Spatial dynamics and changes in northeastern Romania's orchard landscape over the last century

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Abstract: Globally, land use/land cover has suffered significant changes during the last years, some countries being more negatively impacted than others and a good example are countries from the former Soviet Union, including Romania. This paper aims to highlight the evolution of the orchard landscape in a region with a centuries-long tradition in this field in North-East Romania. The analysis will focus on the transitions of orchard landscapes based on literature and cartographic materials, either historical or modern, and on outlining the tendencies that have been seen throughout the past decades. The results show that although fruit growing has been mentioned as a basic activity in this region since the 15th-16th centuries, the peak was reached during the communist period. The new practices in this field are showing a transition regarding the location of the orchards according to the slope. If the orchards from the 80's were located in the largest proportion on slopes of 10-15% or even 15-20%, today, the orchards are located in areas with reduced slopes of 1-3% and 3-5%, areas, that previously served as agricultural land. These changes are exposing the slopes to ongoing geomorphological processes, situation that can be seen in former areas with orchards, where nowadays there can be identified active landslides. It was left to ponder whether this evolution results in degeneration or sustainability in light of the current circumstance.

1. Introduction

The dynamism of land use is a topic addressed internationally, as these changes bring considerable modifications to the natural landscape (Napton et al., 2010; Pelorosso et al., 2009). Natural conditions are the most important factors that set the limits of land use, and also, tend to form the framework for how land is eventually used, as the farmer and his actions "have the last word" in how an agricultural landscape will be produced (Hellström, 2004). Given that human society has an impact on the agricultural environment, it can be deduced that it is also politically sensitive.

Guan (2011) mentions that one of the main factors threatening the environment is represented by these alert changes of land use. Regarding agriculture, in the context of technological evolution and population growth, there is a shift from traditional agricultural practices to the intensive and super-intensive ones, having at the same time repercussions on the environment (Stoate et al., 2009).

In the fields of agriculture, fruit growing is a domain that still manages to balance economic effectiveness with biodiversity preservation. This is particularly clear in the case of traditional orchards, which blend the qualities of both a forest and a pasture to create a uniform surface that serves as a haven for a variety of birds and insects (Horak et al., 2013; Kajtoch, 2017). The above-mentioned scenario can be easily diminished...
because of either land abandonment, either because of the transition to intensive and super-intensive orchards, phenomena often encountered after the second half of the 20th century and the beginning of the 21st century (Eichhorn et al., 2016).

Compared to other regions, this kind of changes have been more intense in former Soviet Union states (Li and Li, 2017; Ustaoglu and Collier, 2018; Subedi et al., 2021). After the fall of the communist regime, in Eastern European countries, a conversion from command to free market economies took place. Cooperatives and state agricultural enterprises were abolished, and the land was given back to the rightful owners (Lerman et al., 2004; Winkler et al., 2021), and in Romania things were no different (Kucsicsa et al., 2019; Petrișor and Petrișor, 2021). Two main directions of development result from these changes: a) the first one leads to the agricultural continuity and its intensification and b) the second one represents the abandonment. Pazúr et al. (2014) states that land abandonment is a gradual process of dereliction of agricultural practices, and Sroka et al. (2019) emphasize in this case that even the complete cessation of agriculture can be registered.

Changes in land use in Romania have also been approached from different perspectives such as: 1) political and economic implications, changing the political regime after 1989 (Kuemmerle et al., 2009; Rusu et al., 2020), 2) from an ecological point of view (Schmitt and Rákosy, 2007), focusing on protected areas (Feurdean et al., 2009; Ursu et al., 2020), 3) regarding the optimum agricultural land use (Niculescu et al., 2015; Enea et al., 2019). Additionally, orchards were examined from the perspectives of heavy metal pollution and climate change (Jitariu et al., 2019; Prundeanu et al., 2020). For the historical region of Moldova (eastern part of Romania) the issue of land use/land cover was analysed by Ursu et al. (2007), Tomasciuc et al. (2015, 2016), Văculișteanu et al. (2022) which highlighted the implications of changes in land use after 1989 on the environment.

These land cover changes are also highlighted in the case of orchards. At a national level, orchards occupied circa 340 000 ha at the beginning of the 20th century (1927), about 180 000 ha at the start of the communist regime, and peaked during the 70s’, to a value of 428 000 ha (Popa, 2008). After 1990, orchards areas decreased, reaching a total of 67 840 ha in 2017 (EUROSTAT, 2022). This considerable decrease, which coincided with the fall of the communist regime, is associated with the fact that public lands were dissolved, and were reassigned to the general population. As a direct effect of this process, the agricultural lands suffered from an intensive restructuring process, coupled with differential degradation, abandonment or complete destruction of orchards or wineries (Popovici et al., 2017; Niculăe et al., 2019; Niculescu et al., 2019). After 2007, the management of agricultural lands and the used work methods suffer a new shift in Romania, this time following a positive trend, due to the adherence to the European Union, which constituted the basis for a sustainable development in the agricultural sector. This development had as its main engine funding, which targeted the agricultural sector and the development of rural areas, but also the implementation of common agricultural politics in the community fund. Their introduction and development have led to a reduction on the agricultural lands’ fragmentation and an increase in the occurrence of agricultural associations and the modernization of the processes behind the exploitation methods (Niculăe et al., 2019).

The present study focuses on highlighting the evolution of the orchard landscape for the nineteenth, twentieth and twenty-first centuries and the consequences of the changes that occurred, based on documentary and cartographic sources.

2. Materials and Methods

2.1 Study area

Orchards in Romania are more widespread in the hilly areas of the south and west of the country, but the North-Eastern Region (Moldova) stands out with one of the first
experimental orchards in the country. In this context, the fruit-growing region of Fălticeni has a high regional importance as an indicator of the spatial and qualitative evolution of Moldavian orchards.

The studied area is part of Suceava County, part of the North-East Development Region of Romania. From an administrative point of view, it overlaps over 4 territorial administrative units: Fălticeni Municipality and Radaseni, Horodniceni and Bunesti communes (Figure 1). Over time, the orchard landscape has changed because of the intensification of agriculture, but the political and socio-economic shifts of the last 30 years have brought other changes of this type of landscape.

![Figure 1. Geographical location of the study area and the areas occupied by orchards](image)

### 2.2 Data

Due to the extended time span covered by this study, a significant amount of materials from various periods, including historical maps, satellite and aerial photographs, have been analysed. (Table 1). The dynamics of the fruit landscape was analysed from two perspectives: descriptive and quantitative.

<table>
<thead>
<tr>
<th>Material</th>
<th>Scale/Resolution</th>
<th>Period/Year</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Military Maps of the Habsburg Empire</td>
<td>1:12800</td>
<td>1763-1790</td>
<td>descriptive</td>
</tr>
<tr>
<td>Moldavian Topographic Atlas</td>
<td>1:50000</td>
<td>1895</td>
<td>descriptive</td>
</tr>
<tr>
<td>Military maps</td>
<td>1:20000</td>
<td>1940</td>
<td>descriptive</td>
</tr>
<tr>
<td>Soviet topographic maps</td>
<td>1:50000</td>
<td>1950-1960</td>
<td>descriptive</td>
</tr>
<tr>
<td>Romanian topographic maps</td>
<td>1:5000</td>
<td>1972-1986</td>
<td>quantitative</td>
</tr>
<tr>
<td>CORONA images</td>
<td>1.8m</td>
<td>1960-1972</td>
<td>descriptive</td>
</tr>
<tr>
<td>Aerophotograms</td>
<td>0.5m</td>
<td>2005 &amp; 2012</td>
<td>quantitative/ descriptive</td>
</tr>
<tr>
<td>Google aerial images</td>
<td>15m-15cm</td>
<td>2018-2020</td>
<td>quantitative/ descriptive</td>
</tr>
</tbody>
</table>
For the end of the 18th century, the Military Maps of the Habsburg Empire were used, and for the end of the 19th century, it was used the Topographic atlas of Moldavia (maps related to 1895). Skaloš et al. (2011) have also used military maps to reconstruct land use and to track the dynamics of land use in the Czech Republic. Old historical maps, along with written information, are very good sources of documentation for tracking the dynamics of a particular type of land use or ecosystem reconstruction, fact observed by Petit and Lambin (2002) for the Ardennes region of Belgium, but also by Patru-Stupariu et al. (2011) and Feurdean et al. (2017) for various areas in Romania.

For the twentieth century a more complex set of materials were consulted from which we mention the military master plans (military maps) with a scale of 1: 20000, plans that cover the entire surface of Romania. The Soviet topographic maps with a scale of 1: 50000 were useful in forming ideas about the orchard landscape in the middle of the 20th century.

The topographic maps, at a scale of 1: 5000 are materials of detail and were executed between years 1972-1986 from which some clear conclusions can be drawn regarding the areas occupied by orchards. Two products were used as aerophotographs, one from 2005 and the other one from 2012, products of great detail.

For the period 2018-2020, were used the satellite/aerial images provided by Google. The information collected from the satellite images were validated in terrain.

As a secondary support, CORONA satellite images were very useful in this study. Corona is part of a reconnaissance action that included multiple spy satellites (Corona, Argon and Lanyard), and was operated by the U.S. from 1960 to 1972 (McDonald, 1995). Corona images are widely used in studies regarding forest cutting (Nita et al., 2004; Rendenieks et al., 2020), in geomorphology (Grosse et al., 2005) or in estimating long term land use changes (Gurjar and Tare, 2019).

Each mentioned material was studied and confronted with information from the literature, their processing consisting in georeferencing and onscreen digitizing orchard surfaces for each period (Figure 2).

![Figure 2. Methodological workflow for the analysis](image)

### 3. Results

The results obtained from our analysis are presented in accordance with the period of the materials, as follows: 1) orchard landscape before the twentieth century; 2) orchard landscape in the first half of the 20th century; 3) the spatial evolution of orchards in the second half of the twentieth century and the beginning of the twenty-first century.

#### 3.1. Orchard landscape before the twentieth century

Regarding the presence of orchards in the study area there are reports made since the 15th century that mention about the concerns of the inhabitants of this area that they traded fruits with the Polish. For the 16th century, there is a clarification related to the fruit landscape at that time: 'impenetrable forest that the inhabitants, cutting down,
found in it apples, pears, plums, which remained as the first beginnings of plantations”. These fruit plantations were also mentioned in "Descriptio Moldavae" written in 1716 by Dimitrie Cantemir, and Groza (1967) mentions in his studies that in the southern part of Rădășeni there is an orchard that was called "Livada Mare" (The Big Orchard), a name used in the contemporary period.

Although the presence of orchards is mentioned in various documents since the fifteenth-eighteenth centuries, the only cartographic material we have mentioned and approaches chronologically that period is represented by military maps of the Habsburg Empire made in the eighteenth century. However, it is impossible to identify a specific region of the orchards; as a result, in this instance, we can speak of the material's descriptive rather than its quantitative nature. According to historical records, we can only speculate as to where the orchards of that era were, presuming that in the immediate vicinity of the localities we could identify the areas targeted by us (Figure 3).

Figure 3. Military maps of the Habsburg Empire

For the beginning of the 19th century, more precisely 1803, the references regarding the orchards from our study area are not only on the landscape, but also on the cultivated varieties (apples, pears, cherries, sour cherries) that the inhabitants of the area sold (Niculăiasa, 1975).

We compared the information from our documents with information from the cartographic material we had available and corresponding to that period, the Atlas of Moldavia (with drawings made in 1895), but we did not notice clear surfaces that would be associated with orchards (Figure 4).

Figure 4. Topographic map from the Atlas of Moldavia (1895)
3.2. Orchard landscape in the first half of the 20th century

The fact that there are species of plum and walnut with which exports were made is also reported for the twentieth century, and regarding the total surface of orchards, it is estimated that in the Fălticeni-Radaseni region would have reached 1400-1500 hectares (Costăchescu, 1941).

In 1908/1909, the Radaseni Nursery was established, which first operated privately and then became state property, being located in the north of Fălticeni, about 3-4 km. Later, in 1936, this nursery would become one of the first three experimental fruit resorts in Romania.

For the first half of the twentieth century, a cartographic base on a very good scale (1:20 000) is represented by military master plans of 1940. Unfortunately, from these materials, the orchards cannot be highlighted, as they were not drawn on the maps from the studied area, except in the area of Fălticeni Vechi (eng. Old Fălticeni) (Figure 5a). For example, where tree nursery was established in 1908/1909, nothing special can be distinguished from which we can deduce that there would have been an orchard in that area (Figure 5b).

![Figure 5. Military master plans (Fălticeni Vechi-Buciumeni area) (a.) and Radaseni Nursery area (b.)](image)

3.3. The spatial evolution of orchards in the second half of the twentieth century and the beginning of the twenty-first century.

Although on a more general scale, the 1:50 000 Soviet topographic maps were more useful. Even though completed in the early 1960s, the data on them could be correlated with the period 1950-1960, based on the military master plans.

From these materials it can be seen the expansion of orchard areas, which shows that the biggest changes took place only in Fălticeni and Radaseni Commune. The total area over which there are fruit trees, according to topographic maps 1: 50 000, is 679.3 ha. For this period in the communes of Horodniceni and Bunesti there are no reports of new orchards, proving that the nucleus from which the Fălticeni orchard was to start in the following years was in Fălticeni and Radaseni (Figure 6).

Movileanu (1996) stated about the time of the Second World War that fruit growing was going through a very difficult phase, and the period of collectivization (in the first period of communism in Romania) only amplified that difficult state. The first measures taken immediately after collectivization in order to revitalize fruit growing are accompanied by many disappointments, because a large part of them were located on unpretentious land. What we know today as the Fălticeni orchard began to take shape only in the last 2 decades of the communist regime, when the successful orchards were planted on hundreds of hectares, on scientific bases with great economic efficiency. This can also be seen from the Corona satellite images that highlight not only the appearance of well-organized orchards (Figure 7a), but also areas where agrotechnical earthworks have been carried out for the location of the orchards (Figure 7b,c).
Figure 6. 1960s orchard map (source: Soviet topographic maps 1: 50000)

Figure 7. Corona satellite images- 12 may 1968: a. New well-organized orchards; b. and c. Orchard terraces
For the collectivization period, as a cartographic source, we used 1:5000 topographic maps, with field information from 1981. Comparing the result obtained with the data from 1960 (Soviet maps, scale 1: 50 000) it is noted the appearance of large areas with compact orchards, not only in Fălticeni and Radaseni, but also in Horodniceni and Bunesti communes (Figure 8).

Based on these maps, it could be estimated that in the studied area the total surface with orchards (only large orchards were taken into account and we excluded orchards from the built-up area) would have reached 1156.1 ha. The largest area with tree plantations belonged to Radaseni commune (528.32 ha), followed by Fălticeni municipality (365.9 ha), Bunesti commune (158.78 ha) and Horodniceni commune (102.8 ha), most among them being apple and plum orchards.

The following material used is an aerial image obtained from a flight made in 2005, a source that provided detailed information both on the area occupied by orchards, but also on how they evolved in post communism period and privatization. The process of privatization started after 1990, by the enactment of a set of laws: Land Law 18/1991, completed by Law 169/1997, Law 1/2000 and Law 247/2005. Another aspect that stands out in this situation is the fragmentation of large plots as, for example, happened in north and east of Radaseni commune (Figure 9). In 2005 the largest areas with orchards belong to Fălticeni municipality (437.2 ha), then Radaseni commune with 301.3 ha, Horodniceni commune with 134.5 ha and Bunesti commune with 112.4 ha. The maintenance of the orchard areas in Fălticeni was also because a large part of these plantations belonged to the Fălticeni Fruit Research and Development Station, an institution with a coherent structure and organization, which better preserved the orchards and the condition of the orchard’s trees.
Figure 9. Orchard areas in 2005 (source: Orthorectified aerial imagery - 2005 edition)

More recent images, aerial photos and satellite images, have also highlighted some conclusions about the condition of the orchards, pointing out different features from the perspective of tree density or orchard organization. The surface of the digitized degraded orchards on the aerial photos from 2005 is found on 260 ha (approx. 26%) out of a total estimated at 990 ha. Bălteanu and Popovici (2010) are highlighting the fact that in 2005, in Romania, there were over 4.25 million farms, most of them categorized as small and very small farms, because of privatization, but this excessive fragmentation did not have an impact on the orchards as it did in the case of arable land. In our case, most of the orchards were only ten years old in the '90, meaning that they were very productive, reason for which a good part of the orchards was kept even after the return of the lands. The degraded condition of the orchards was caused either by ignorance in the field of fruit growing, or by carelessness, by not granting specific works and necessary treatments (Figure 10).

Figure 10. Degraded orchard in southern part of Horodniceni commune
The fruit trees situation in 2012 follows a downward trend for all the studied administrative units, except for the commune of Horodniceni that registers an increase of 6.7 ha, reaching 141.17 ha. From these data, it results that in the Fălticeni Municipality there were 434 ha of orchard, in Radaseni 260.6 ha, and in Bunesti 95.2 ha. The orchards in a degraded state occupied 214.2 ha out of approximately 934 ha (Figure 11).

**Figure 11.** Orchard areas in 2012 (source: aerial image)

The aerial photo from 2012 compared to the one from 2005 outlines very well the way in which a degraded orchard (in 2005) is found to be removed almost entirely in 7 years (Figure 12). At the same time, we mention that also during this period new and well-organized orchard were identified, which create in the landscape a strong contrast between the old and the new orchards.

**Figure 12.** The condition of the orchards in 2005 and 2012
In the period 2018-2020, the fruit tree plantations occupied an area of 382 ha from the territory of Fălticeni municipality and in Radaseni commune, the orchards were found on 276.3 ha. In Horodniceni commune, the orchards occupy 194 ha, and in Bunești commune 129.1 ha. Apart from Fălticeni municipality, the areas with orchards have registered an increase in the last period taken into account in each administrative unit. Areas with degraded orchards occupy an area of about 240 ha out of 972 ha (Figure 13).

For this period, there is a considerable number of orchards on the western side of the study area, on the territory of Radaseni and Horodniceni commune, but also on the territory of Bunești commune, in the eastern part of the study area.

**Figure 13.** Orchard areas in 2018-2020 (source: Google Satellite & field validation).

4. Discussions

4.1 The dynamism of orchard surfaces

An overview of the results from the analysis of cartographic materials highlights some general features regarding the evolution of fruit plantation areas. Therefore, the information on the topographic plans with a scale of 1:5000 (1981) captures the period after the collectivization process, described by large and homogeneous orchards, the most visible being found on the territory of Fălticeni municipality and Radaseni commune, but also on the territory of Horodniceni and Bunești communes (Figure 14). New orchards were established after 1981, also during the communist regime. The situation of the orchards from 2005 presents a completely different scenario than the previous one. A large part of the studied orchards (26%) is in a state of degradation. The restitution of land (after 1991) also led to a subdivision of the old compact parcels under the different vision of the new owners resulting in important changes in the landscape. In 2012, except for the commune of Horodniceni that registered an increase of approximately 7 ha, all the other administrative units registered decreases of the areas with orchards. However, in the last analysed period, it is still marked by modest increases in orchard areas in each administrative territory except for the municipality of Fălticeni. In addition, during this period, we identify the appearance of plots with super-
intensive orchards, which can represent the start of a revitalization of fruit growing in this area. The move towards super intensive orchards with a high tree density per ha (up to about 4500 trees/ha) (Costa et al., 1996; Trunov et al., 2021) is motivated by an improvement in cost/benefit justification (Papikhin and Dubrovsky, 2018).

**Figure 14.** Orchard areas in the period 1981-2020 per administrative unit

4.2 Transitions and consequences on the landscape

If in the ’80s the typical landscape of orchards was quite clear and uniform characterized by classic or intensive orchards placed on very large areas, in the last 2 decades there are some clear changes regarding the size of orchards, their typology and the location.

In the period 2005-2012 it is noticed the removal of some orchards from lands with a rather high slope 10-15% (57.3 ha), respectively 15-20% (50 ha), but it is also observed the presence of some young orchards on slopes of 5-7% (4.29 ha), 7-10% (31 ha), 10-15% (17.44 ha).

The 2012-2020 interval is marked by the disappearance of old and degraded orchards on slopes of 7-10% (35 ha), 10-15% (77 ha), 15-20% (26 ha), but the appearance of new orchards is observed on slopes of 1-3% (18.75 ha), 3-5% (100 ha), 5-7% and then on slopes of 7-10% (36 ha) and 10-15 (53 ha) (Figure 15).
Figure 15. Spatial evolution of orchards by slope categories (2005 - 2020)

The recent trends mark a transition of fruit growing practices from areas with a higher slope to areas with less inclined terrains, over which were usually found arable land. This transition of orchards towards low slope areas with their intensification has also been noted by Koulouri and Giourga (2007); Duarte et al., 2008 for olive orchards in Portugal (Tra´s-os-Montes), but also by Debussche et al., (1999) for the Mediterranean region of France. In Slovakia, in the Dolnozemlinsky region, traditional orchards in areas with higher slopes have also been abandoned due to reduced accessibility (Lieskovský et al., 2015; Žarnovičan et al., 2020). It is also observed that on slopes higher than 10% more orchards are removed than planted, which could expose the respective slopes to current geomorphological processes. Viana (2003) mentions that the abandonment of orchards on steeper slopes has a considerable impact on soil resources, landscape and wildlife communities. It is, thus, noticeable in the central and southern part of the study area the appearance of landslides precisely, on the areas where in the past there were orchards, but also on which terraces were made and then the orchards were removed or abandoned (Figure 16).

Figure 17. Spatial distribution of landslides on the site of former and actual orchards
Grazing activities were also carried out on a significant share of the abandoned orchards, which amplified the occurrence of land degradation processes, especially in the areas where the agro-terraces were also identified (Wu and Sidle, 1995) (Figure 18).

The occurrence of landslides in areas with a high dynamics of land use is a problem encountered on a much larger scale, vegetation having a particularly important role in ameliorating these problems (Chen and Huang, 2013; Arnaez et al., 2011). The abandonment of orchards leads to exposure to degradation processes, especially in areas with a higher slope (Gurung and Gurung, 2013), and if the agrotechnical works are not suitable, these processes are manifested at an even higher intensity (Lesschen et al., 2008; Ioniță et al., 2014). Moreover, the current situation of the areas affected by these processes requires conservation measures to be taken to stop or slow down land degradation. (Niacsu et al., 2021;2022)

5. Conclusions

Landscapes are characterized by a continuous dynamism that can sometimes be analysed from a quantitative perspective (based on detailed cartographic materials or based on documents attesting to the presence or absence of elements in the landscape) and sometimes only a descriptive analysis can be done.

Agricultural landscapes have changed, or rather, they have become more efficient with the technological evolution, passing only from the 50's until today from the classical agriculture, to the intensive and super-intensive one.

The fruit growing area studied by us, although it has been described since the 15th-16th centuries, and in the 18th century there are also mentions related to the orchard landscape, goes through various stages due to sensitivity to social, economic or political context, fact deduced both from the specialized literature and from cartographic materials, aerial or satellite images. Although this branch of agriculture is a representative one for the analysed area, it does not start to take shape on the cartographic materials until the 1950s. The first half of the 20th century is marked by the appearance of the fruit nursery, which would later become one of the first 3 experimental resorts in Romania. The second half of the 20th century is marked by the installation of the communist regime and the process of collectivization. From the fruit-growing point of view, it led to the appearance of a modern fruit growing, characterized by compact bodies of orchards, according to scientific criteria.

The current orchard landscape seems to follow two main directions: 1) the old, abandoned orchards, characterized by low tree densities and old trees, 2) the new orchards, characterized by smaller plots, but with a high density of trees (super intensive orchards). Following the approach of the new practices in this field, there is also a transition regarding the location of the orchards according to the slope. If the orchards from the 80's were located in the largest proportion on slopes of 10-15% or even 15-20% (with the related agrotechnical works), today, the orchards are located in areas with reduced slopes of 1-3% and 3 -5%, areas, that in the past, were used for arable...
land. The removal of the orchards from higher slopes may expose the slope to current geomorphological processes, which can be seen in former areas with orchards, where today we identify active landslides.

In the context of these dynamic changes and transitions, some principles of local land use policies should be established, taking into account a development of the area on multiple levels: economic, through the idea of increasing productivity and a better valorisation of the product, but also local branding. Nevertheless, all this should be done in the context of principles related to biodiversity conservation, land & soil conservation, precisely in view of a sustainable evolution of the area.

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