

Using GIS techniques in the analysis of land use in the Soloneț river catchment between 1856 and 2011

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ABSTRACT: Unreasonable use of land is an actual problem both for local authorities and European Union, as a result of population growth and economic activities development, which causes many changes in geographical landscape. Irrespective of the cause of enlargement / reduction of certain land use categories (residential, economic) it has a major impact on ecosystems. The present study aims at performing a spatial and temporal land use analysis in the Soloneț river catchment (right tributary of the Suceava River, with an area of 211 km²) through digital mapping, in order to obtain results on the dynamics of geographical landscape for the interval 1856 - 2011. We therefore used the 1856 Austrian cadastral maps (scale 1:2880), the 1982 cadastral plans (scale 1:5000) and ortophotoplans from 2011. Comparative analysis revealed that, within the studied region, geographical landscape has undergone significant changes over the past 150 years. The most important change is that of the forest-covered area, a response to the expansion of built and agricultural areas, but also the main cause for the occurrence of geomorphologic, hydrologic and climatic risks. In our opinion, in the absence of any measures to stop this phenomenon, the irreversible process will continue to directly affect land use structure by further expansion of built areas at the expense of woodland and arable land. Moreover, the problem of land susceptibility to geomorphologic, hydrologic and climatic risks becomes increasingly acute.

KEY WORDS: land use, the Soloneț river catchment, GIS, geographical landscape, changes, risks

1. Introduction

The complex landscapes of the Soloneț catchment experienced spatial and temporal dynamics, because of constant changes in topography, climate, hydrographic network, and especially due to man's action.

The Soloneț River is right tributary of the Suceava River, being the second largest after the Sucevița River, and has a length of 31 km. In terms of total catchment area, it covers 210.77 km² and belongs mostly to the Suceava Plateau (Figure 1) and to a lesser extent to Obcina Mare

Mountains, according to its geographic coordinates: North = 47°44'6"N - 26°2'18"E, East = 47°42'41"N - 26°6'27,381"E, South = 47°34'41"N.

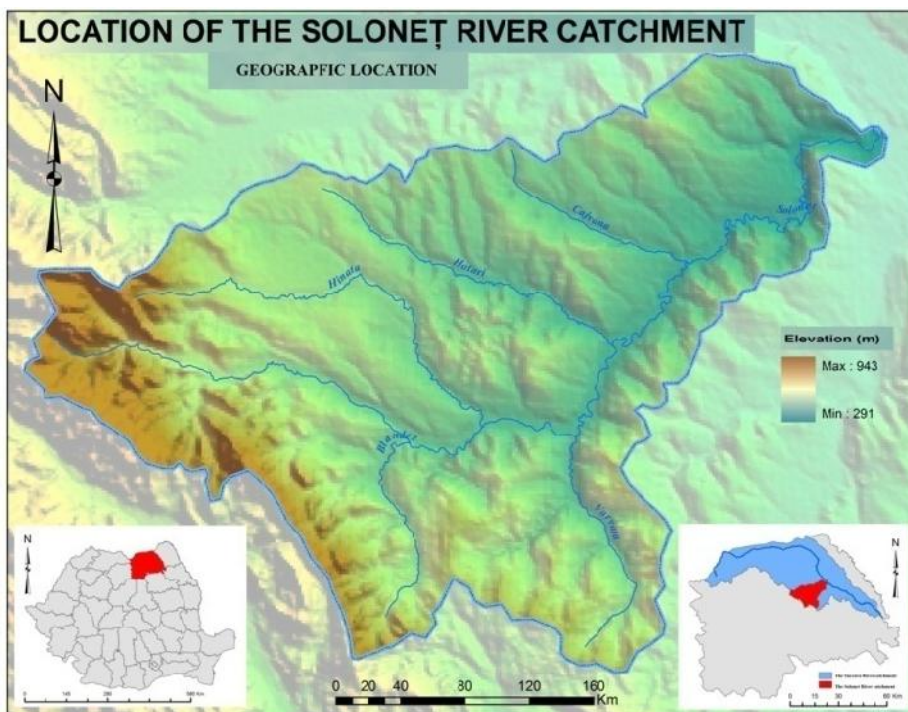


Figure 1. Location of the Soloneț River catchment.

Its catchment is characterized by elevation values between 291m at the confluence of Soloneț with the Suceava River and 943m at Pleșa Hill in Cacica Mountains. The Soloneț River has a convective valley sector from its spring to the confluence with the Blandet brook, followed by a subsequent valley sector to its flow in the Suceava River.

Characteristic of this catchment is the presence on the left side of a row of structural plateaus that extend to the Soloneț valley, providing favorable living conditions over time. By contrast, its right side is represented by steep slopes affected by landslides and river erosion. These changes occurred in the geographical landscape were caused by intense deforestation, as currently there are only clumps of trees in Bâdigani Hill, Brădățel Hill or Dealu cu Rupturi, areas which were completely forested before 1856.

2. Methods

Data acquisition consisted in identifying the documents that constitute the main source of cartographic information. For preparing land use dynamics maps, we used three sets of cartographic sources, namely the Dorf Bukowina Austrian maps from 1856, cadastral plans from 1982 and ortophotoplans from 2011.

After transforming maps according to the rectangular coordinate system of the study area, the spatial data vector system was identified and created, which was necessary for performing

cartographic analysis of the geographical landscape dynamics in the Soloneț River catchment area. Two types of vector layers were used for this study, namely: polygon (for surface calculation) and polyline (for length calculation).

After extracting the three sets of vector data from the maps mentioned above, we used the overlapping layers method to highlight the dynamics of geographical landscapes in the Soloneț River catchment area.

We only digitized the geographic items necessary for the land use evolution analysis in the Soloneț catchment, according to the class they belong to: river network, lakes, forests, pastures, hay-meadows, arable land, human settlements, road network and fruit and vine-growing areas.

Following the completion of digitizing, three vector models were obtained, one for each cartographic set analyzed respectively.

Based on the digital models, several geographical landscapes in the Soloneț catchment were identified, each belonging to the two basic categories mentioned, namely natural and anthropogenic landscape (Figure 2).

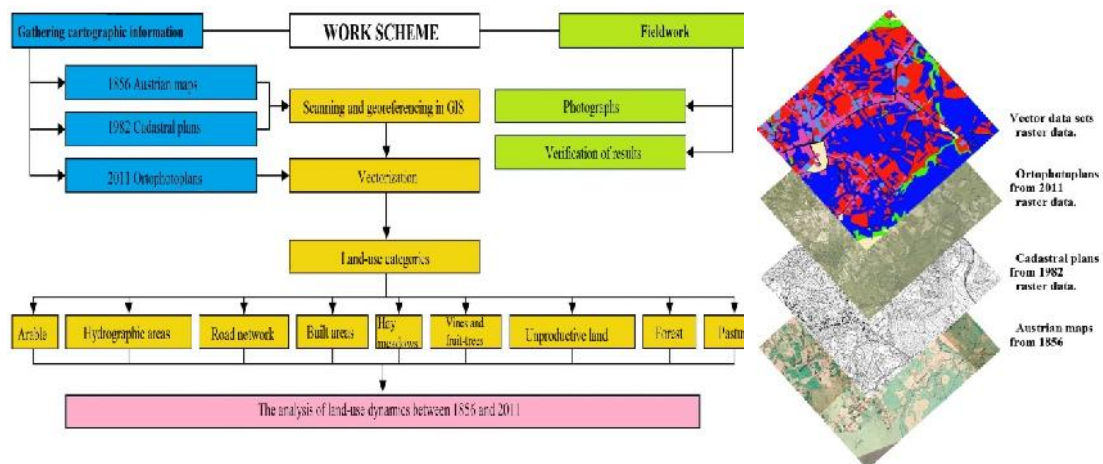


Figure 2. The work methodology scheme.

In order to obtain the data necessary for the geographical landscape dynamics analysis, it is required to quantify the data at a time. Identification of landscape changes is an important step in the process of giving predictions of the future evolution of landscape dynamics, but also for the prevention and mitigation of changes occurring in the natural landscape.

3. Results

The study of geographical landscape dynamics in the Soloneț catchment is the comparative analysis of the 3 sets of cartographic data representing land use categories and their evolution over time.

Studies of Bahram (1988) highlight the fact that man has influenced the landscape since 7000 years ago, thus turning it into a mosaic of anthropogenic and natural landscapes.

3.1. Natural landscapes

In the study area, natural landscapes include: forest landscape, fruit and vine growing landscape, pastures and hay-meadows landscape (pastoral landscape), rivers, ponds and lakes landscape and the landscape of unproductive land.

The forest landscape

According to forest areas obtained by analyzing the three sets of maps, this landscape encompasses the largest area of all land-use categories identified in the Soloneț catchment, closely followed by arable land areas. This high percentage of forested land is explained by low change caused by human impact, compared to arable land, where significant changes have occurred to the detriment of the natural landscape.

Forest covered areas in the Soloneț River catchment have extended and reduced over time on no clear regular basis.

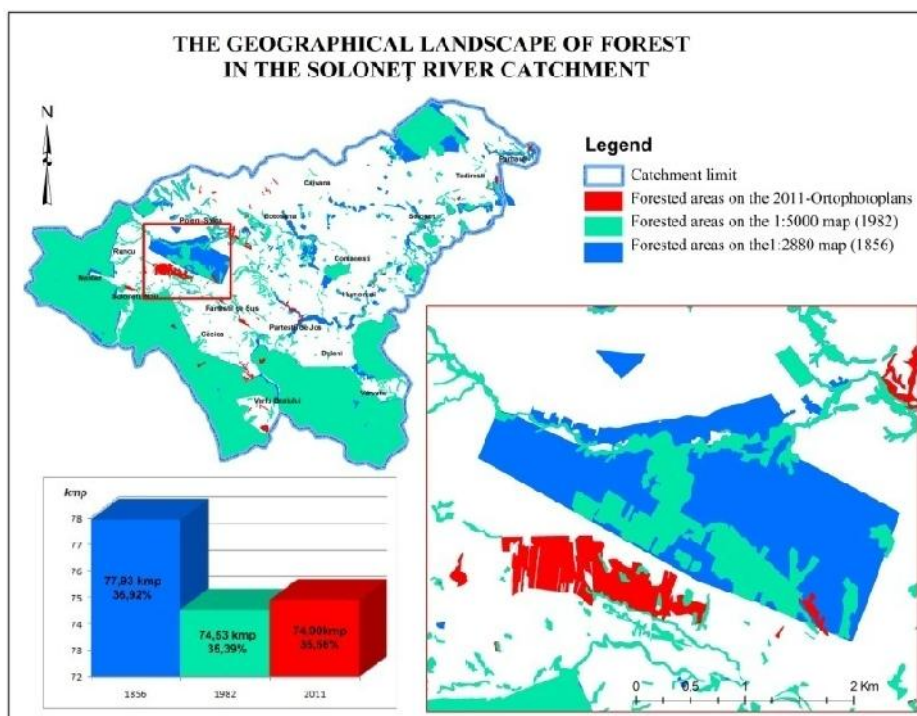


Figure 3. Evolution of the forest landscape in the Soloneț River catchment, between 1856 and 2011.

The largest forested area appears on the 1856 maps and covers 77.93km², with a percentage of 36.92% of the total catchment area (Figure 3).

Compared to the 1856 maps, the forest-covered areas were reduced to 74.53km² in 1982 due to intensive deforestation aimed primarily at extending agricultural areas and secondly at using wood as a construction material. In 1982 forested areas represented 35.39% of the total study area.

From 1982 to 2011 there has been a very slow extension of forested areas, which reached 74.9km², as a result of the policies employed by local authorities to restore forestry real estate.

The pastoral landscape

Pastoral landscape is represented by areas covered with pastures and hay meadows. This landscape has an area of 23.1% of the total catchment area, equivalent to 49.53km².

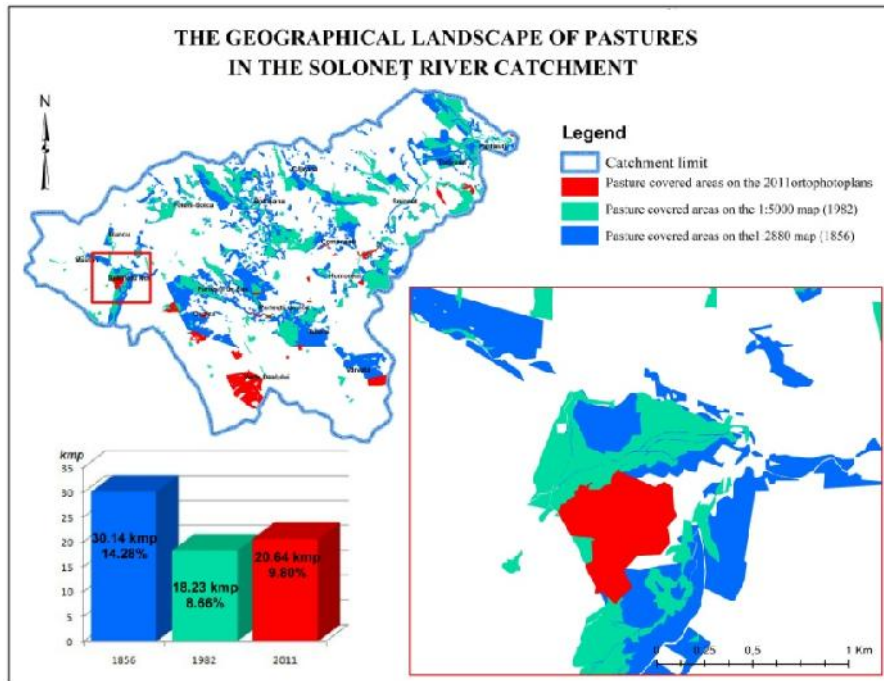


Figure 4. Evolution of the pastoral landscape in the Soloneț River catchment, between 1856 and 2011.

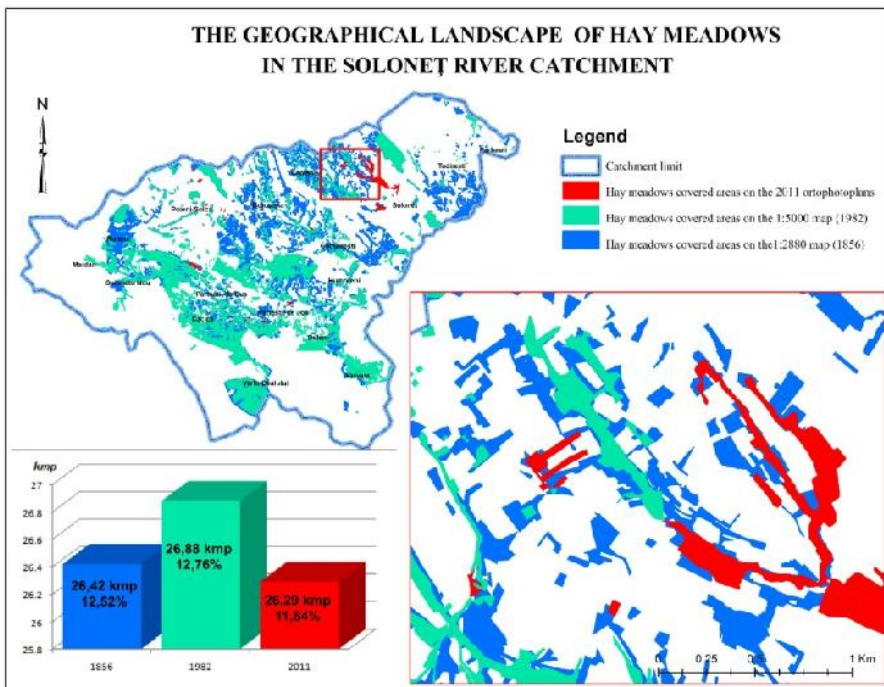


Figure 5. Evolution of the hay meadows landscape in the Soloneț River catchment, between 1856 and 2011.

For the analysis of this landscape, we distributed two categories of land-use: hay meadows accounting for 26.53% and pastures with 10.91%.

Analyzing the evolution over time of this type of landscape we observe that on the old 1856 maps pastures covered 30.4km², i.e. 14.28% of the total area and hay meadows 26.42km², which was equivalent to 12.5%.

Extended pasture and hay meadows areas during this period are due to the fact that agriculture and livestock growing were the main branches of economic activity for local population at the time.

In what concerns pastures (Figure 4) we can see a sharp decline until 1982, leading to an area of 18.23 km² (8.66% of total), followed by a slow growth until 2011, when pastures covered an area of 20,64 km².

The hydrographic landscape

The hydrographic and lake landscape is represented on the 3 sets of maps taken into consideration by the permanent and secondary river network, together with the areas occupied by lakes, ponds and swamps.

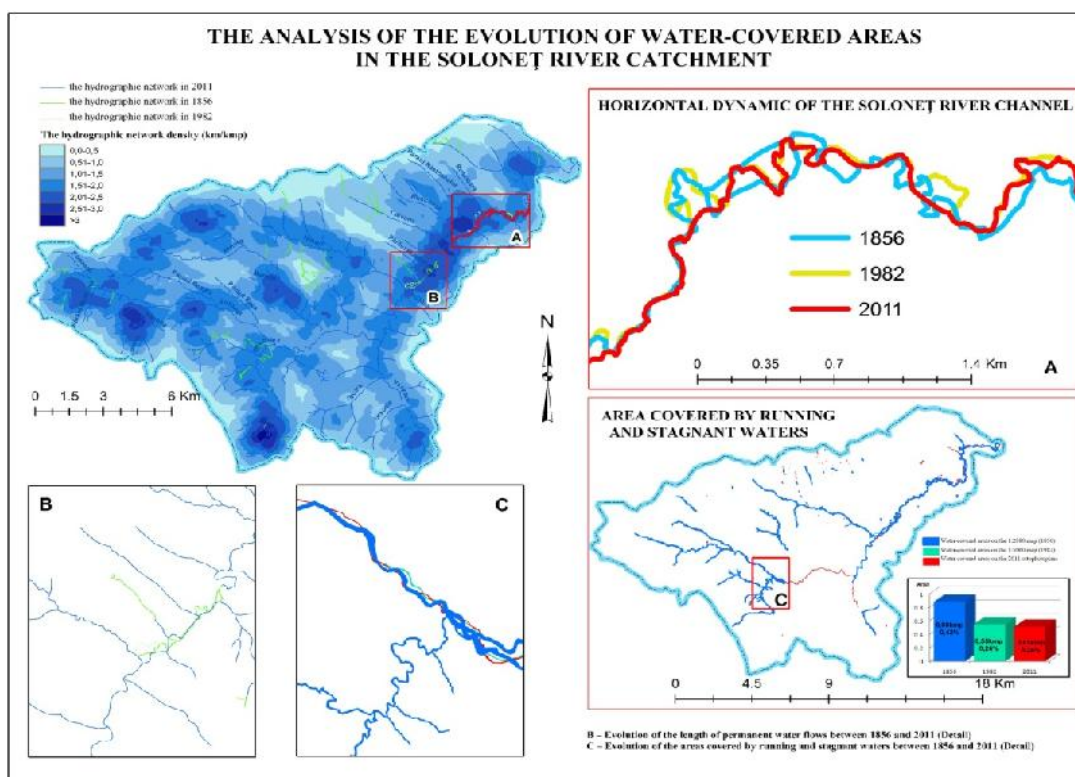


Figure 6. The analysis of the evolution of water-covered areas in the Soloneț River catchment.

These areas are very well highlighted on the 2011 orthophotoplans, while the 1856 old maps do not have all detail elements but only the permanent river network.

The total hydrographic network length is 231km, of which the permanent water course of the Soloneț River is 31km, representing 13.31% of the total length. In what concerns area, this category covers only 0.24% of the total Soloneț catchment area.

By analyzing the chart in Figure 6.C, one can observe a gradual decrease in surface for the hydrographic network. This shows that rainfall amounts are lower in recent decades, and global warming has also had its say in this regard.

The landscape of cultivated land

The landscape of cultivated land is represented by areas covered with orchards and vineyards. They have a very low percentage, only 1.42% of the total catchment area.

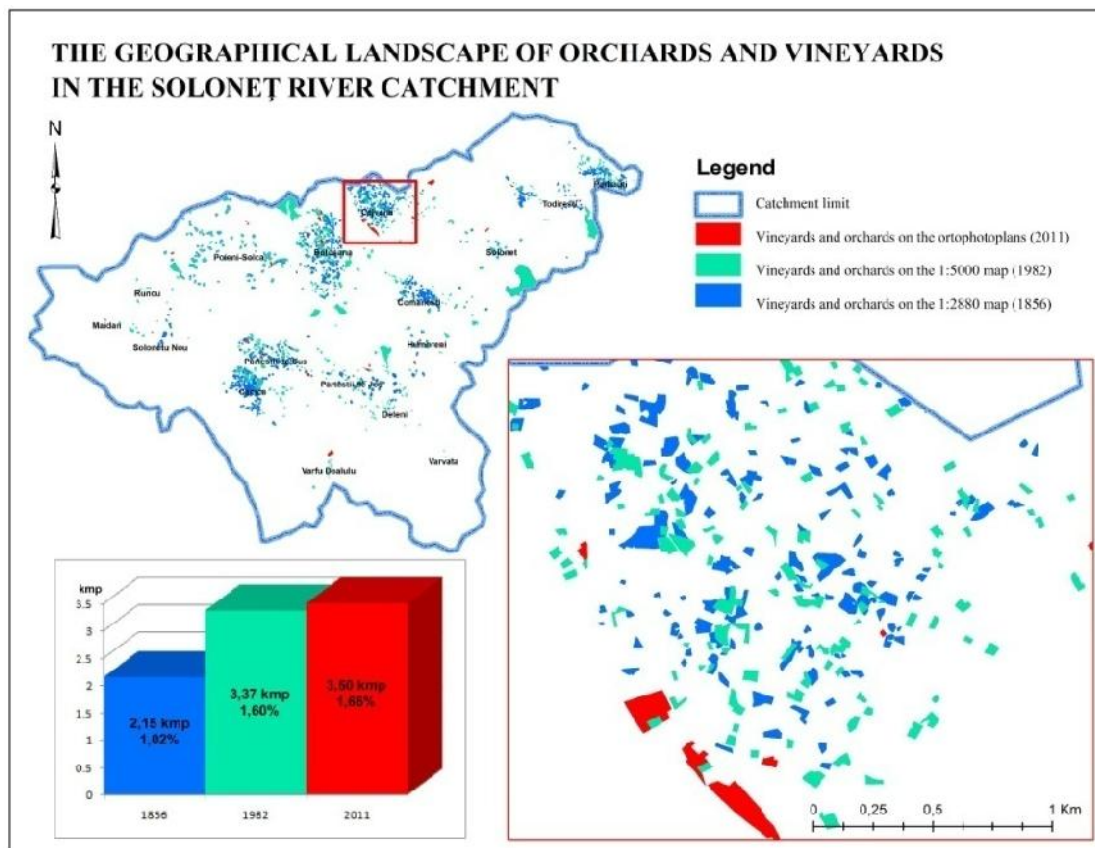


Figure 7. Evolution of the landscape of cultivated land in the Soloneț River catchment, for the interval 1856-2011.

This land use category has been experiencing slow extension (Figure 7) in the last 150 years, i.e. in 1856 it covered an area of 2.15 km², reaching 3.37 km² in 1982 and 3.5 km² 2011, with 3.64% of the total catchment area.

3.2. Anthropogenic landscapes

Within the Soloneț River catchment, 3 types of land-use categories belonging to anthropogenic landscapes were identified: the landscape of urban and rural settlements, the road network landscape and the landscape of arable land.

The landscape of urban and rural settlements

The landscape of urban and rural settlements is one of the most complex landscapes, having an uneven spatial distribution in all the 3 types of cartographic materials, where it appears under the form of built areas.

Built areas have significantly extended over time. Analyzing the evolution of built areas we see a significant increase trend in the last 150 years, especially in Cajvana, Cacica or Pârteștii de Sus.

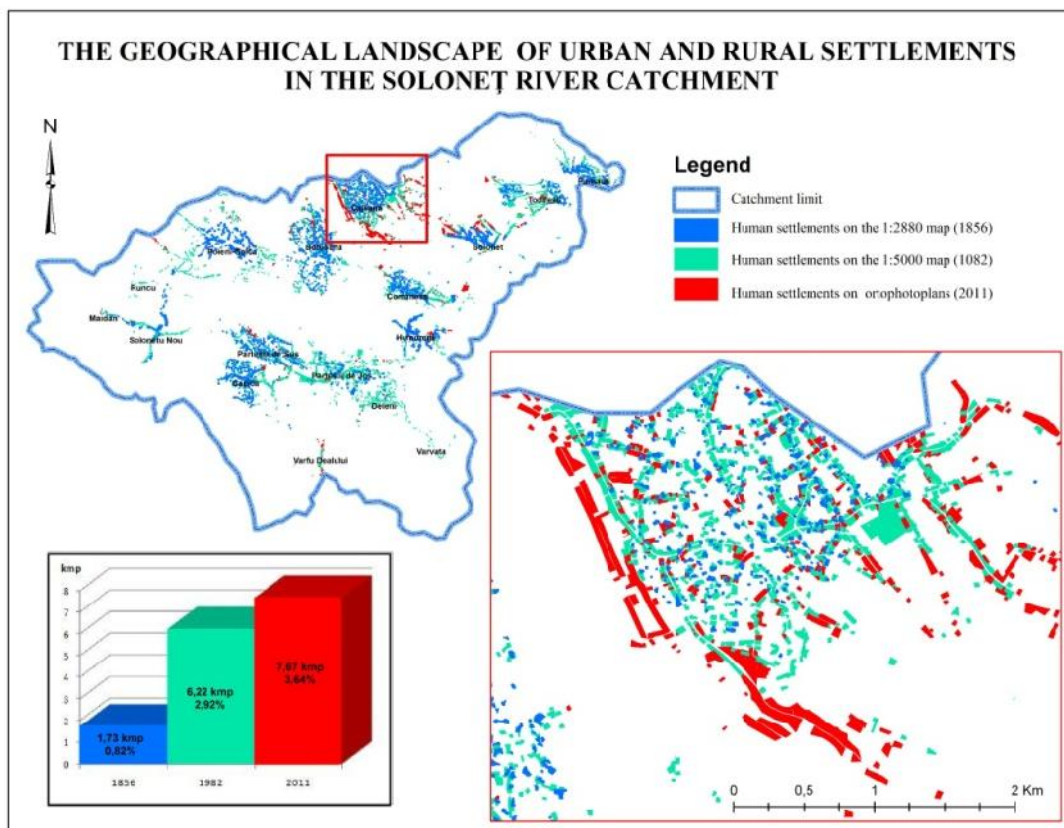


Figure 8. Evolution of the landscape of urban and rural settlements in the Soloneț River catchment, for the interval 1856-2011.

This upward trend is characterized by extension of these surfaces from 1.73 km² in 1856, to 7.67 km² in 2011. Between 1856 and 2011, urban and rural settlements area has increased six times, covering 0.82% of the total area in 1856 and 3.64% of the total in 2011 (Figure 8).

By analyzing in detail these sets of maps we see that on the 1982 cadastral plans three new villages appear (Runcu, Vârful Dealului and Varvata) which didn't exist on the 1856 Austrian maps.

The explanation for the extension of built areas within rural and urban settlements is given by the numeric increase in population from 1930 to 2002.

We can thus see from the chart representing the evolution of the residents' number of this area (Figure 9) a fluctuating population growth. Between 1941 and 1956 there has been a decrease in population number because of damages caused by the Second World War (1939-1945).

Population growth after this period results from the transition between the postwar period underdevelopment and the economic development specific to the communist regime, that had a pronatalist policy, and during which people began to experience improvement in living conditions.

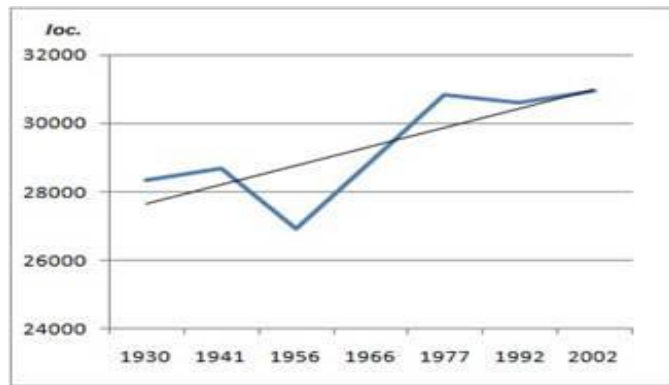


Figure 9. Population growth in the Solonet River catchment, between 1930 and 2002.

The anthropogenic landscape of road networks

This type of landscape has an uneven spatial extension in the Solonet catchment area, with a higher density in the central - northern part of the catchment.

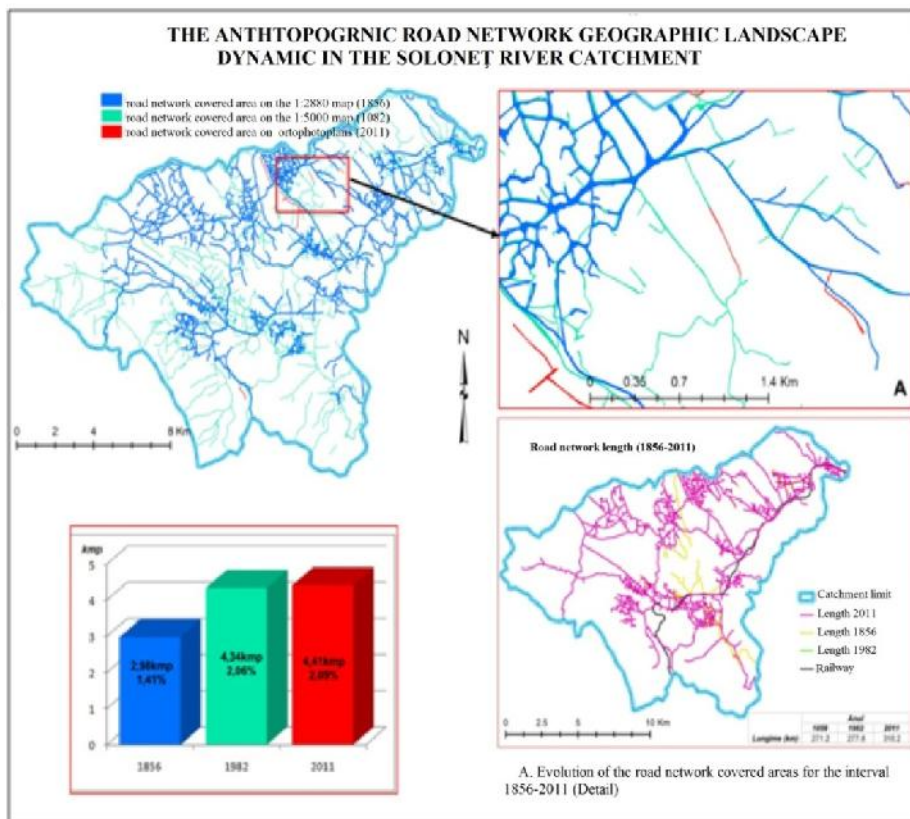


Figure 10. Analysis of the geographical anthropogenic landscape dynamics in Solonet catchment.

In Figure 10 we can see a detail of the road network dataset obtained from the 2011 ortophotoplans, where the road network has an overall length of 310.2 km, compared with the data sets obtained from the 1856 Austrian map, where the total road network length was 271km. In the analyzed period (1856-2011) the road network length has grown very slowly, with only 39km linear extension. These 39 km of road network were constructed to service the newly built areas at the periphery of existing urban and rural settlements.

In terms of spatial distribution of road network elements, these areas are very small, with a share of 1.14% in 1856, followed by a slow increase until 1982, when it reaches 2.06% and after that 2,09% of the catchment area in 2011.

The railway network was built after the 1856 Austrian maps were edited, and therefore appears only on the last two sets of maps, with the same length.

The landscape of arable land

The geographical landscape of arable areas is the second land cover category as a percentage (34.19% of the total catchment area). Regarding the evolution of this type of landscape, it is characterized by a slow extension from 68.43 km² in 1856 to 74.71 km² in 1982, followed by a decrease in 2011 (73.06 km²), caused by arable land conversion and integration in the landscape of rural and urban settlements (Figure 11).

Arable land is uniformly distributed and concentrated around the cores of the built-up village areas. Of all the landscape types analyzed, this category of landscape has had the highest degree of stability in terms of land spatial dynamics over the past 150 years.

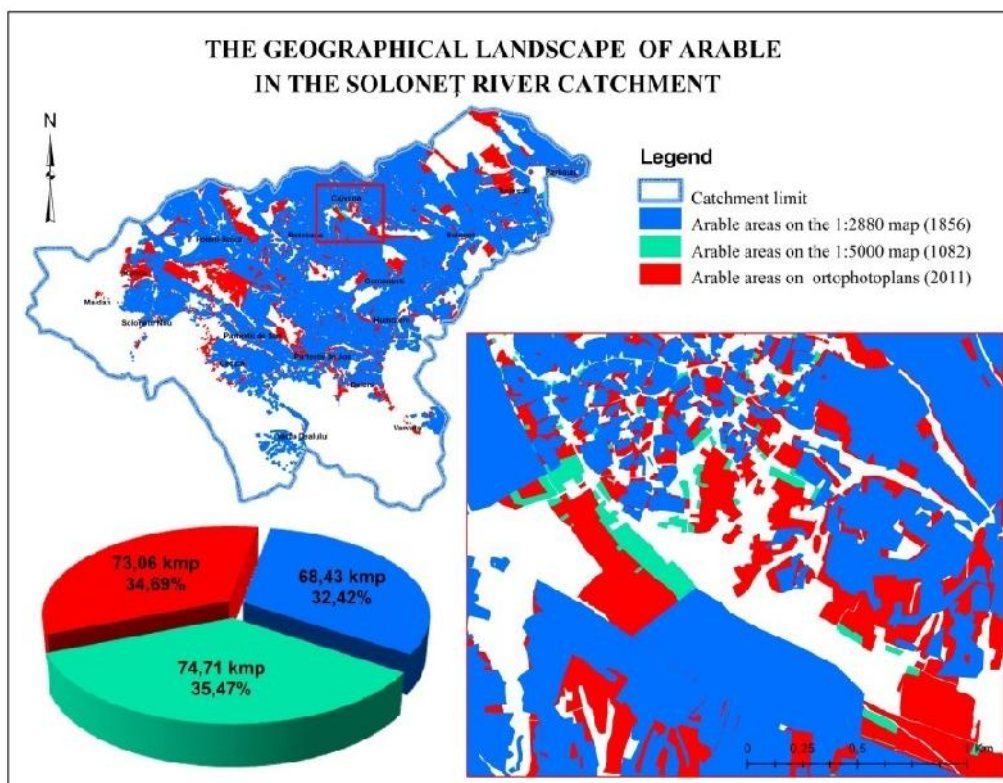


Figure 11. Evolution of the landscape of arable land in the Soloneț River catchment.

Taking as reference the last 150 years and observing the strong stability of this type of landscape, we can expect that in the following years the category of the arable land geographical landscape continue to remain stable, satisfying social, economic and agricultural needs of the population.

In the last years, a share of about 4% of this geographical landscape's area remained uncultivated, due to the migration abroad of young people, able to work, and abandonment of arable land.

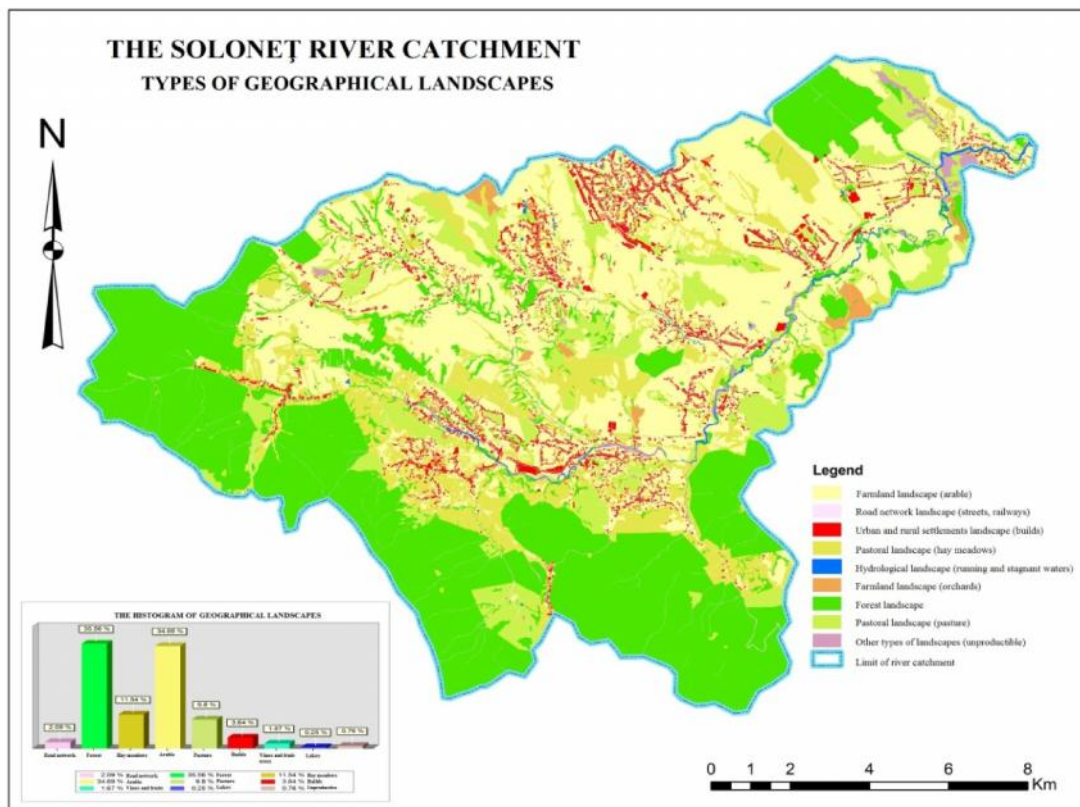


Figure 12. Types of geographical landscapes (on ortophotoplans - 2011).

Analyzing the map of all types of geographical landscapes in the Soloneț River catchment according to the 2011 ortophotoplans (Figure 12) it can be observed that most of the areas belong to the geographical landscapes of forests (35.56%) and arable land (34.69%), which together cover more than half of the total catchment area, i.e. 70.95%.

Hay meadows (11.54%) and pasture (9.8%) geographical landscapes are also widespread in the catchment, ranking three and four position as a percentage respectively, with an area of 21.34% of the total Soloneț catchment area.

The area of the Soloneț River catchment land - not taking into consideration the four main geographical landscapes - totals 8.41% and is divided among the other five types of geographical landscapes: the geographical landscape of built areas - 3.64%; the geographical landscape of road network - 2.09%; fruit tree and vine-growing geographical landscape - 1.67%; the geographical landscape of unproductive areas - 0.76%; and the geographical landscape of lakes with - the lowest percentage of the total catchment area, i.e. 0.25%.

4. Conclusions

Landscape dynamics in the Soloneț River catchment experienced changes both in land use and composition (eg. conversion of forest landscape in pastoral landscape or of arable land landscape in landscape of built areas).

Many of the changes occurred in the Soloneț River catchment are due to anthropogenic influence that exerts an increasing pressure on the land, based on the population growth trend between 1856 and 2011, with some fluctuations. The changes are therefore a response to the expansion of rural and urban settlements and of road network. This quite obvious anthropogenic pressure led to the extension of unproductive land areas and decrease in the hay meadow, pasture, and forest covered areas.

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