

Article

The (Evolving) Vineyard's Age Structure in the Valencian Community, Spain: A New Demographic Approach for Rural Development and Landscape Analysis

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Abstract: Vineyards have assumed a key role as rural landmarks in recent decades. Investigating vineyard dynamics and contexts may reveal various economic, cultural, and environmental aspects of rural landscapes, which can be linked to land-use changes and major soil degradation processes, including soil erosion. As a contribution to rural landscape studies, the purpose of this work is to investigate the spatial distribution of vineyard plots in the Valencian community, located in the eastern area of the Iberian Peninsula, focusing on the final product, the type of vineyard and how long each vineyard has been settled over time. The work provides a comprehensive analysis of a wine-growing landscape, considering strategic (spatial) assets in present and past times. Vineyards were interpreted as a distinctive landmarks that give value to local economies; basic knowledge of how long different types of wine plots have been present in the Valencian community is useful when estimating their degree of sustainability and formulating suggestions, policies, and strategies to prevent processes of landscape degradation at various spatial scales.

Keywords: vineyards; age class; land-use change; landscape structure; soil degradation

1. Introduction

In the last few decades, vineyards have assumed a key role in the primary sector. Their recent expansion in several rural areas in Mediterranean Europe reflects a cultural heritage (re)acquired from a local product revalued over time. In respect to other agricultural crops, the cultivation of wine provides high economic profitability [1,2], and determines both positive and negative socio-environmental impacts and implications [3].

Among emerging concepts, the ‘terroir’ notion was introduced to highlight the contribution of vineyards to cultural, social, and economic heritage [4,5]. Around the world, the Mediterranean agricultural landscapes in Europe achieve a multifunctional role that surpass the traditional production of commodities and food, by providing further advantageous services, e.g., socioeconomic viability of rural areas and protection of biodiversity [6–11].

The impact of vineyards was primarily focused on a plot scale, applying biophysical approaches [12–14] and interpretative frameworks more oriented to social sciences [15,16]. However, a broader analysis of spatial and temporal changes in vineyards is required to offer a more comprehensive interpretation of landscape complexity in rural Mediterranean contexts [17,18]. A specific and additional objective is to address complex socioeconomic dynamics vis à vis current challenges [19,20], e.g., climate change [17,21,22], soil degradation, [23–25] and desertification [5,26–31].

From the environmental point of view, concerns about the negative impact on soil quality, as well as the occurrence land and water losses due to non-sustainable management of vineyards have frequently emerged [32]. Vineyards produce the highest soil and water losses [27–30]. For instance, other Mediterranean orchards, e.g., persimmon [33], citrus [34,35], olive [9,36,37], apricots, [38] and avocado, [39] bring more sediment and water than neighboring natural areas [3]. Vineyards are a tree crop associated with environmental vulnerability [27–30,40] due to their lack of leaf cover during the winter and low plant cover in summertime [3,30,41–47]. Generally, the main driving factors of soil erosion in vineyards are: (i) lack of vegetation; (ii) high slope angles; (iii) weak soil aggregate permanency; (iv) risky rainfall events, permitting rapid raindrops access to the soil surface; (v) intensive tillage; (vi) applied chemicals that increase soil contamination; and, (vii) nutrient impoverishment due to the lack of organic fertilization [48–50].

Today a conflicting situation is caused by the recent growth of the (highly profitable) wine-growing regions in Mediterranean landscapes; on the one hand, there is an increase in wine consumption and the use of intensive management techniques due to the high demand (and appreciation) of wine in the economic market [13,26], on the other hand, wine cultivation has led to a decrease in local biodiversity and high rates of soil erosion and degradation in several local landscapes [50,51]. Some improvements to reduce soil losses in vineyards, e.g., the use of organic farming strategies [52], have been implemented. At the same time, enduring plant cover is useful for managing rural land and water resources in a sustainable way and consequently preventing soil erosion and desertification processes [53,54].

Recently, researchers have shown that the age of vineyards can portray a key factor of environmental sensitivity, useful for monitoring soil erosion processes [3]. In fact, the planting of new vineyards leads to an increase in soil erosion, possibly leading to greater exposure to land degradation [31,55]. Therefore, the areas that are both (i) more prone to intensive wine production and (ii) more sensitive to higher erosion rates [27] seem to coincide with the youngest vineyards [55]. While, older root systems can reinforce hillslopes against erosion better than young root systems [55]. Due to this discovery, recent studies are increasingly dealing with the impact and influence of the age of plantation on forested soils and agricultural fields with trees [3,55,56].

Based on these premises, the purpose of the present work is to analyze how vineyard plots are distributed in the Valencian community, located in the Iberian Peninsula. Studying each plot according to age, type of vineyard, and the final product provides a contribution in the analysis of rural landscapes dominated by vineyards of different ages and functions. Studies on the demographic balance of vineyards by age class are relatively recent. For instance, one example came from Italy and covered a relatively short period [56] and another came from the Southern Spain [3]. Vineyards were considered a distinctive landmark of the local economy and rural landscape in the Valencian community, a typical Mediterranean region. Distinguishing different types of wine plots, their spatial distribution, and their age, the present analysis contributes to a broader reflection on rural landscape development and sustainability, allowing formulation of informed suggestions, policies, and strategies to prevent soil degradation processes.

2. Materials and Methods

2.1. Study Area

The Valencian community is located along the Mediterranean Sea coast on the eastern side of the Iberian Peninsula (Figure 1), and extends along a coastal line towards the mountains, presenting a variety of representative Mediterranean environmental conditions. The Valencian Community is

divided into three provinces, Valencia is the capital city and the third largest metropolitan area in Spain (indicated with a star in Figure 1), Castellón de la Plana, and Alicante. The area has 518 km of coastline on the Mediterranean Sea, covering a total area of 23,255 km², with 4.5 million inhabitants and 534 municipalities. The entire region can be classified a Mediterranean climate regime, even if the western area has a more continental climate with less humidity and broader diurnal swings.

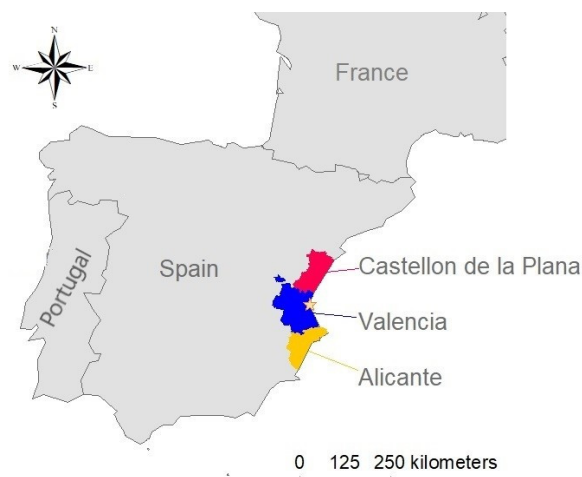


Figure 1. The Valencian community, its three provinces (Castellon de la Plana, Valencia, and Alicante), in Spain.

Spain is the second-largest producer of grapes for wine in Europe, encompassing 29.6% of Europe's yearly wine production [53,57]. The Valencian community is known for its traditional vineyard areas, which also produce quality products [58,59]. Valencia is responsible for 5% of the enological production in Spain since it is the fourth most extensively planted area with 61,226 hectares under vine crop. Valencia district was initially recognized for its bulk wine, the Bobal wine, which is native to this area and is the third most widely planted grape in Spain; other cultivars are Airén and Tempranillo.

Three distinct DOs (denomination of origin) were officially located within Valencia's boundaries: (i) the southern area in Alicante, (ii) the most inland region of Utiel-Requena, and (iii) Valencia. DO wines have to be produced and processed in a defined area and enjoy great commercial prestige because of their origin (at least 5 years, with prior geographical protection). Vine quality and characteristics depend on contextual factors, which include natural and human conditions. Only Utiel-Requena is considered a contiguous area, while both Alicante and Valencia consist of distinct portions of land connected within a normative DO district.

2.2. Data and Variables

The available data from the Agrarian Studies Service of the Generalitat Valenciana were collected and processed. As a snapshot of today's situation, data refer to all existing vineyard plots in the Valencian community. Therefore, it is not possible to study how many vineyards have been lost over time, but the present study explores how long the current vineyards (2017) have enriched the rural landscape in the region, considering the vineyard's age structure from a demographic point of view. Data describe all the rural plots intended for viticulture indicating the type of wine cultivated, the year in which each vineyard was planted, if each vineyard is labeled as protected designation of origin, the surface area occupied by each plot, and in which municipality it falls.

Through analysis we evaluated the surface area occupied by type of wine and final use of the wine produced in each parcel. Each wine parcel was dated according to the year of its planting, which was useful in defining how long it has been present in the Valencian landscape. Based on this information, the periods of greatest expansion of the vineyards (both in number of plots and

extension of occupied surface area) can be identified (also according to the final product cultivated). By these means, it is conceivable to detect in which time period a greater fragmentation of vineyards took place. Indicators were illustrated on maps by means of a Geographic Information System (ArcGIS release 10.x, ESRI Inc., Redwoods, CA, USA). In this way, vineyard distribution can be detected at different spatial scales (from local to regional), offering a comprehensive analysis of vineyards' landscape in the Valencian Community.

3. Results

Descriptive Analysis

In 2017, about 71,000 ha were devoted to wine production in the Valencian Community. Three basic indicators are represented in maps (Figure 2):

- the number of wine parcels in each municipality (a);
- the density of wine parcels understood as the number of parcels on the municipal surface area (b);
- and the average age of wine parcels by municipality (c).

The greatest landscape fragmentation of vineyards was observed inland of the Valencian community, but also in local contexts where the average age of the vineyards is around 5 and 25 years. The northern area displays a more homogeneous and dense vineyard landscape, revealing a historical presence of vineyards. On average, many northern municipalities recorded an average age of their existing plots above 45 years.

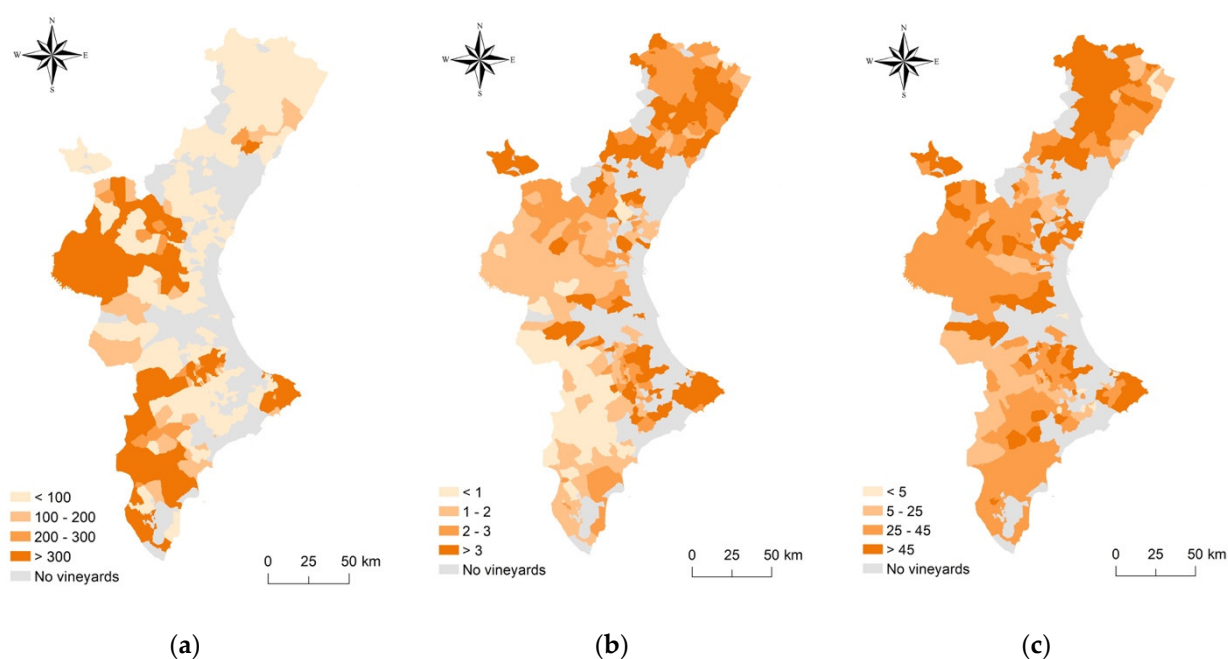


Figure 2. Number of wine parcels in each municipality of Valencian community (a); density of wine parcels (b); and average age of wine parcels per municipality (c).

Eight out of ten vineyards in the Valencian Community were cultivated for winemaking processes ('V' in Figure 3). Table wine ('M') was also appreciated in the area and represents 17% of the cultivated wine. Moreover, a good portion of land in Valencia's province was destined to the cultivation of mother vine variety (1%) ('PM'). Few parcels were also designated to satisfy family consumption, experimentation and wine passification (to make "*passito*" wine). The wines that are produced by the oldest plots include: Garnacha Peluda, about 67 years old on average; Leopoldo III

(65 years old); Zalema (62 years old); and Grumier Tinto (60 years old). The youngest vineyards preferentially produce Marselan and potential graft mother vine variety.

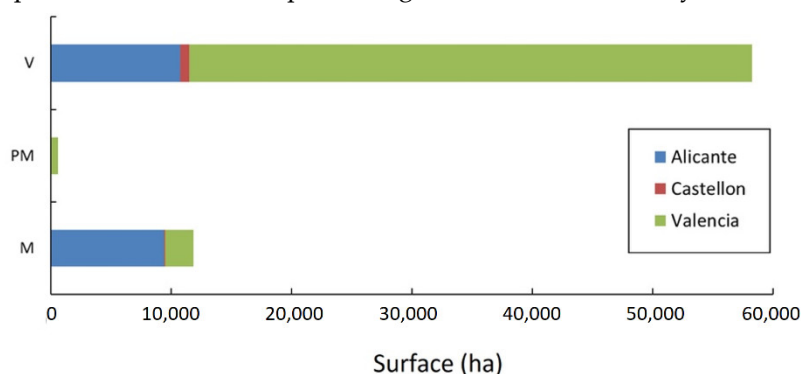


Figure 3. Type of wine cultivated (winemaking processes: ‘V’; table wine: ‘M’; mother vine: ‘PM’) in each province of the Valencian Community.

As well as providing a source of income for the agricultural economy, vineyards are a characteristic landscape in the Valencian community. Following a 10-year historical series, they have experienced a considerable expansion in the 1960s and 1970s (Figure 4). About 23% of the existing vineyards were specially planted in the 2000s. Mainly vineyards are dedicated to winemaking, while the current vineyards used only to make table wine were planted mostly among the 1970s and 1990s. Consequently, the largest area for table wine vineyards was established specifically in those years, offering more commercial wines in the economic market. Figure 4 reports a current assessment of vineyards (in 2017), following their planting year (x-axis) and surface areas in the Valencian community (y-axis, in mega hectares) according to each final wine product. Other uses of the wine have been reported with other (‘O’) but have a minimal relevance as can be seen from the Figure 4.

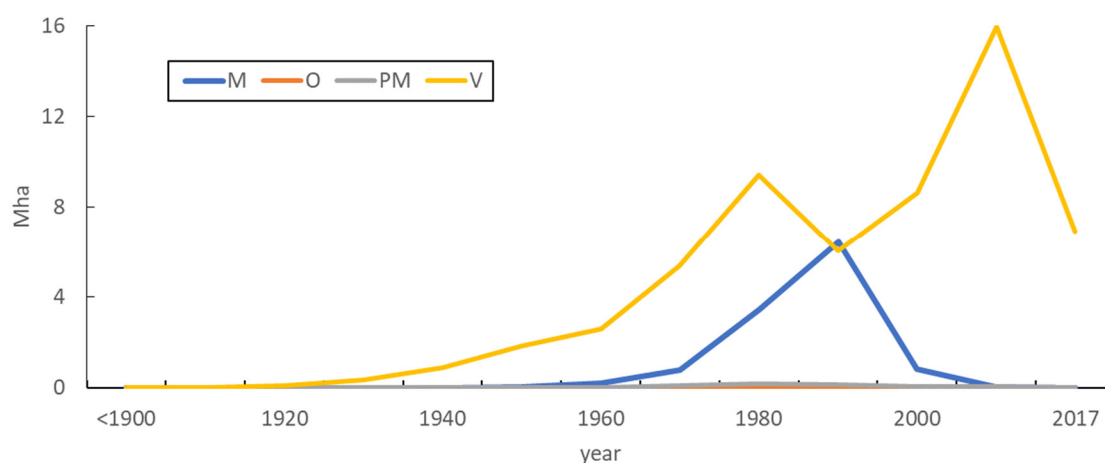


Figure 4. Time period of plantation (x-axis) and surface area in the Valencian community (y-axis, in mega hectares) by final wine product.

In addition to observing the surface area occupied by each vineyard planted by year, the number of plots can be extracted depending on the period of planting (Figure 5). The 1970s and the 1980s were the periods with the highest fragmentation of vineyard areas. In fact, 21% of existing wines were planted in these two decades. After this period, a reduction in the fragmentation of vineyards occurred in 1990–2000, increasing drastically in 2000–2010, and then decreased slightly in the last period. During the 1970s and the 1980s, the greatest fragmentation came from a demand for vinification and table wine; whereas, vineyards were planted mainly for wine in the 2000s.

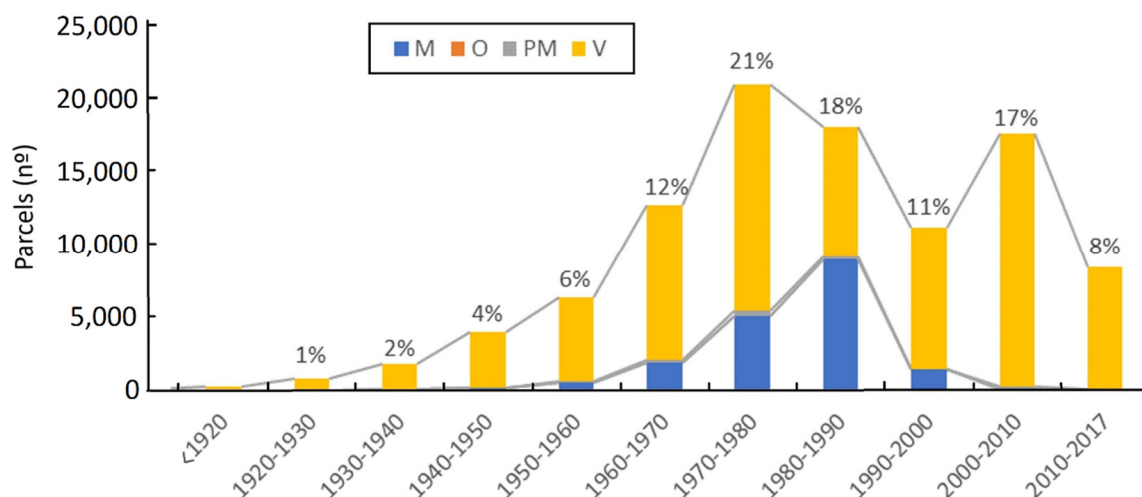


Figure 5. Time period of plantation (x-axis) and number of parcels planted in the region (y-axis, in hectares) according to each final product of wine.

In line with the spatio-temporal evolution of vineyards, the most successful types of wine were also detected. Considering the vineyards that today cover an area greater than 100 ha at a regional scale, the most characteristic wines are: Macabeo, Moscatel Malaga-De Alejandria-Romano, Italian Moscatel, Monastrell (Garrut), Tempranillo and Bobal. Considering 10-year intervals, planting of vineyards has mainly occurred in two decades: 1970–1980 and 2000–2010 (Figure 6).

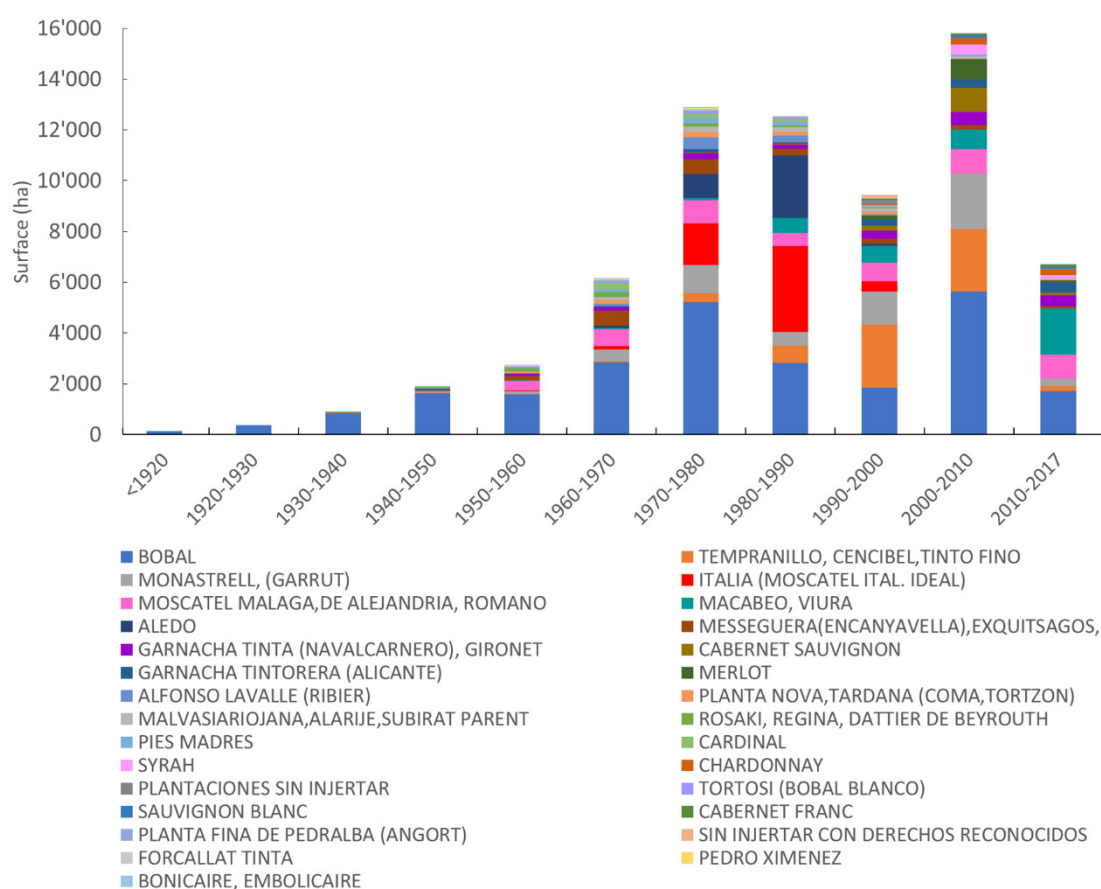


Figure 6. Type of wine (x-axis) and the relative surface area occupied in the region (y-axis, in hectares).

A total of 61% of the vineyards recorded in 2017 were labelled as DO: 15,288 ha planted in DO Alicante, 12,963 hectares in DO Utiel-Requena, and 14,723 ha in DO Valencia (Figure 7). There is also the IGP Castelló (wine with protected geographical indication) which covers about 35 ha. D.O. Alicante and D.O. Valencia included the most fragmented vineyard areas even though they have many hectares dedicated to the production of wine. On average, D.O. Valencia has younger vineyards and greater spatial fragmentation. However, the IGP Castelló is concentrated in some small areas in the northern part of the Valencian community, with a higher average age of existing vineyards. Wines with a protected geographical indication are produced following specific regulations that are less demanding compared to DO regulations, e.g., at least 85% of the production should come from the protected area.

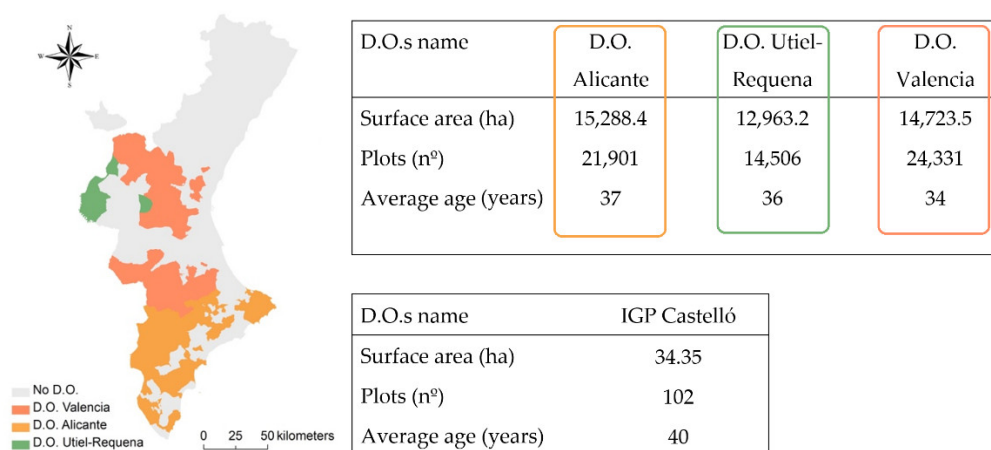


Figure 7. Denomination of origin (DO) in the Valencian community and selected indicators.

4. Discussion

Vineyard productivity and quality are intensively affected by plant age and modifications may require that a new plantation is set replacing the earlier one [56]. However, the age of the vineyards has been poorly studied since now. Only recently, an in-depth study was proposed focusing on soil erosion [3,41–44,46,47]. The importance of exploring vineyard contexts implies different environmental repercussions, but also, they can be linked to land-use changes and variation in rural landscape and intrinsic stimuli from local markets [2,48–60].

Joined “spatial patterns” and “temporal processes” and phenomena through spatial-temporal examination tools to discover the pattern of dynamic processes should be used to study land-use dynamics and strengthen the spatio-temporal feature-oriented investigation at the regional scale [61,62]. The “temporal fragmentation” in the present work, the higher number of vineyard plots planted in one period compared to another, explains several issues, e.g., dissimilar market trends at the regional scale, notables depending on the final wine produced (e.g., winemaking or table wine). Furthermore, the presence of subsidies or market interests are possibly linked to labelled wines that provide farmers a greater income. Furthermore, the presence of diseases may have burdened specific plants which were planted during a certain period [56].

Vineyards in the Valencian community experienced a considerable expansion since the 1960s–1970s, highlighting two decades of peak growth in 1970–1980 and 2000–2010. They are mainly dedicated to winemaking, even if in the 1970s and 1990s table wine was intensively produced. Therefore, the largest area for table wine vineyards were used give space to those producing-wines: this result highlights a relationship of change according to the type of wine, the year of planting and its final use. Furthermore, 1970–1980 is the temporal period that caused a greater fragmentation of the vineyard areas. In fact, 21% of the existing wines were planted in this period. Though, after this period, a reduction in the fragmentation of vineyards occurred in 1980–2000 and then dramatically increased in 2000–2010, and then slightly decreased in the last period. The “temporal fragmentation”

explains a higher number of vineyard plots planted in the defined period compared to another. For instance, during the period between 1970–1980, the greatest fragmentation came from a demand both for vinification and table wine, while in the period between 2000–2010 recent vineyards were planted mainly for wine. Correspondingly, according to D.O. wine, it is possible to read spatial-temporal fragmentation. Valencia D.O. exposed the most fragmented vineyard areas even though they have many hectares dedicated to the production of wine. On average, D.O. Valencia has vineyards of younger age and greater spatial fragmentation.

The analysis also permitted the subdivision of different areas between them. Most municipalities have a high extension of vineyards dedicated to winemaking and are composed of fragmented parcels. The other areas diverge by different indicators. Few areas are dedicated to table wine cropped in numerous and fragmented plots; other areas exposed a high density of vineyards, since they occupy large territorial areas, especially dedicated to table wines, but the plots are less fragmented. And finally, some municipalities take up older contexts in terms of minimum age and average age. Given this characteristic, in this group emerge the vineyards intended for mother vines.

Furthermore, the study carried out may be linked to other research intended to identify the areas with younger vineyards and more prone to erosion processes [63–66]. The area that needs to be more attentive to erosion processes is the southern part of the Valencian community, as they have a dispersive density of vineyards and a very low average age compared to other regional areas. These areas (e.g., the municipalities of Ayora, Enguera and Moixent) are more sensitive since the combination of types of crops (vineyards) and frequent new planting can cause a higher probability of soil erosion, which is exacerbated by a climate composed of very dry summers, which makes water not able to penetrate the soil during periods of rain, prompting more intense phenomena of soil erosion (Figure 8a, b). As already reported by [3], the age of the vineyards and the presence (or absence) of ridges developed by tillage are responsible for the dis-connectivity of the rural system, and consequently reduce soil erosion rates. Furthermore, a probable solution could be to increase the density of vineyards and therefore their vegetation cover, which then can restrict erosion processes [67–69] and set a limit on the number of new plantings. Particularly, new plantings should follow a suitable management and planning approach for more sustainable agricultural practices, with the intention of restraining negative impacts on the environment and the landscape (Figure 8c, d).

Ensuring the sustainable development of rural areas is also necessary today, adapting suitable agricultural practices by type of cultivation [70–74] with the purpose of preserving soil quality and properties [23,61,75–78]. In the future, careful study of the socioeconomic impact on land-use change at regional scales and on global environments will be crucial to join investigations of life material's physical, chemical, and biological procedures in land cover [36,40,48,54,60,62].



(a)



(b)



Figure 8. Sediment collected at the bottom of the slope after a thunderstorm in September 2018 in a vineyard in Fontanars dels Alforins (a) and in a young vineyard in Font de la Figuera (b). (c), recent vineyards landscape in Requena; (d), recent organic wine farming in Moixent.

5. Conclusions

The present work reflects on how to analyze vineyards, given their recent economic success and expansion in agricultural landscapes, and especially given their predisposition to make agricultural land more sensitive to the processes of soil erosion, compared to other crops. One of the main challenges of this rural context is to balance the needs of wine production, as a major socioeconomic activity [2,56,60], with environmental impacts on the landscape [8]. The method allows for the identification of areas that allow further development of wine production without compromising environmental protection objectives. Taking a picture of their current state, planting age exposed the areas more sensitive to the development of soil degradation. Due to the recent phenomena of climate change (e.g., very hot summers and intense storms) the approach offered in this paper is meant to be a springboard for improving the sustainable development of Mediterranean agricultural landscapes dominated by vineyards.

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