REMOTE SENSING AND GIS FOR CHANGE DETECTION IN THE AGRO-FORESTRY-PASTORAL SPACE

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Abstract. *The systems, whose practices can be considered agro-forestry-pastoral, can contribute to the development of rural communities. Our country's traditional agriculture incorporates these sustainable practices of natural resource management, which contribute to the economic use of land. In Romania, small farms continue to play an important role in providing families with food for their own consumption. Agricultural farms are mostly mixed, multi-active, the main occupation being animal husbandry, depending on the area and traditions, agricultural crops in arable land, vineyards and orchards. The monitoring of the changes regarding the land use in ATU Pişchia, Timiş County, was performed based on the land cover maps from the Corine Land Cover database, in different years and the statistical and cartographic data processing was done with the Land Change Modeler (LCM) module implemented in Idrisi Selva software. The data were analyzed both in terms of quantity (losses and surface increases) and in terms of locating changes for different categories of land use. The analyzed area has a rural character, the land use is predominantly agricultural and the lands belong to private owners, which means "mobility" in land use from one year to anotherr.*

Keywords: *change detection, land use, agro-forestry-pastoral space, European Green Deal.*

INTRODUCTION

Agriculture plays a major role in shaping the landscape and supporting livelihoods in rural areas (IMBREA, 2011a). Kremen C. (2020) supports the idea that a landscape diversified agricultural system opens up an open "agricultural matrix" to biodiversity and contributes to the conservation of biodiversity.

The EU's Common Agricultural Policy (CAP) is now being formulated in an effort to move towards more sustainable forms of production that take into account the quality of the environment (soil, water, vegetation), plant and animal productivity and socio-economic viability (IMBREA, 2011b). The agri-environment and climate measure (PNDR 2014 - 2020), implemented in all European Union countries, aims to optimize the benefits of agricultural activities, especially low-intensity agricultural systems (by gradually reducing or eliminating fertilizers and pesticides and rational grazing) in with a view to minimizing the negative impact on the environment.

The European Green Deal - the new EU strategy (published by the European Commission (COM) on 11 December 2019), sets the direction for various European policies in connection with a number of legislative and non-legislative initiatives in multiple areas, such as environment, climate change, agriculture, etc. (SIKORA, 2021). A first set of proposals for the implementation of the European Environment Pact was launched on 14 January 2020 by the Communication from the European Commission on the Investment Plan for a Sustainable Europe and the Establishment of the Fair Transition Mechanism..

The components of agro-forestry-pastoral systems combine ecological (JOSE, 2009) and economic objectives at the agricultural and regional level, under the given conditions and are considered the main form of agricultural land use in many rural areas of the world (BELL, MOORE, 2012; STENSEKE, 2006), supporting agro-ecological policy.

Agriculture and animal husbandry can no longer be seen as a relationship between man and animals, but as a complex integration in specialized ecosystems, respectively agro-forestry-pastoral systems, which mainly produce food security products (GARIBALDI ET AL. 2017). These can be characterized as “ecological systems arranged by the anthropic factor and piloted (directed) by it” (GRUIA, 1998).

Grasslands are already known for their ecological role, for the quality of the landscape and ways to ensure a more sustainable soil - plant - animal food chain. In Europe, High Natural Value (HNV) grassland habitats are part of low-intensity agricultural systems (BAKKER, BERENDSE, 1999). Preserving and conserving grassland biodiversity, an environmental objective of European agricultural policy, requires the definition of appropriate management regimes (SMITH ET AL. 2003). Crop diversification, preservation of protective curtains with trees, shrubs and plants from spontaneous flora complete the "intentions to improve" the results of biodiversity in agricultural landscapes (ROBINSON, SUTHERLAND, 2002), offer the possibility of in situ conservation of a wide range of wild plants and ensure connectivity improved between conserved areas (BROOM ET AL. 2013; VOGT, 2021).

Depending on local agro-forestry-pastoral practices and specific traditions, land areas, especially those used as grasslands, have undergone changes, both in terms of extension and spatial location (BÂRLIBA, COJOCARIU, 2010).

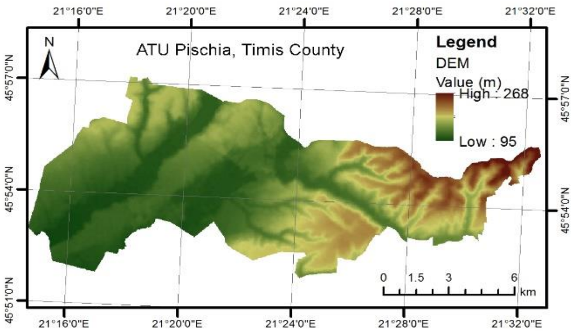
Currently, the dynamics of the pastoral space can be analyzed by remote sensing and GIS methods, based on aerial and/or satellite images, procedures supported both by the literature at international level and in our country (COJOCARIU ET AL. 2015; COPĂCEAN ET AL. 2019; FU ET AL. 2007; PRAKASAM, 2010; SIMON ET AL. 2017; SHALABY, TATEISHI, 2007; TARANTINO ET AL. 2016; WANG ET AL. 2003). Land Change Modeler (LCM), implemented in Idrisi software, is one of the most useful tools in analyzing changes in land use, but also for making predictions, important in land planning and management (KHOSHNOOD MOTLAGH ET AL. 2021; MEHRABI ET AL. 2019; ZARE ET AL. 2017).

The aim of the research is to evaluate the spatio-temporal dynamics of agro-forestry-partoral systems (by increases or reductions of surface), on the administrative territory of Pişchia, in an interval of twelve years, by processing Corine Land Cover databases, 2006 edition and 2012 edition, through remote sensing and GIS technology.

MATERIALS AND METHODS

Location of the study area

The study area is located in the north of Timiş County, in the area of Lipova Hills, respectively ATU Pişchia, having low altitudes, between 95 - 268 m (Figure 1).



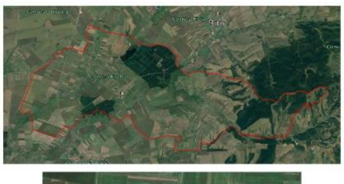


Figure 1 Location of the study area (processing according to ANCPI, EEA-EU-DEM)

Research methodology

The first stage of the research methodology was the processing of geospatial databases. The Corine Land Cover database from 2006 - the beginning of the analyzed interval - and from 2018 - the end of the considered interval was used. The area of interest was extracted and the land use categories were established.

In the first stage, the geospatial data were processed with ArcGIS 10.2.1 software.

The second stage of the research involved the analysis of changes. The Land Change Modeler module implemented in the Idrisi Selva software was used; this module was used for the analysis and modeling of changes in land use, in the time interval 2006 - 2018, according to the specific methodology (EASTMAN, 2012).

RESULTS AND DISCUSSION

Considering the complexity of the research area, but also the administrative hierarchy of the territory, different levels of representation and to the same extent characterization of agrosylvopastoral systems can be distinguished: at macroscale level, which means the incorporation of the entire administrative-territorial unit Pişchia, with all the exchanges and relationships between the components. At the lowest level, at the microscale, the silvopastoral systems represented by entities of meadows with forest vegetation were identified; open systems controlled to a greater or lesser extent by the anthropogenic factor.

The degree of mechanization of work in meadows is usually lower.

Changes in the agro-forestry-pastoral space

For the analysis of the land use, at the level of the administrative-territorial unit Pişchia, the Corine Land Cover database from two different time periods was used, respectively the years 2006 and 2018 (Figure 2). According to Figure 2, the analyzed area has a rural character, and in the way of using/covering: arable lands, pastures and forests predominate, which represents the clear spatial structure of an agro-forestry-pastoral system, at macroscale level, respectively Pişchia ATU.

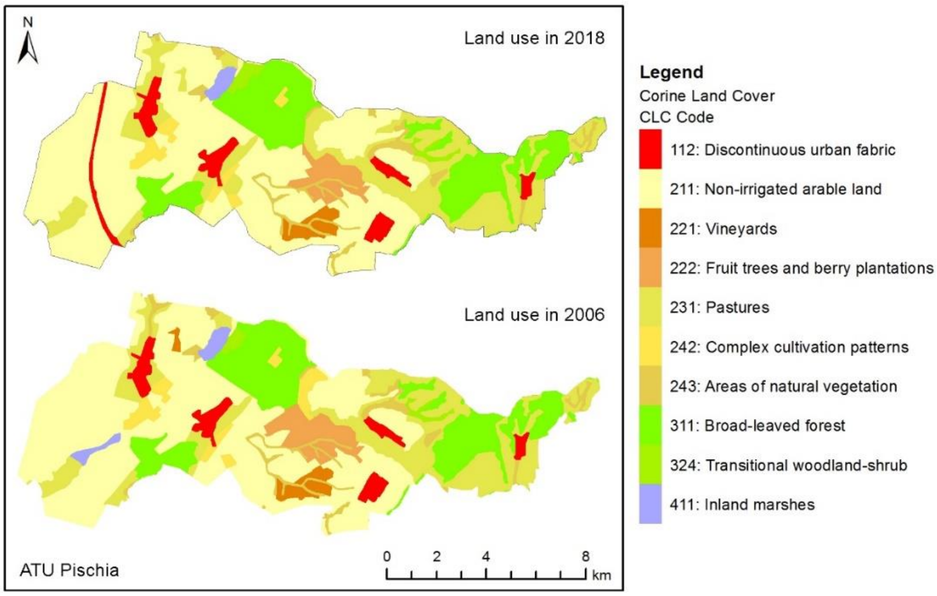


Figure 2 Land use in 2006 and 2018 (processing after EEA - CLC)

The visual analysis of Figure 2 shows changes in the structure of the components of the agro-forestry-pastoral systems in the analyzed area, in the time interval 2006 - 2018.

In order to "quantify" the changes produced in the period taken into analysis, ie the quantitative analysis, the two data sets were processed in the GIS environment and thus it was possible to compare the areas "passed" from one land use category to another (Table 1).

Tabelul 1

Quantitative analysis of changes in land use between 2006 and 2018

Land use (CLC code and description)		Surface (ha)	
		2006	2018
112	Artificial surfaces	461.52	567.96
211	Arable land	5836.61	5959.35
221	Vineyards	197.7	170.87
222	Fruit trees	474.39	347.11
231	Pastures	2149.50	2292.07
242	Complex cultivation patterns	361.51	253.13
243	Areas of natural vegetation	474.20	431.08
311	Broad-leaved forest	2135.00	2104.01
324	Transitional woodland-shrub	111.77	142.77
411	Inland wetlands	157.89	91.75

The data summarized in Table 1 show that there are increases in area, especially in the categories: arable land, from 5836.61 ha (2006), to 5959.35 ha (2018); pastures, from 2149.50 ha (in 2006), to 2292.07 (in 2018), as a result of subsidies granted by European Union programs to stimulate agriculture (PNDR 2014 – 2020).

The data presented above indicate surface losses or gains for land use categories, but for detailed analysis, it was necessary to use the Land Change Modeler (LCM), designed for environmental change analysis and implemented in Idrisi Selva software, model which supports the analysis of the causes, but also of the consequences of the dynamics of land use/coverage (MISHRA ET AL. 2014).

In the first stage of the territorial analysis, through the LCM module, the graph of the changes produced within each category of land use was generated (Figure 3). It is observed that in the category of arable lands there were changes as follows: on the whole analyzed surface 139 ha were lost in certain areas, but 263 ha were also gained, in other areas, from other categories.

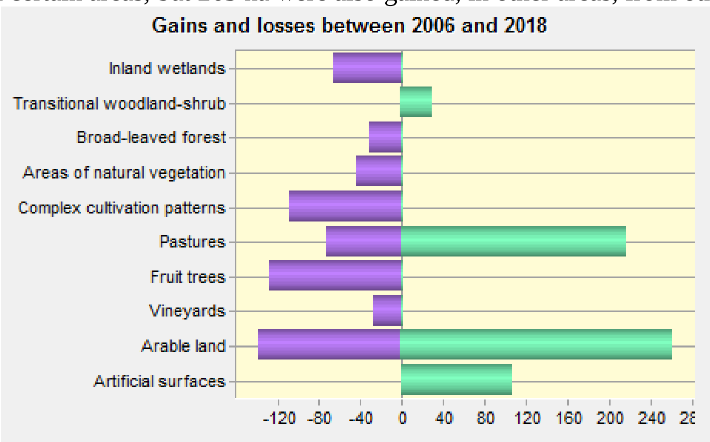


Figure 3 Area losses and gains for each land use

The grasslands, in some areas, lost 73 ha, but gained in other areas 216 ha.

Figure 3 shows that most land use categories have lost land, being distributed to other categories. For clarification, it was necessary to analyze the net changes (Figure 4) which captures the "inputs" and "outputs" of the surface, for each category.

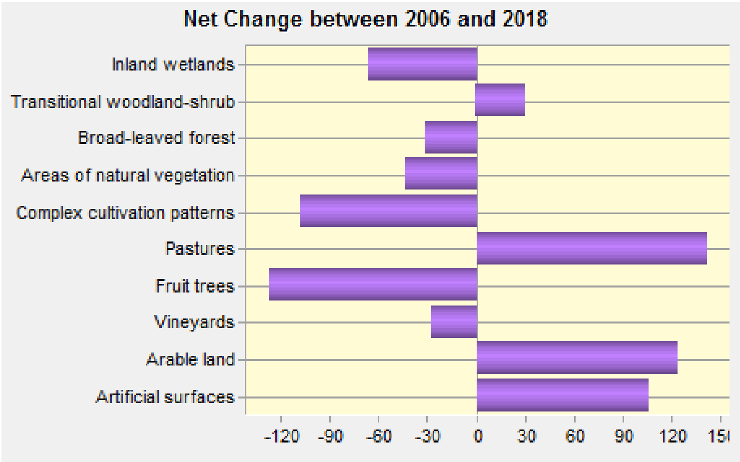


Figure 4 Net changes for each land use

An even more detailed analysis, also through the LCM module, establishes the “contributions” to the net changes, by categories (Figure 5, Figure 6).

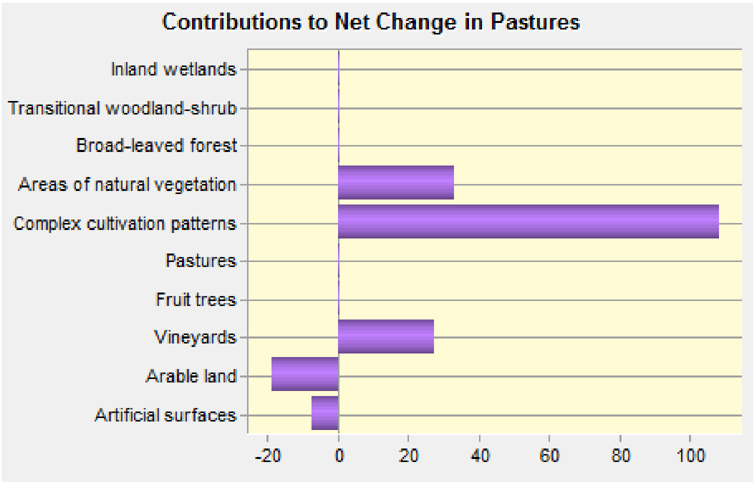


Figure 5 Monitoring the changes produced in the grassland surfaces

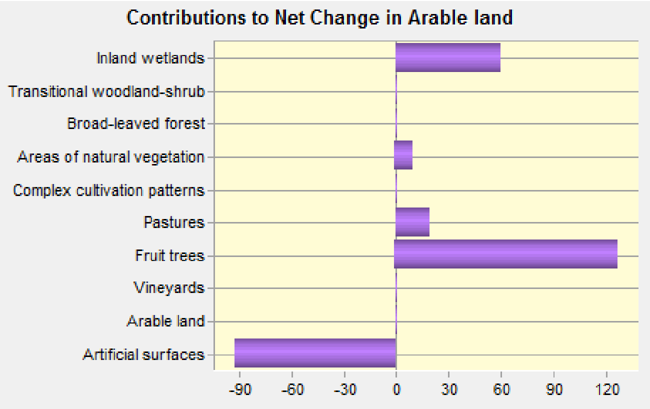


Figure 6 Monitoring changes in non-irrigated arable land

Within the category of use "pastures" the "surplus" of 142 ha comes from the following categories: agricultural areas, generally with natural vegetation (33 ha), vineyards (27 ha) and complex crops (109 ha), which means 169 ha. The "minus" of surface is found in the following categories: artificial surfaces (8 ha) and arable land (19 ha), which means a net loss of 27 ha.

The changes produced in the area occupied by a certain category of use allow the complex analysis of the entire agro-forestry-pastoral system of which they are part.

The agro-forestry-astoral systems offer, temporarily, economically efficient solutions in the analyzed area; these studies being useful for a better understanding of the correlation between natural resources, environmental issues and the production process in rural areas.

Grasslands encompass a range of sustainable economic uses (MOISUC ET AL. 2000) and contribute to the provision of goods and services that can ensure human, socio-cultural and heritage well-being. The functions of the grassland ecosystem include water and climate regulation and provide life-supporting services (HEIDENREICH, 2009; SWINTON ET AL. 2007; ŞMULEAC ET AL 2020; YUAN-FARRELL, KAREIVA, 2006).

Figure 7 Cartographic representation of surface losses and gains in the pasture category

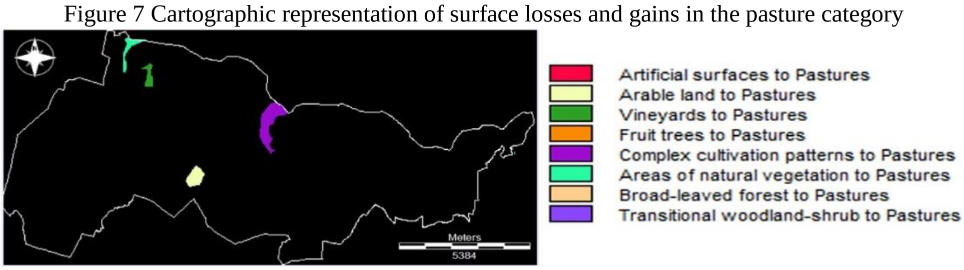


Figure 8 Transition from all categories to Pastures in ATU Pischia from 2006 to 2018

Figure 9 shows the situation of the changes produced between 2006 - 2018. The appearance of road infrastructure instead of arable land or grassland areas is noticeable. There is a reduction in the area of vineyards, arable land and complex crops, in favor of grasslands.

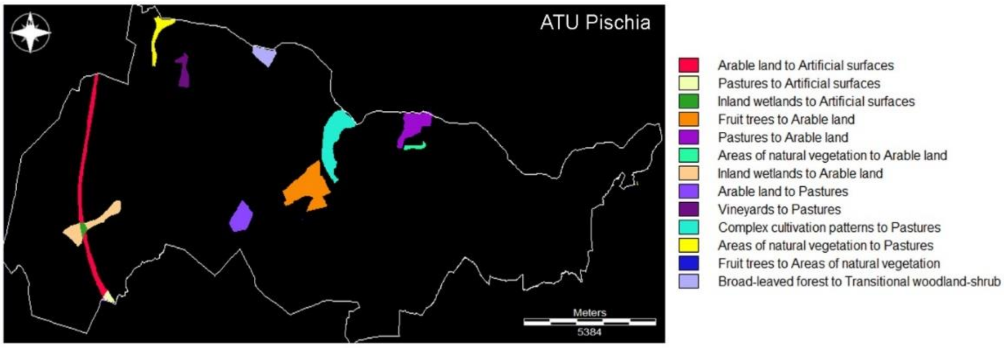


Figure 9 Change in ATU Pischia from 2006 to 2018

Some of the orchards that once existed have disappeared in favor of arable land, and another part has been abandoned.

CONCLUSIONS

At the level of the administrative-territorial unit Pişchia there is a mosaic of agricultural crops that are logically framed in agro-forestry-pastoral systems (arable land, pastures, vineyards, orchards and forest areas).

The use of the Land Change Modeler tool allowed the detailed investigation of the land use in the two reference years (2006 and 2018), but also the “transitions” from one land use category to another, particularly important aspects in land planning.

Thematic maps are useful tools in the agronomic and ecological management of agro-forestry-pastoral systems. The analysis of land use maps, derived from satellite images, could improve knowledge about the evolution of land cover in the analyzed area, in the analysis of land mosaics in ATU Pişchia, of grassland areas used for grazing and could be useful in pastoral planning, as well as in determining the availability of feed and its variation.

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