or events, thereby obscuring causal mechanisms (Bürgi et al., 2017; Szabó, 2010; Ziter et al., 2017). Using an appropriate temporal scale of analysis is especially critical in locations that have undergone profound institutional changes that influenced their land use histories, such as the emergence and fall of communism or periods of autocratic or dictatorial rule. The historical range and variability of those landscapes (Keane et al., 2009) is likely to be more extreme due to the disruptive transformation(s) that accompanied these institutional alterations. In such a context, the baseline reference serving as a target in policy initiatives becomes much harder to determine or define. In this article we aim to analyse the role of potential socioecological regime shifts and time-lagged responses as a determinant of land system changes over the past 100 + years. We use Terras de Trás-os-Montes (TTM), a relatively remote mountainous region in Portugal prone to depopulation and land abandonment, as a case study that is exemplary for many other rural regions facing similar challenges. Portugal underwent intense sociopolitical changes during the 20th century, including an extended period of autocratic rule followed by gradual integration into the EU and CAP, all of which heavily influenced its socioecological systems (Amaral and Freire, 2017). Using an event ecology approach, we traced the timeline of TTM's landscape and its processes back to the start of the 20th century, to identify the principal causal elements that produced the observed outcomes (Walters and Vayda, 2009), using a mixed method approach detailed in Section 2. Section 3 presents the findings of both the qualitative and quantitative analysis which are discussed in Section 4. A better understanding of these causal mechanisms will not only help explain the present land management challenges in all their spatiotemporal diversity and complexity, but also provide pathways to address them in a more realistic and effective manner.

## 2. Methods

### 2.1. Case study areas

The study area, Terras de Trás-os-Montes, is a statistical and administrative sub-region ("NUTS 3") in the northeast of Portugal that includes nine municipalities, with about 107 000 inhabitants (INE, 2022) across 5544 km$^2$ (Fig. 1). It has a continental Mediterranean climate with cold, wet winters and hot, dry summers, which can be split into two sub-climates: *Terra Quente* or 'hot land' in valleys and basins at lower altitudes and *Terra Fria* or 'cold land' at higher altitudes (Aguiar and Vila-Viçosa, 2017). While Mediterranean mountains have been European hotspots of agricultural abandonment over the second half of the 20th century (García-Ruiz and Lana-Renault, 2011), this process has recently slowed down in TTM and recultivation processes have gained traction (Imbrechts et al., 2024).

We selected three case study sites that are representative for the different contemporary landscape changes that occur in the region. Using Portuguese official land use data from 1995, 2007 and 2018 (DGT, 2025), we clustered all parishes according to the most dominant direction in which their land uses are changing, e.g. Spontaneous Revegetation, (Re-)afforestation, Return to Agriculture or Mixed Trajectories (Imbrechts et al., 2024). Three parishes located close to their respective cluster mean were chosen to be comparable in area size and distributed in such a way that the region of TTM would be geographically well-covered: (1) Espinhosela, (2) Vila Chã de Braciosa (hereafter "Vila Chã") and (3) Vilas Boas e Vilarinho das Azenhas (hereafter "Vilas Boas") (Fig. 1, Table 1). The change trajectory that is not represented in this selection is (Re-)afforestation, as it has become virtually non-existent in the 2007–2018 period after being prevalent in 1995–2007 (Imbrechts et al., 2024). More details on the selection process are available in Supplementary Material.

### 2.2. Methodology

A causal-historical approach based on event ecology (Vayda and Walters, 1999) starts from observed landscape changes to reconstruct a timeline of historic events. To explain the causal links between observations and events, we used a mixed methodology that includes both quantitative and qualitative data analysis. The observation of LULC changes across an extended period (1899–2018) were complemented with oral history interviews (OHI) which we linked together on a socioecological event (SEE) timeline. This way, we aim to explain the emergence of landscape change processes in TTM in a retrogressive way and connect its current challenges to its ecology, culture and recent history (Antrop and Van Eetvelde, 2017; Meyfroidt, 2016). Historic approaches allow for the description and understanding of complex processes, such as the disappearance of a dune system in the Spanish Canary Islands (Santana-Cordero et al., 2016), the reduction of the landscape mosaic in Catalonia (Tello et al., 2014) and the emergence of agroforestry landscapes in the Mediterranean basin (Wolpert et al., 2020), but it can also explain specific aspects of the landscape, such as soil quality and degradation after agricultural expansion (Carmo and Domingos, 2021) or the influence of the historic practise of leaf litter collection on forest compositions in Central Europe (Bürgi and Gimmi, 2007). Each of these (hi)stories bring insight into the landscape dynamics, its historical range of variability and its adaptability in response to evolving management challenges and narratives (Bürgi and Gimmi, 2007; Dolejš et al., 2019; Landres et al., 1999).

#### 2.2.1. Historic land use reconstruction

We combined various LULC data sources available for the study area, from 1899 to 2018, including maps, aerial photography and official

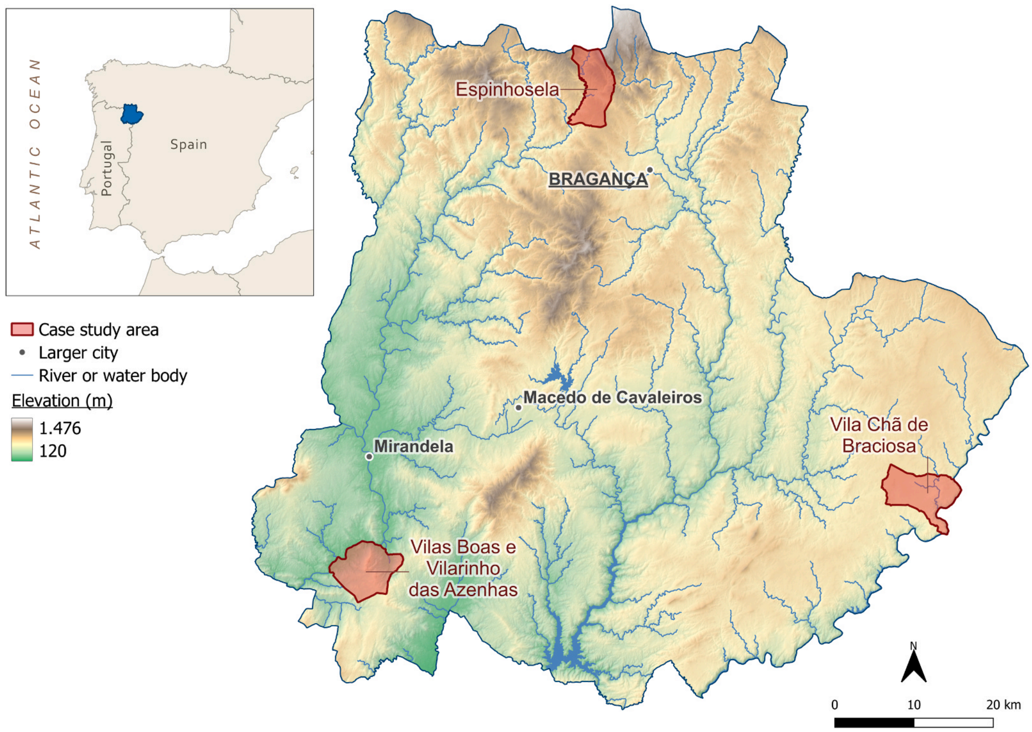



**Fig. 1.** Location of Terras de Trás-os-Montes in the Iberian Peninsula (inset map), its main urban centres and the 3 case study areas in TTM considering elevation profile, rivers and water bodies in the region. Sources: DGT (2025), Gonçalves, Pinhal (n.d.).

**Table 1**
Profile of each case study site and the available historic spatial data types and years. Sources: DGT (2025), Imbrechts et al (2024), INE (2022).

| | Case Study | Area (ha) | Population in 2020 | 1995–2018 Trajectory profile | Digitised maps* / aerial photos^ (year) | Vector LULC maps (year) |
|---|---|---|---|---|---|---|
| a. | Espinhosela | 3 703 | 227 | Spontaneous revegetation | 1899*, 1947^, 1958^, 1985^ | 1978, 1985, 1995, 2007, 2018 |
| b. | Vilas Boas e Vilarinho das Azenhas | 4 296 | 525 | Return to agriculture | 1899*, 1947^, 1958^, 1985^ | 1975, 1995, 2007, 2018 |
| c. | Vila Chã de Braciosa | 4 294 | 259 | Mixed trajectories | 1899*, 1947^, 1958^, 1977–78^, 1985^ | 1995, 2007, 2018 |

LULC coverage to reconstruct the land system's history. For the earliest date available, 1899, we digitised analogue land use maps (*Pranchetas corográfico-agrícolas* or "*Cartas de Pery*"; 1:50 000) that served to inform Portugal's very first land use map published by *Direcção Geral dos Serviços da Carta Agrícola* in 1910. These maps distinguish 31 individual categories of temporary and permanent crops, shrubland, forests, open woodlands (*montado*), pastures and fallows alongside several combined land use types (detailed description in Supplementary Material). We followed the approach developed by Loureiro and de (2021) for georeferencing the maps, using the geodesic markers indicated on the maps, as well as other notable features in case additional reference points were required. Polygons were adapted to natural features such as rivers or streams in more detail when such information could be inferred from the original map. To rule out large discrepancies, we cross-referenced the results with tabular land use data gathered between 1882 and 1910 detailing the area in hectares of different land uses per parish [National Archive Torre do Tombo PT/TT/MOPCI-DGA/E-B/8–1] (Supplementary Material).

Next, we obtained aerial photographs from 1947 at scale 1:29 500 (Pinto et al., 2019), 1958 (1:26 000) and 1985 (1:15 500) which were orthorectified and georeferenced using Agisoft Metashape, following a methodology adapted from the United States Forest Service (2019). We used additional spatial information in vector format to complete the time series (Table 1). The Fireland project's MAF1951–1980 covers the 1975–1978 period for our research area (Sequeira et al., 2022). Data for 1995, 2007 and 2018 was drawn from the Portuguese official LULC maps (*Carta de Uso e Ocupação do Solo* - COS) mapped at a scale of 1:25 000 (DGT, 2022). We followed the COS classification and manually adapted the LULC polygons for 1985, 1958 and 1947 using photointerpretation, adapting the COS 1995 shapefile to the 1985 aerial photos, and henceforth continuing backwards in time. There were a few gaps in the LULC data due to missing photos (1947 in Vilas Boas) or missing detailed LULC categories in cartography (1978 in Espinhosela), which were completed based on the available data from the previous and next date in the time series, choosing the closest reference in time in case these reflected a change in LULC (see Supplementary Material).

We subsequently reclassified the detailed data into six general LULC classes. The agricultural LULC classes were split into "Arable land", which includes annual crops, vegetable gardens and permanent crops (mainly chestnut, almond, olive and vineyards). A crossover class called "Semi-natural areas" was created to cover a broad range of systems that tend to be managed extensively, such as grazed woodlands, naturally irrigated pasturelands (*lameiros*) and other utilised areas with natural elements. The forest categories are "Natural forest", which includes all spontaneous woodlands with native species, and "Plantation forest", indicating even-aged monoculture forestry. Finally, the "Shrubland" category includes all unmanaged areas without tree cover, while a general "Urbanised" class was used to delineate villages and other builtup areas. A detailed overview of the reclassification methods covering the various source materials is available in Supplementary Material. It should be noted that the boundaries between the LULC classes can be quite porous. For instance, areas identified as forests and shrublands may still be used for extensive grazing, but not enough to be considered a semi-natural area. On the other hand, semi-natural systems can at times be quite intensively used, yet topography, rocky outcrops or the presence of trees always retain the semi-natural aspects.

We calculated the transitions in area (ha) between LULC classes in a transition matrix for each study area in the time series in QGIS. We then used NetworkD3 package in R to visualise the area proportions of each of those transitions in an alluvial diagram that spans the entire study period from 1899 to 2018 (Allaire et al., 2017; Seripieri, 2023). For purposes of clarity, only transitions covering a total area > 30 ha were included in the diagrams.

### 2.2.2. *Socioecological event timeline informed by OHI*

We used existing literature on land use and policy change in Portugal (Baptista, 1993; Jones et al., 2011; Mather and Pereira, 2006; Mendes and Dias, 2002; Nunes, 2002; Viegas et al., 2023) to build a timeline that included major socio-political and -economic events, including agricultural and forestry policy changes. This timeline, as well as the observed spatial changes in LULC over time, helped shape an open questionnaire that was used in semi-structured OHI with (elderly) inhabitants with farming experience. We interviewed 6–8 long-term residents in each parish, working with local intermediaries to establish first contact. In total, we did 21 interviews following the guidelines set out by Mohr et al. (2023b). The eldest interviewee was born in 1933 and the youngest in 1970, while the average age of all respondents was 79. Fourteen interviewees were male and seven were female, and this disbalance may have skewed OHI results, although we did not note contradictions in the information shared by each gender group. The open questionnaire also included parish-specific questions based on local events or census data. The interviews were recorded (audio only) and transcribed using AI-based transcription software (HappyScribe), whereby identifying references were removed. Qualitative data analysis (QualCoder) was done on the redacted transcriptions by applying a coding system that focused on causality and driver influence on decision-making processes. Each transcript was assessed with a combined inductive and deductive coding methodology that included land management activities, tenure dynamics, drivers and environmental changes. Statements were also given a timestamp to place them along the timeline. The OHI procedure was approved by the Ethics Commission of the Instituto Politécnico de Bragança. All details regarding the OHI and the coding system can be consulted in Supplementary Material. The benefit of OHI in land system change analysis is that it provides an actor perspective on the decision-making processes that underlie land use changes (Biró et al., 2024; Mohr et al., 2023a). In other words, it allows landscape actors to express their own reasons and motivations for changing specific land use practices, thereby revealing the potential causal effects of policy initiatives. We then returned to the timeline to integrate the local impacts and effects as told by the interviewees, adding additional historic information or published references to contextualise or verify the shared information. The resulting socioecological event (SEE) timeline permits a systematic analysis of socioecological dynamics and feedback loops resulting from those events (Kristensen et al., 2009; Reenberg et al., 2008; Reid et al., 2000).

## 3. Results

### 3.1. *Spatial land use reconstruction 1899–2018*

We visually represented the LULC changes observed in each parish between 1899 and 2018 (Fig. 2), while detailed area proportions for each LULC category across the time series can be found in Supplementary Materials Table S4. In 1899, Espinhosela had a much smaller proportion of semi-natural area (3%) compared to the other parishes, but was mapped as having widespread heath (*Erica* spp.) shrubland areas (53%) located at higher altitudes in the northern section of the parish. Subsequent aerial photos show that by 1947, most of this heathland was intensively used for cultivation and grazing, justifying a classification as semi-natural area. In 1958, freshly implemented forest plantations start to appear, which by 1978 cover most of the northern section (25% of the total area). However, by 1985, much of the plantation forest had transformed once again to a shrubland state. Existing natural forests continued to expand gradually over time (25% by 2018).

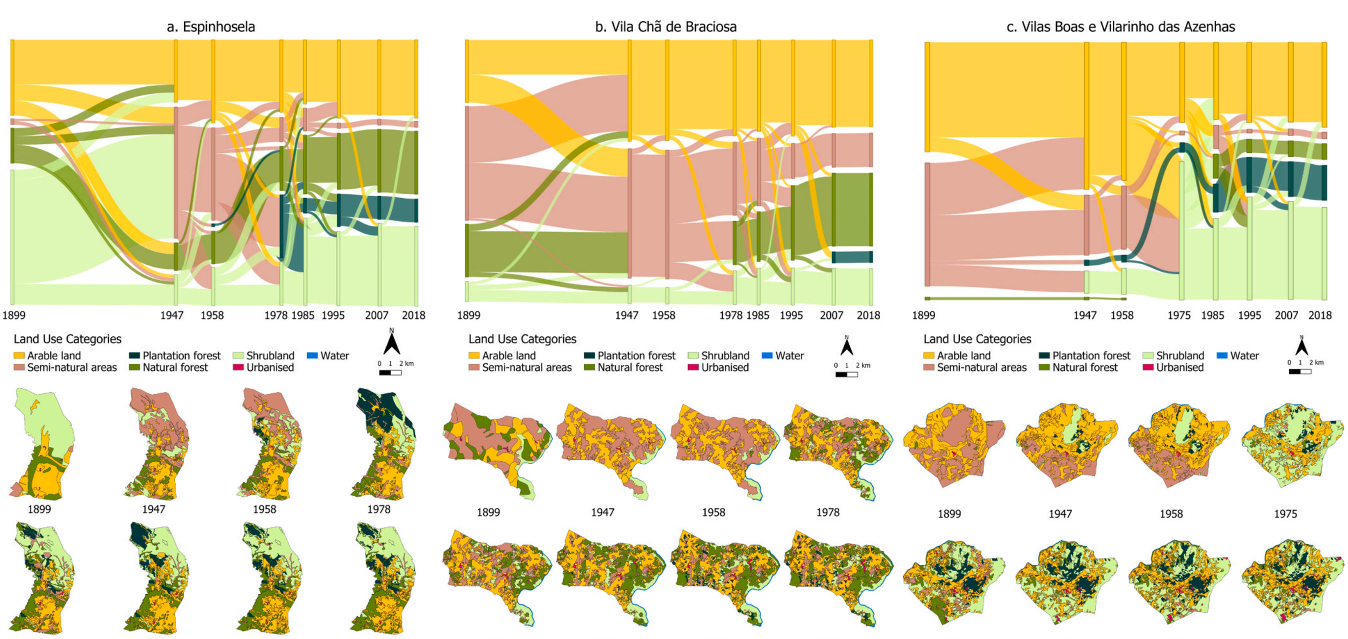



**Fig. 2.** Spatio-temporal expression of LULC changes in the three case study areas between 1899 and 2018 and an alluvial graph demonstrating the scale of the transitions between LULC classes (only transitions >30 ha were included) at each interval. Sources: own elaboration based on DGT (2022), ESA (1995), Sequeira et al (2022).

Its arable land area hovers around 30% across the entire time series.

Vila Chã had the smallest area of arable land of all parishes in 1899 (25%), but it had a comparatively large proportion of natural forest (21%), and its widespread semi-natural areas (45%) mainly consisted of pastures and other extensive grazing areas. Its natural forests were more intensely grazed and cropped during the 1940s and 1950s, turning them into semi-natural open woodlands. After 1978, many of these agroforestry areas returned to a natural forest state. The proportion of arable land remained remarkably stable from 1947 onwards (between 35% and 40%).

Vilas Boas, with its milder *Terra Quente* winters and longer growing season, had a larger area of arable land compared to the other parishes in 1899 (47%). It also experienced agricultural intensification at a larger scale through the transformation of semi-natural areas into arable areas, while the other parishes mainly saw a conversion of natural areas (shrubland and forest) into semi-natural areas. Peak arable land was reached during the 1940s, as by 1958 the first signs of abandonment were already prevalent. After the 1970s, all parishes experienced a steep abandonment of semi-natural areas, yet in Vilas Boas a large portion of arable land was also abandoned (from 57% in 1958–33% in 1975). By 2018, natural (6.6%) and plantation forests (14.5%) had expanded on these former shrublands.

### 3.2. SEE timeline

The SEE timeline (Fig. 3) includes events within and outside Portugal that created the socioeconomic and political context in which agricultural and forest policies took shape. Compared to other Western European countries, Portugal was late to join the industrial revolution and the associated agricultural modernisation (Carmo and Domingos, 2021; Jepsen et al., 2015). With its largely agrarian economy, protectionism and agrarian reform became part of the political strategy around the mid−19th century (Jones et al., 2011). This strategy remained in place while the monarchy ended (1910), through the political turmoil of the first republic (1910–1926) and the *Estado Novo* (1933–1974) corporatist regime (Nunes, 2002; Reis, 1979). In the first phase of the dictatorship, family farms were considered the basis of the Portuguese economy, absorbing much of the available labour force, guaranteeing cheap food production and high levels of social control at the village level (Baptista, 1981).

The corporatist regime applied a colonial mindset to the rural interior, sending out researchers and engineers to better understand the landscape and its economic inefficiencies and opportunities (Silva, 2020). Land reforms were implemented with a campaign to expand and intensify cereal production (*Campanha do Trigo*, 1929–1938) (Pais et al., 1976), followed by the nationalisation and afforestation of many community lands (*baldios*) through the *Plano de Povoamento Florestal* (1938–1977) (Baptista, 2010). These policies caused a rupture in the traditional mixed farming landscape structure, particularly in northern Portugal, which was characterised by small-scale subsistence farming (Baptista, 2010; Mather and Pereira, 2006). Over time, the state's policy priorities shifted towards industrialisation and "agrarian capitalism" (Baptista, 1993). These changes involved radical modernisation projects, but also facilitating the use of chemical fertilisers and expanding market access through infrastructure development, such as grain silos (Pais et al., 1976). Between 1930 and 1950, Portugal's population grew by 23.7% to almost 8.5 million inhabitants (Valério, 2001). Despite a long tradition of (temporary) emigration, the *Estado Novo* regime applied strict border controls and harsh punishments for clandestine emigration (Baganha, 2003; Solsten, 1993). When the state finally started to ease its rigidity on emigration in the early 1960s, a true rural exodus ensued (Baganha, 2003). In addition, Portugal's Colonial Wars (1961–1974) also mobilised 820 000 men, removing many from rural areas (Campos, 2008). An estimated 1.4 million Portuguese – more than 15% of the total population – emigrated between 1960 and 1974 (Baganha, 2003). As of 1975, emigration started to slow down: the general recession made economic opportunities in common destination countries more precarious (Moreira, 1989; Peixoto, 1993).

After a preparatory transition period, Portugal officially became part of the European Economic Community (EEC) in 1986 (European Commission, 2025). Throughout this period, forestry continued to be incentivised as an alternative for agriculture, first with the World Bank's "Portuguese Forest Project" (1981–1988) and the EEC-funded "Forest Action Programme" (1987–1995) (Mendes and Dias, 2002). Subsequent programmes stimulated forest development on smaller scales, including the conversion of agricultural land (Mather and Pereira, 2006). By joining EEC, Portugal also joined the Common Agricultural Policy (CAP), which meant that prices for agricultural products were lowered to EEC-levels, with guaranteed pricing as the main support mechanism (Giuliani and Baron, 2025). In the 1990s, the first CAP reform tried to answer the inequalities between agricultural regions by shifting towards income support and introducing rural development goals (Giuliani and Baron, 2025; Martinho, 2017). The creation of environmental measures such as Less Favoured Areas and Natura 2000 all aimed to be relevant to Portugal's farming context (Caraveli, 2000; Hermoso et al., 2018; Plieninger and Bieling, 2013; Viegas et al., 2023). Overall, the CAP led to an expansion of forestry, increased specialisation of livestock production and permanent crops, while traditional cereal cropping and extensive or multifunctional farming systems reduced strongly over time (Baltas, 1997; Jones et al., 2011; Nunes, 2002; Ribeiro et al., 2014).

### 3.3. OHI results

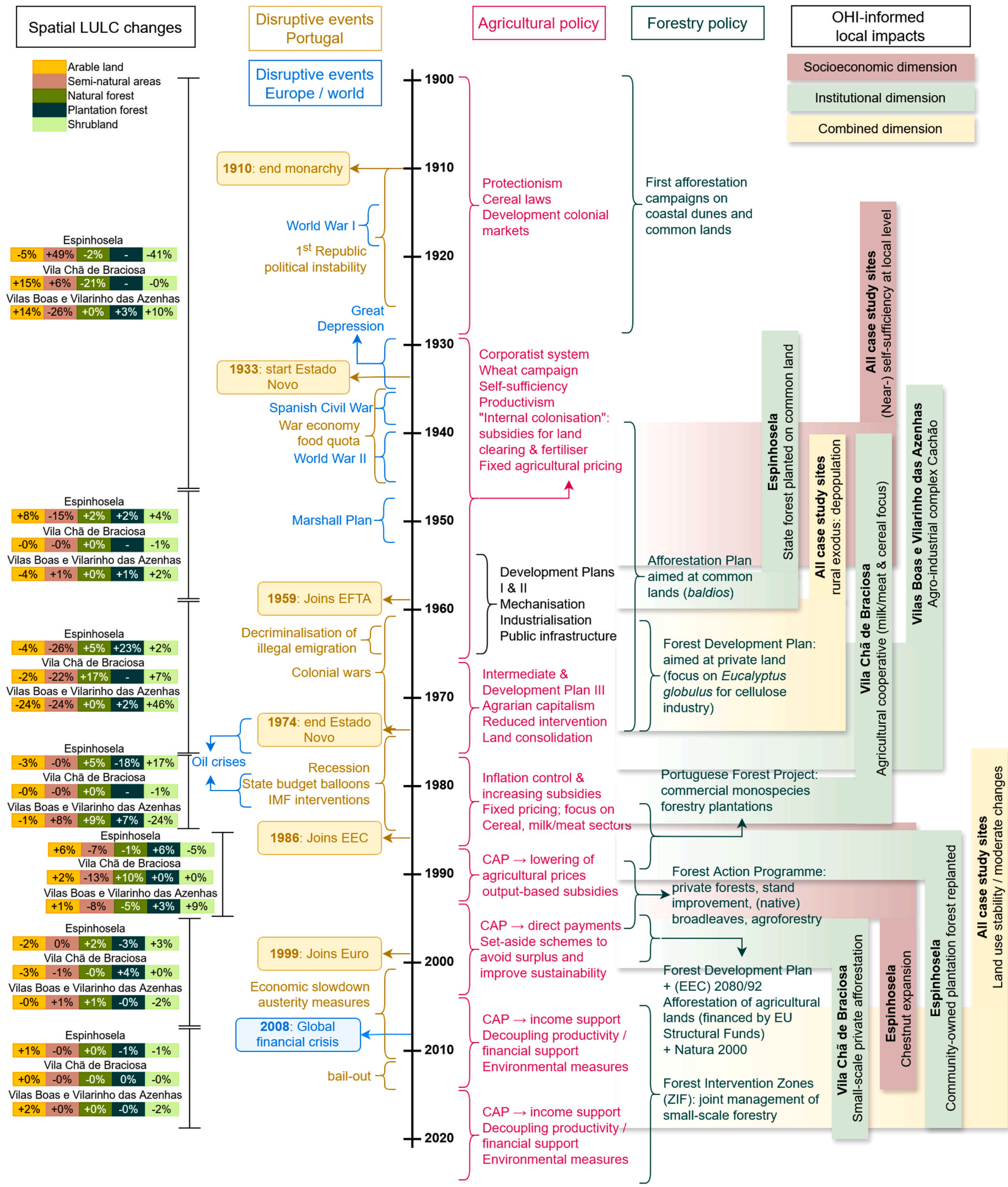
Below we present the results of the OHI split into a socioeconomic, institutional and a personal dimension, while the OHI-sourced information is referenced according to the interviewee code which consists of an abbreviation for the case study area (Espinhosela = Esp, Vila Chã = VC, Vilas Boas = VB) and a number referring to the interviewee who contributed the information (Dossche et al., 2016; Santana-Cordero et al., 2016). The OHI statements are supplemented with additional information from other published sources, including official statistics, books and peer-reviewed literature, to facilitate the integration of the OHI information into local impacts detailed on the SEE timeline (Fig. 3, right-hand side), enabling us to link local events with specific policies or other (telecoupled) contexts.

#### 3.3.1. Socioeconomic dimension

Historically, land use in TTM was organised around the settlements, with fertile horticultural areas in the immediate surroundings (infield), further off dryland areas used in cycles of cereal cultivation, fallowing and grazing by small ruminants, and irrigated grasslands *(lameiros)* alongside streams or in low-lying areas, for more nutrient-rich hay production and cattle grazing (outfield) (Aguiar et al., 2010). Most families had mixed farms that were spatially spread out. Self-sufficiency was the norm while any surplus was sold at markets and fairs to cobble together enough money for essentials which was hard for everyone, even those who had more means (Esp1–4; VC1–4).

> *'We had the cows on the lameiros … there were no olive trees up here, they were all by the [river] canyon … the vegetable gardens too … they were not near the house [but] by the creek' (VC1).*
>
> *'Everything was for consumption … Nothing was wasted; nothing was lost' (Esp4).*
>
> *'My mother, with that little donkey, would go to Bragança, sell potatoes, and I did that too … so we could buy what we needed there' (Esp1).*
>
> *'It wasn't about being expensive. There wasn't money like there is today, you understand' (VC4).*

The spatial organisation of the rural community was overlaid with variable land access systems that mixed feudalism and private property with commons (Rodrigues, 2000). Feudalism was abolished in the 19th




| | Arable land | Semi-natural areas | Natural forest | Plantation forest | Shrubland |
|---|---|---|---|---|---|
| Espinhosela | -5% | +49% | -2% | - | -41% |
| Vila Chã de Braciosa | +15% | +6% | -21% | - | -0% |
| Vilas Boas e Vilarinho das Azenhas | +14% | -26% | +0% | +3% | +10% |
| Espinhosela | +8% | -15% | +2% | +2% | +4% |
| Vila Chã de Braciosa | -0% | -0% | +0% | - | -1% |
| Vilas Boas e Vilarinho das Azenhas | -4% | +1% | +0% | +1% | +2% |
| Espinhosela | -4% | -26% | +5% | +23% | +2% |
| Vila Chã de Braciosa | -2% | -22% | +17% | - | +7% |
| Vilas Boas e Vilarinho das Azenhas | -24% | -24% | +0% | +2% | +46% |
| Espinhosela | -3% | -0% | +5% | -18% | +17% |
| Vila Chã de Braciosa | -0% | -0% | +0% | - | -1% |
| Vilas Boas e Vilarinho das Azenhas | -1% | +8% | +9% | +7% | -24% |
| Espinhosela | +6% | -7% | -1% | +6% | -5% |
| Vila Chã de Braciosa | +2% | -13% | +10% | +0% | +0% |
| Vilas Boas e Vilarinho das Azenhas | +1% | -8% | -5% | +3% | +9% |
| Espinhosela | -2% | 0% | +2% | -3% | +3% |
| Vila Chã de Braciosa | -3% | -1% | -0% | +4% | +0% |
| Vilas Boas e Vilarinho das Azenhas | -0% | +1% | +1% | -0% | -2% |
| Espinhosela | +1% | -0% | +0% | -1% | -1% |
| Vila Chã de Braciosa | +0% | -0% | -0% | 0% | -0% |
| Vilas Boas e Vilarinho das Azenhas | +2% | +0% | +0% | -0% | -2% |

**Fig. 3.** SEE timeline depicting major sociopolitical or economic events affecting Portugal (left of timeline) from 1900 to 2020 that form the context in which land use policies took shape (right of timeline). Quantitative impact on LULC (change in % of total area for each category) for each parish is presented on the left-hand side. Qualitative information regarding the local impacts was added after conducting the OHI (right-hand side). Sources used for the timeline elements: Baptista (1993), Jones et al (2011), Mather and Pereira (2006), Mendes and Dias (2002), Nunes (2002), Viegas et al (2023).

century (Pires, 2021), but the church and rural nobility continued to play a central role in the social and administrative organisation of most communities (Baptista, 1981). In the OHI, respondents mentioned stark economic differences at the local level, detailing how people with little means were desperate enough to work for wealthier residents at miniscule wages [Esp4−6; VB3−4–5, VC3]. In Vilas Boas, few families controlled much of the land (VB5) but also held the rights to the grain mills [VB1−3–4−5]. In Espinhosela, land ownership was more equal, and grain mills were part of the commons, but wealthier inhabitants relied on the cheap labour of poorer inhabitants to work their fields.

*'Half was for the owner and half was for us. Back then the owner would give us a pittance. [It] was a pittance' (VC3).*

*'Part of the land wasn't theirs; maybe 80% was rented. [People] had to rent land because those who didn't farm, didn't have [food]' (VB5).*

*'Here, the rich have always been well off because they forced the common people to work for them, as they had nowhere else to work' (Esp5).*

*'[My father] paid dues [to operate the mill] … it's like renting a house. That mill belonged to [a lady from] Vilas Boas' (VB1).*

This situation started to change in the 1960s, when mass emigration severely reduced the size of the available labour force, after which many landowners started selling land or lowering rents [Esp5; VB3−4–5]:

*'The poor started to manage to get something after they started to emigrate. Yes, before they emigrated, there wasn't any [land available]' (VB4).*

Secondly, there is a strong tendency towards agricultural specialisation in TTM, partly determined by the environmental conditions. Espinhosela experienced a chestnut boom since the 1990s and all respondents confirmed transforming most of their cereal fields into chestnut orchards during the last decades [Esp-all]. Chestnut orchards had been widespread in Espinhosela in 1899 as well (17%), but its area had diminished to just 5% around the 1950s. However, the crop has been plagued by disease, pests and mortalities in recent years [Esp1−4–6−8], which makes the parish quite vulnerable:

*'[Back then] who cared about chestnuts? … It was all potatoes [that mattered]' (Esp4).*

*'Here in our village, there were always plenty of chestnuts, but now the supply has tripled' (Esp6).*

*'For now, this village persists because of chestnuts' (Esp7).*

The parish of Vila Chã is part of the *Planalto Mirandês* subregion that has long been known for its cattle production. While Mirandese cattle were appreciated across *Terra Fria* for their capacity to work the fields, their beef is also valued and currently holds a protected designation of origin status. After the revolution in 1974, some farmers temporarily switched to dairy cows [VC2−4–6].

*'We ploughed the land with cows, we fetched firewood with a cart pulled by cows, we did everything with cows, there were no tractors' (VC1).*

*'Back then, there was a milking stable down there, there were about 200 Turina cows here … all [for] milk. Because milk, back then, paid well' (VC2).*

Cattle numbers remained fairly stable over time: in 2019 there were 412 heads of cattle in the parish, while the average number between 1934 and 2019 was 518, even though the number of farms with cattle has reduced significantly (138 at its peak in 1955 compared to just 15 in 2019) (INE, 2025, 1973, 1958, 1941). Unsurprisingly, Vila Chã has also maintained a comparatively large semi-natural area (13% in 2018), mainly consisting of extensive grasslands.

In Vilas Boas, historic farming was centred on olive production, which continues to be the most widespread crop. Permanent crops such as almond were also incentivised by strong CAP support in recent decades [VB3−4–5]. While the market for olive oil has been quite reliable, most respondents only produce for their own (and their wider families') consumption, as market access, prices and payments remain tightly controlled by the olive presses, with limited transparency, in an echo of past times [VB2−3–4−5–6−7]:

*'We sold [olive oil] but they never paid. Last year's [harvest] stayed all there' (VB2).*

The region's remoteness has long been a limiting factor that has also contributed to its modest industrial development. Aside from agriculture, work opportunities were always few and far between. In fact, only two interviewees had non-farming careers outside government [VC3; VB1]. All former emigrants mention the lack of work opportunities as the main reason to move away [Esp2−4–5; VC1−2–3−4; VB1−3–4−5], which affected young people across the entire spectrum of wealth:

*'[All] the young [people had to emigrate]. Because there were no factories here, there was nothing, right?' (VC1).*

#### 3.3.2. Institutional dimension

Few people relate that the government had an influence on their land-use decision-making during the Estado Novo regime. Most simply remember that the value they received for their agricultural produce was comparatively higher [VC1−2–6; VB5], yet one interviewee recalled that cereal production was subsidised indirectly:

*'[The State] would order wheat from abroad because Portugal never had enough wheat to eat, so [they] would pay five abroad and they would pay us six … a discrete subsidy like that' (VC5).*

Despite the restrictive nature of the regime's policies, many people still described the government as a faraway entity with little interest in their lives, except as a regulator:

*'As agriculture declined, people [started working as] foresters, as police officers … they would come asking for information, because that was the government we had … they called [many] people communists' (Esp1).*

Nevertheless, the government initiated several large-scale development projects with high local impacts. In Vila Chã, the construction of a hydroelectricity dam in neighbouring Picote (1953–1958) created a rare temporary work opportunity and market for produce [VC1−2]. In Vilas Boas, a state-funded development project took shape in the form of an agro-industrial complex in the neighbouring hamlet of Cachão. This regional agricultural hub was constructed between 1964 and 1968 and included processing facilities for all types of regional produce (Viseu, 2007). The complex, run and managed as a single entity, provided ample work opportunities for many local inhabitants [VB-all] as well as a market opportunity for farmers. The project did not survive the turbulence of the 1970s and most of its facilities were closed by 1977 (Viseu, 2007):

*'There was the olive press, chestnut, … there was a lot, a lot, a lot, a lot of work' (VB4).*

*'The farmers planted peppers, beans, everything, and that's where they took it, delivered everything to that [canning] factory' (VB7).*

The Afforestation Plan (*Plano de Povoamento Florestal*, 1938–1972) was initially created to optimise land use in Portugal and affected two of the case study sites: Espinhosela and Vilas Boas. Pine plantations were implemented in Espinhosela at the end of the 1950s, specifically in the hamlet Vilarinho, which actively integrated access to and use of its extensive *baldios* (1 550 ha according to the then-government (JCI, 1942)) in its socioeconomic organisation at the time [Esp-all] (Rodrigues, 1999). These common lands were abruptly appropriated by the state, leading to local defiance [Esp1−4]. This is easily perceived as the cause for the mass emigration that followed, but emigration was as fierce in other parishes without such levels of disruption:

*‘If I wanted to go cut some broom, some heather, I would have to go and ask [permission from]* [dismissive] *His Excellency, the Forest Guard’ (Esp4).*

*‘Ever since the forest came, emigration began… families have had to leave… wherever they could go. Because they lived off firewood, some charcoal making and agriculture. The forest came and tied their hands and feet’ (Esp1).*

Following the revolution in 1974, the new government offered communities like Vilarinho the chance to reclaim their *baldios*, which they did. By then, the parish had already lost about 35% of its population compared to 1950 (INE, 2014) while the number of small ruminants had halved (INE, 1973, 1958), resulting in reduced grazing and management activities on their common land areas. Multiple wildfires returned much of the now community-owned forest to shrubland after 1978 (ICNF, 2025), some of which was replanted in the following decade with new funding schemes.

Vilas Boas already had mature plantation forest present when its largest *baldio* (*Serra do Faro*) was slated for afforestation (JCI, 1942). Even though considered common land, much of the area was privatised and individual fields were leased to landless farmers needing to cultivate every available inch of land to feed themselves [VB3−4−5]. Vilas Boas had a larger population (INE, 2014), resulting in more pronounced pressure on the land, making restorative practices such as fallowing impossible. Unsurprisingly, many of these eroded areas were abandoned as early as 1958, as inhabitants moved to Brazil and the African colonies in search of a better future [VB1−5], which is also apparent in the spatial analysis. The actual afforestation of *Serra do Faro* was only implemented by the Portuguese Forest Service between 1975 and 1985, without any social disruption.

*‘[Fallowing] is how [land] should [have been] treated. But the poor had no [other] land, so they had to make do’ (VB4).*

*‘The forest occupied a lot of our [privately owned] land’ (VB6) … ‘It wasn’t registered in the land registry office even though it was a large area’ (VB7).*

The most impactful policy change happened when border control policies became less rigid. Even though illegal emigration had been common, the exodus truly started in the 1960s

*‘[We crossed the border] without getting caught. We were quick bunnies’ (Esp8).*

*‘I went to France in 1968, October 1968. It was when Salazar died … Many people had already left. Almost half of the population had left. And afterwards even more left’ (VC3).*

Many people relate that, since joining the EU and CAP, agricultural subsidies have made a big difference [Esp1−7−8; VC1−6-; VB2−5], especially in the early days. Yet some also believe that the policies contributed to processes of abandonment and extensification:

*‘Back then they paid more, better than now… It's not like it used to be’ (VC6).*

*‘People didn't want to stop [farming], [the government] stopped them with money … we were forced not to grow cereal’(Esp1).*

Others stress the system should be fairer and less bureaucratic (VC3−6; VB2), although some also made good use of new opportunities presented:

*‘Subsidies are a fortune, you understand? For many people, but not for me … for others, yes, those who have many [animals], they are fortunes’ (VC3).*

*‘Pine, cork oak, and ash trees. I planted all of that. That's all gone now. But that was for 20 years. I have land that was paid for and repaid for. It's not worth what I received [for it]’ (VC2).*

In any case, practising full-time agriculture today requires persistence, an entrepreneurial spirit and a willingness to deal with a lot of paperwork [Esp7–8; VC6; VB2]:

*‘I am insane, I am insane [to be farmer]’ (VB2).*

*‘I [managed contracts to] supply three supermarkets. I do everything. I have a transport van to go to the slaughterhouse…’ (VC6).*

### 3.3.3. Personal dimension

Not mentioned on the SEE-timeline is the fact that the OHI also revealed that land management decisions are a very personal matter. For instance, changes were often made after disruptive personal events, for example after a serious accident, illness or death in the family [Esp1−3−6−7; VC1−2–4; VB5]:

*‘Then [my father] had a stroke and he also passed away. … After that, my mother was alone. That's it, we sold the cows and… Then it all ended’ (VC1).*

In total, 13 of the 21 interviewees emigrated, of whom five returned after a short period abroad, while others stayed for ten years or more. Many are nostalgic for the strong social fabric their villages used to have [Esp1−3−4−6−7; VC1−3−4−5; VB3–4) even though times were hard:

*‘We used to be more united because we were all poor, right? Now some people think they are better than others, and that makes them more two-faced’ (Esp3).*

*‘The women used to come, seven or eight of them, to harvest for a week. And today there's nobody here … I miss those times’ (VC4).*

Nevertheless, most maintain strong place attachment, even when their families live far away. Several respondents talked about the peace and sense of belonging they feel, despite the many challenges [Esp1−3–5; VC1; VB6−7]. This hardship may also have contributed to attachment people have to their agricultural land as a source of identity, (partial) subsistence and a safety net for uncertain times (Baldwin et al., 2017; Marks-Bielska, 2013), which may disappear with the next generations of landowners. Nevertheless, most respondents have (grand) children who (occasionally) partake in the current land management activities and harvests [all except Esp6−8; VC6].

## 4. Discussion

Our spatial analysis confirmed earlier research findings for the case study region that land use intensified during the *Estado Novo* dictatorship, followed by a period of abandonment (Amaral and Freire, 2017). However, the OHI revealed that the socioecological relationships within the landscape remained similar throughout this period, with most inhabitants practising subsistence agriculture in the absence of other work opportunities. The legal or financial obstacles against outmigration during the dictatorship, a longstanding solution, kept a fast-growing rural population stuck in place and inevitably led to increased agricultural land use to facilitate said subsistence. Despite the investments made during this time to create a modern, productivist land system, TTM quite easily reverted to extensive land uses once the pressures of the authoritarian state started to wane. This brings nuance to the agricultural abandonment trends observed from the 1960s onwards. It also shows that even within regions that are depicted as dynamic on a European scale, a high level of persistence can be found (Bürgi et al., 2015). As the OHI confirmed, CAP policies have also permitted the region to embrace a certain degree of post-productivism (Mather et al., 2006), with set-aside, the afforestation of agricultural land and incentives for permanent crop planting among its measures. Modern farming techniques have rarely led to either modern productive or environmentally sustainable farms though, rather, they helped many elderly or otherwise employed farmers to continue in a less demanding way (MacDonald et al., 2000). With an average area of 8.62 ha in 2019 (INE, 2025), most farms are modest in size, aiming for (partial) subsistence and/or supplemental income from small-scale production and aided by CAP subsidies. This may be more indicative of a lock-in state described as a "trap" or a tendency of the system to always return to the same equilibrium state (Allison and Hobbs, 2004). TTM's land system dynamics seem to oscillate between a few closely related alternative states. The region has seen millennia of varying intensities of human land use (Blondel, 2006), accompanied by de- and repopulation, de- and reforestation, as well as the loss of certain keystone fauna species (e.g. extinction of the European beaver around the 14–15th century) (Pinto et al., 2010). Anthropogenic influence grew while natural processes that increase resource availability, such as microclimate regulation or soil formation, reduced in expression (Butzer, 2005; Godinho et al., 2016; Pinto et al., 2010). This resulted in strongly path-dependent systems, where changes can be characterised as "adaptation responses" to outside pressures (Zariņa, 2013), rather than regime shifts. As each case study site confronted slightly different sets of external forces, such as the loss of common land in Espinhosela or the elevated population pressure in Vilas Boas, variations in landscape change trajectories emerged. The causal chains resulting from these changes persist to this day, which may help explain the spatial variability in today's landscape change trajectories. Finally, the concept of path dependence also highlights that our research outcomes were determined and limited by how far we were able to go back in time (Santana-Cordero et al., 2024).

Recent policy initiatives are focused on sustaining the anthropogenic influence and protect against wildfires by increasing the scale and means of land management activities, for instance the Land Transformation Programme for collective/joint forest management (DGT et al, 2020) or land parcel sizes and farm viability by promoting land consolidation (DGADR, 2025). While these measures may reduce wildfire risks in poorly managed forests and enhance farming scale, they do not address the core of the path-dependency, namely that TTM is characterised by a subsistence farming land system incompatible with current European livelihood standards. Marginal conditions and historic lack of investment in remote regions contributed to the 'lock-in'-effects, resulting in what Sarkki et al. (2025) call a "multidimensional polytrap", whereby path dependence, institutional rigidity, poverty and lack of development all intertwine. Even with CAP-support, OHI respondents admit that fulltime farming is incredibly hard today, value chains are poorly developed and non-farming career opportunities remain limited. With increased scales of operation, agro-enterprises or renewable energy investors may be attracted to the region, but this is unlikely to improve the landscape polarisation (or population) dynamics (Almeida, 2020). Even though there is still a reasonable number of ruminants in the landscape (−19% in 2019 compared to 1955 across all case study sites (INE, 2025, 1958)), large areas of formerly semi-natural extensive grazing areas are rewilding, which might increase the supply of ecosystem services (Sil et al., 2016) but also the risk for destructive wildfires (Moreira et al., 2001; Sil et al., 2019). Access to fossil fuelled tractors replaced the historic use of cattle and equines fed on aboveground biomass fuel, hence today's shepherds can simply choose the best pastures available – unless they are incentivised to expand their grazing areas (Pinto et al., 2023). Nevertheless, local people are still managing land if risks are low (for instance they have alternative sources of income) and rewards or support is guaranteed – at least for now. The OHI proved that the socioecological bonds are strong and passed on, even to absent (grand) children. The same values also appear in local NGOs and initiatives that have embraced the particularities of this region and work to protect them. In such a scenario, it may be worth aiming for improved land management standards that maximise environmental returns (with economic importance) rather than purely productive ones. This requires a better understanding of the ecology of the landscape and its varying responsiveness to either climate-smart (rewilding, afforestation) or fire-smart (agroforestry, agriculture) management approaches (Campos et al., 2022).

## 5. Conclusions

This study used a mixed methods approach in combining OHI, secondary sources of historic information and a spatial analysis over an extended timeframe using available vector data, aerial photography and historic maps. This approach provided complementary insights in terms of the land change processes as well as a distinction between how things are perceived and how they show on a map. For instance, while there has been (local, national and international) preoccupation with agricultural abandonment, the long-term analysis indicates this is partially a recalibration process after profound land use intensification, rather than a true regime shift. SEE timelines are particularly useful to address the influence of driving forces that are hard to quantify, including policy interventions, technological evolutions and economic factors, however they do not lead to straightforward policy recommendations, nor do they capture personal motivations. While being a functional tool for building causal chains or showing path-dependence in land systems, they mainly highlight variability and complexity, even within a relatively homogenous socioeconomic and -ecological context such as TTM. In addition, the study presents an isolated and very localised outtake of a much longer history as told by a limited number of people, i.e. this (hi) story can never be conclusive, "finished" or replicated elsewhere. Still, studying longer-term LULC histories is useful to understand the potential impact and reach policy initiatives might have on these land systems. Here we have seen that most policy initiatives, including some aiming for profound changes, had relatively short-term impacts without changing the overall trends or land systems in the area, mostly because the policies were too short-lived to address the underlying factors of the path-dependence. Future research should address the role of policy durability and longevity in directing land system trajectories. In addition, comparing the influence of megatrends across different yet similar local land systems may be more revealing for studying regime shifts than focusing on policy analysis alone. Finally, our results indicate that land systems are often the result of deeply held values on the human-land relation and are therefore a reflection of the socioecological system. Disruptive change does not necessarily alter these underlying values, which is also an asset that can be geared towards achieving beneficial socioecological results.

## CRediT authorship contribution statement

**Imbrechts Lien:** Conceptualization, Funding acquisition, Investigation, Methodology, Visualization, Writing – original draft. **Azevedo João C:** Conceptualization, Funding acquisition, Methodology, Supervision, Writing – review and editing. **Bürgi Matthias:** Writing – review and editing. **Dossche Rebekka:** Funding acquisition, Methodology, Investigation, Writing – review and editing. **Bürgi Matthias:** Writing – review and editing. draft. **Verburg Peter H:** Conceptualization, Funding acquisition, Methodology, Supervision, Writing – review and editing.

## Declaration of Competing Interest

The authors declare no competing interests.

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## Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.landusepol.2026.108152.

## Data availability

Data will be made available on request.

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