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CHANGE DETECTION OF THE GRASSLAND SURFACES IN HUNEDOARA COUNTY BY LAND CHANGE MODELER

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Abstract. *At the level of Hunedoara County, according to the National Institute of Statistics, deciduous forests (approx. 50%), grasslands (approx. 18%) and arable lands (approx. 10%) predominate in the structure of the land fund.. In the case of grasslands, the monitoring of their dynamics is of particular importance, in this process being identified the directions and behavior of grassland areas in relation to other components of the environment. One of the most effective land use monitoring procedures is that involving geospatial data and GIS and remote sensing methods. In the case of this study, the Corine Land Cover databases from 1990 and 2018 were used to highlight the changes in land use in Hunedoara County, in the mentioned time interval, and the main objective referred to the trends in "mobility" of grassland areas. Change analysis was performed by comparing geospatial data in Land Change Modeler, a tool implemented in TerrSet software. From 1990 to 2018, the area of pastures decreased by 13071 ha, and the area of natural grasslands increased by 17845 ha. In the "pasture" class, in addition to the changes produced by the inclusion of "natural grasslands", 10776 ha were transformed into deciduous forests and 2763 ha were included in the category "agricultural land with natural vegetation". The pastures gained areas by transforming the use classes of "complex crops" (6960 ha), fruit tree plantations (4990 ha) and as a result of the restriction of the built space (2840 ha). In the case of natural grasslands, the decrease of surface was due to their transition to the category of deciduous forests (1366 ha) and as a result of the expansion of non-agricultural areas (612 ha), and the increase of surface comes from the categories of pastures (14819 ha), complex crops (4323 ha) and shrub vegetation (1418 ha). The changes produced have been "spatialized" by maps of the changes through which different territorial analyzes can be made.*

Keywords: *land use, grasslands, Land Change Modeler, change detection.*

INTRODUCTION

Agro-forestry-pastoral systems, through all their ecological and economic components (JOSE, 2009) can be seen as the main form of land use in many rural areas of the world (STENSEKE, 2006; BELL, MOORE, 2012). This context is also found in Hunedoara county, where, according to the National Institute of Statistics, the structure of the land fund is dominated by forests, pastures and, to a lesser extent, arable land.

In addition to their particularly important role in the economy of the analyzed region (MOISUC ET. AL, 1998; DUDA, IMBREA, 2012; VIDICAN ET AL, 2019) or for the quality of the landscape (IMBREA ET AL, 2010), it is the role of pastures in ecological and biodiversity conservation (BAKKER, BERENDSE, 1999; ROBINSON, SUTHERLAND, 2002; SMITH ET AL, 2003; BROOM ET AL., 2013; COJOCARIU ET AL, 2018; COJOCARIU ET AL, 2019; VOGT, 2021) and regarding the preservation of pastoral traditions (MOISUC ET AL, 1997; HOANCEA ET AL, 2017).

Given the importance of grasslands in regional geosystems, it is equally important to monitor the dynamics of pastoral space (BÂRLIBA, COJOCARIU, 2010; COJOCARIU ET AL, 2015), a process that identifies the directions and behavior of grassland areas in relation to other components of the physical environment. The idea of "mobility" of grassland is supported by the hypothesis that in any territory, regardless of its natural or socio-economic characteristics, land use is constantly changing and indicates directions and trends in zonal or regional development.

One of the most effective procedures for assessing the current situation, but also for analyzing changes in land use, is that which involves geospatial data and GIS and remote sensing methods (GHOSH ET AL, 1996; SHALABY, TATEISHI, 2007; MISHRA ET AL, 2014; TARANTINO ET AL, 2016; SIMON ET AL, 2018; CEGIELSKA ET AL, 2018; MEHRABI ET AL, 2019).

Within the available data, the analysis of changes by computerized comparison of two or more sets of geospatial data can be applied to any type of space or region in the world, and the result can be used in various fields of activity. (WANG ET AL, 2003; HE ET AL, 2005; FU ET AL, 2007; BĂLTEANU, POPOVICI, 2010; PRAKASAM, 2010; WANG, YANG, 2011; POPOVICI ET AL, 2013; HANGANU, CONSTANTINESCU, 2015; COPĂCEAN ET AL, 2019; SIMON ET AL, 2017).

The main purpose of this study was to highlight the changes in land use in Hunedoara county, between 1990 and 2018, and the main objective was to refer to trends in the "mobility" of grassland areas. The analysis of the changes was done by techniques and geomatic methods, and the obtained results outline, on the one hand the "quantitative" situation of the grassland resources of Hunedoara county, on the other hand, the degree of "stability" of these resources.

MATERIALS AND METHODS

1. Study area

The study area completely overlaps Hunedoara county, a territory with great variability of physical and geographical conditions (GEOGRAPHY OF ROMANIA, 1992; POSEA, 2005; RUSU, 2007), from meadow areas, with minimum altitudes of 151 m, at high mountain areas, with maximums of 2494 m (figure 1).

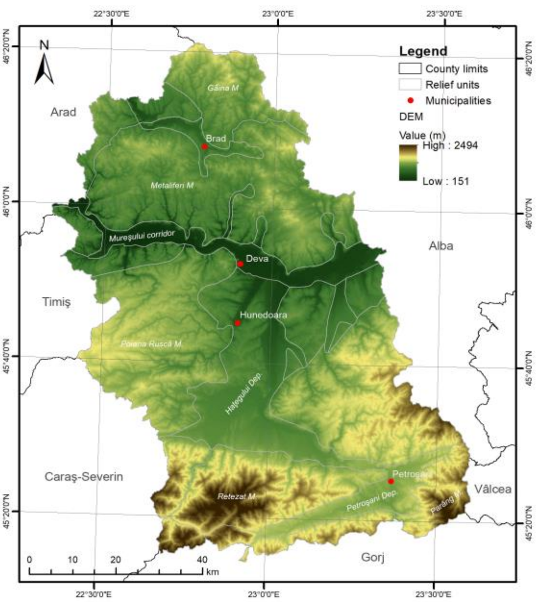


Fig. 1. Location of the study area (processing after GEOSPATIAL; EEA - EU-DEM; ANCPI)

Variabilitatea condiţiilor de relief se reflectă şi asupra modului de utilizare a terenului.

2. Used materials

For the study, the following data sets were used:

- Digital Elevation Model, with a spatial resolution of 25 m, taken from the website of the European Environment Agency, based on which the physical-geographical characterization of the area of interest was made, necessary description to explain the spatial distribution of land use categories;
- Land use maps for 1990 and 2018 (EEA-CLC), obtained by processing the Corine Land Cover database
- Auxiliary geospatial data, such as county boundary and localities in the area of interest (GEOSPATIAL; ANCPI), used as spatial orientation elements.

3. Research methodology

In order to achieve the objectives and purpose of the research, the work steps presented in Table 1 have been completed.

Table 1

Research methodology

Generation of land use maps in 1990 and 2018 from the CLC database	Software used: ArcGIS 10.4
	Working protocol:
	➢ Extracting the area of interest
	➢ Coding by use categories
	➢ Conversion .shp – raster - ASCII
Data processing for change detection	Software used: TerrSet
	Working protocol:
	➢ Conversion ASCII - ..rst
	➢ Legend normalization
	➢ Export for LCM
Change detection in LCM module	Software used: TerrSet
	Working protocol:
	➢ Change detection - losses and gains by categories of use
	➢ Analysis of net changes by use categories
	➢ Contribution to change
	➢ Maps of change

Initially, from the Corine Land Cover database, the land use maps for the area of interest were extracted at the level of 1990s and 2018 (ARCGIS DOCUMENTATION). The graphic entities were grouped according to the land use; .shp formats have been converted to .ASCII format for import into TerrSet software (EASTMAN, 2016).

Land use data sets were imported in the TerrSet-specific format (.rst) and legend normalization procedures were applied. The land use data, together with the Digital Elevation Model (as ancillary data), was uploaded in Land Change Modeler, which analyzed the changes for the analyzed time interval, according to the methodology proposed by Eastman, 2012.

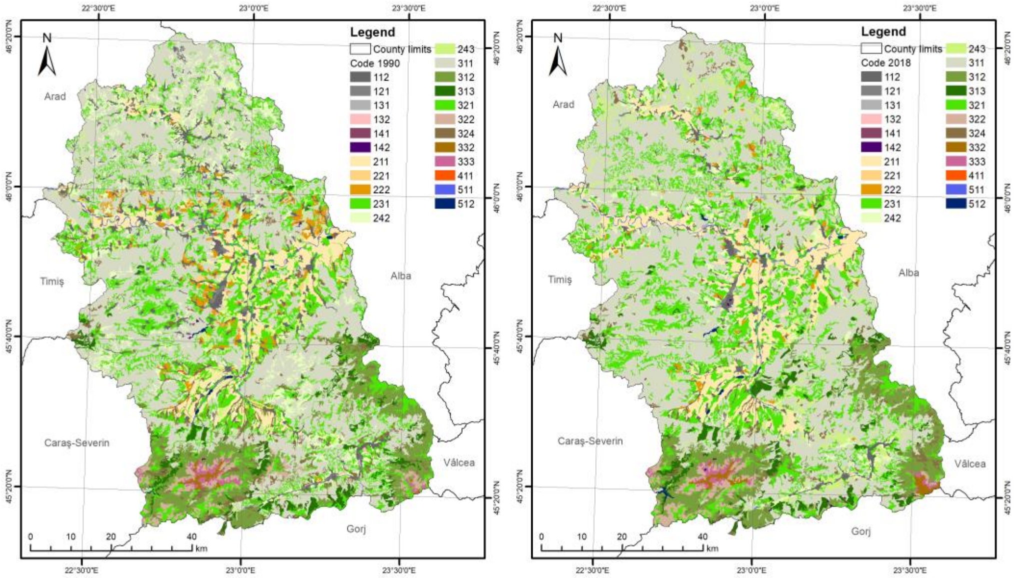
In accordance with the objectives and purpose of the work, the analysis of the changes was carried out especially for the meadow areas and aimed at: the analysis of the changes - losses and surface gains by categories of use; analysis of net changes by use categories; contributing to changes in the "pastures" and "natural grasslands" categories. Change maps have also been generated, showing the location of areas where they have occurred.

RESULTS AND DISCUSSION

Before any quantitative analysis with concrete results, the idea of transformation and / or relocation of meadow areas can be induced by several mechanisms: legislative changes during twenty-eight years (1990 - 2018), professional reorientation of the inhabitants area, socio-economic and political changes. All these considerations were established as a starting point in the analysis of changes, with concrete data and automated analysis tools. Thus, the Land Change Modeler (LCM) module implemented in the TerrSet software was used, which provides both graphical data and change maps. LCM is used to provide predictions (EASTMAN, 2012; EASTMAN, 2016), in environmental analysis or in sustainable development hierarchies (ZARE ET AL, 2017; MEHRABI ET AL, 2019; KHOSHNOOD MOTLAGH ET AL, 2021).

1. Land use in 1990 and 2018

In 1990, in the structure of the land fund of Hunedoara county (Figure 2), the largest land areas were covered with deciduous forests, respectively 310666 ha, which represents 43.93% of the total area. The grasslands covered an area of 124749 ha, respectively 17.64% of the county's area, and the arable lands occupied 43978 ha, which means 6.22% of the total. This distribution in the use of the land is closely correlated with the physical-geographical characteristics of the area of interest in which the relief of hills and the mountain predominates (Figure 1). The three categories of land use mentioned above amount to 67.78% of the total area of Hunedoara County, the difference being divided between other categories of use, with low weight (Figure 2).



1990 2018

The numbers from the legend represent: 112 - Urban fabric; 121 - Industrial, commercial, transport units; 131 - Mineral extraction sites; 132 - Mine, dump and construction sites; 141 - Green urban areas; 142 - Sport and leisure facilities; 211 - Non-irrigated arable land; 221 – Vineyards; 222 - Fruit trees and berry plantations; 231 – Pastures; 242 - Complex cultivation patterns; 243 - Agriculture land with natural vegetation; 311 - Broad-leaved forest; 312 - Coniferous forest; 313 - Mixed forest; 321 - Natural grasslands; 322 - Moors and heathland; 324 - Transitional woodland-shrub; 332 - Bare rocks; 333 - Sparsely vegetated areas; 411 - Inland marshes; 511 - Water courses; 512 - Water bodies

Fig. 2. Land use in 1990 and 2018 (processing after EEA - CLC, GEOSPATIAL)

The grasslands are distributed in all the relief units, from low altitudes, in the case of meadows, to the high mountain area, in the case of alpine grasslands (Figure 2). In addition to the categories called "pastures" and "natural grasslands", areas used as pastures and hayfields can be included in other categories: agricultural land with natural vegetation, transition areas with shrubs, etc.

At the end of the analyzed interval, respectively the year 2018, the land use (Figure 2) keeps, in general, the same structure: deciduous forests 46.81%, grasslands 18.31% and arable land 8.14%.

However, a closer analysis highlights changes both in the distribution of land use categories and in the "quantitative" aspect, from one category to another (Table 2).

Table 2

Land use between 1990 and 2018 (processing after EEA - CLC)

Land use	**Surface (ha)**		**The difference**	**% of total area**	
	1990	**2018**	**1990 - 2018 (ha)**	**1990**	**2018**
Urban fabric	34244	18246	-15998	4.84	2.58
Industrial, commercial, transport units	2896	2312	-584	0.41	0.33
Mineral extraction sites	759	1381	622	0.11	0.20
Mine, dump and construction sites	841	384	-456	0.12	0.05
Green urban areas	96	75	-21	0.01	0.01
Sport and leisure facilities	167	176	9	0.02	0.02
Non-irrigated arable land	43978	57552	13574	6.22	8.14
Vineyards	1204	244	-960	0.17	0.03
Fruit trees and berry plantations	15300	5335	-9965	2.16	0.75
Pastures	98525	85454	-13071	13.93	12.08
Complex cultivation patterns	40329	20275	-20053	5.70	2.87
Agriculture land with natural vegetation	19946	34540	14595	2.82	4.88
Broad-leaved forest	310666	331059	20394	43.93	46.81
Coniferous forest	49665	51310	1645	7.02	7.26
Mixed forest	18157	19096	938	2.57	2.70
Natural grasslands	26224	44069	17845	3.71	6.23
Moors and heathland	11902	11559	-343	1.68	1.63
Transitional woodland-shrub	22915	14190	-8725	3.24	2.01
Bare rocks	2062	3244	1182	0.29	0.46
Sparsely vegetated areas	3523	3324	-199	0.50	0.47
Inland marshes	455	119	-336	0.06	0.02
Water courses	2606	2122	-484	0.37	0.30
Water bodies	775	1166	391	0.11	0.16

Given that the purpose of this study is to analyze the spatio-temporal trends of grassland areas, in the following we will refer to the changes in this category of land use.

2. Spatial-temporal analysis of grassland surfaces

According to the data presented in Table 2, at the beginning of the analyzed interval, the pastures extended on an area of 98525 ha, and the natural grasslands, on 26224 ha. At the end of the analyzed period, in 2018, the area occupied by pastures decreased to 85454 ha, and the area occupied by natural grasslands increased to 44069 ha.

For detailed analysis of trends in grassland mobility, we used Land Change Modeler, implemented in TerrSet software, a tool that allows us to identify the nature of transformations, the contribution of other land use classes to changes in grassland class, but and the location on the map of the areas affected by these changes.

Regarding the net changes produced in the “pastures” class (Figure 3), it can be seen that from the beginning of the analyzed interval until the level of 2018, 13071 ha were lost, and in the case of natural grasslands, an area was gained. of 17845 ha.

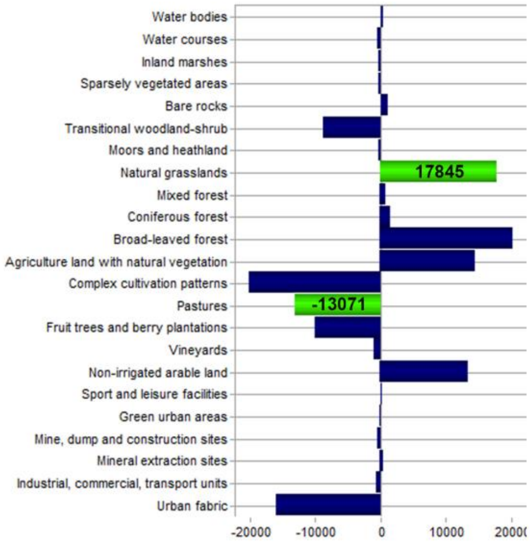


Fig. 3. Net changes in land use between 1990-2018

Regarding the contribution of other land use classes to the modification of pasture areas, the situation was as follows (Figure 4):

- the pastures lost 14819 ha, by reclassifying them as “natural grasslands”; 10776 ha were transformed into deciduous forests; 2763 ha were included in the category “agricultural land with natural vegetation; In the opposite direction, the category of “pastures” gained areas by transforming the use classes “complex crops” (6960 ha), fruit tree plantations (4990 ha) and as a result of the restriction of the built space (2840 ha);
- overall, between 1990 and 2018, the pastures lost an area of 13071 ha.

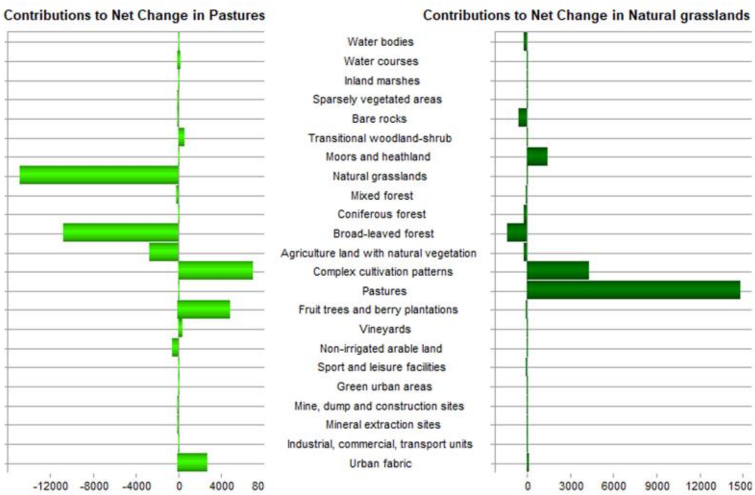


Fig. 4. Contributions to net changes in grassland areas (pastures and natural grasslands)

Regarding the contribution of other land use classes to the modification of natural grassland areas, the situation was as follows (Figure 4):

- overall, the natural grassland category gained 17,845 ha;
- the decrease of surface was due to the transition of natural grasslands in the category of deciduous forests (1366 ha) and as a result of the extension of non-agricultural areas (612 ha), and the increase of surface comes from the categories of pastures (14819 ha), complex crops (4323 ha) and shrubby vegetation (1418 ha).

By analyzing the change distribution map, in the case of the two analyzed categories (Figure 5) the following aspects are highlighted:

- în the case of pastures, the surface losses were registered especially in the low mountainous areas (Metaliferi Mountains, Poiana Ruscă Mountains), by classifying these areas to the category of natural grasslands, but also in some places, in Petroşani Depression and Haţeg Depression, by passing in other categories of use;
- pastures have gained ground in all relief units except high mountain areas;

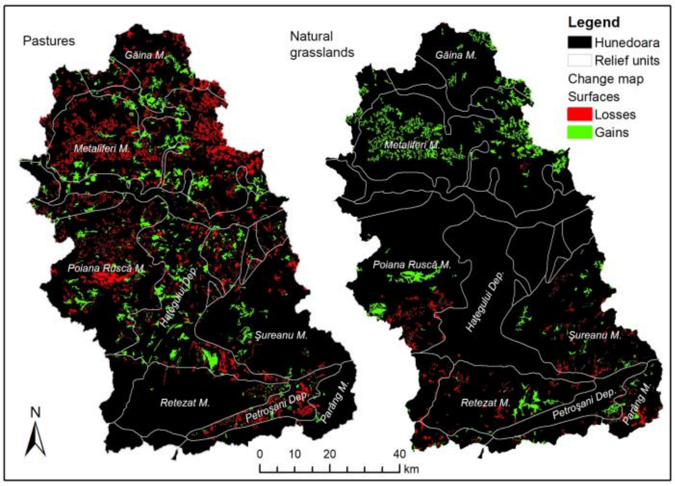


Fig. 5. Distribution of surface losses and gains to the categories of pastures and natural grasslands

- unlike pastures, the natural grasslands distributed by definition in the mountainous areas, have gained areas in the area of the Metaliferi Mountains, in Retezat and Poiana Ruscă Mountains.

CONCLUSIONS

Both at the beginning of the analyzed interval and at the end of this period, in the structure of the land fund, the forests predominate, followed, at large differences in weight, by the areas of grasslands and arable lands. The other categories of land use have shares below 10% of the land fund area.

The analysis of the changes, expressed by concrete statistical data but also by cartographic materials, highlighted the following aspects: the surface occupied by pastures decreased by 13071 ha, and the surface occupied by natural grasslands increased by 17845 ha. Regarding the contribution of other land use classes to the changes produced in the “pasture” class, in addition to the changes produced by their inclusion in “natural grasslands”, 10776 ha were transformed into deciduous forests and 2763 ha were transferred to the category

„Agricultural land with natural vegetation". The pastures gained areas by transforming the use classes of "complex crops" (6960 ha), fruit tree plantations (4990 ha) and as a result of the restriction of the built space (2840 ha).

In the case of natural grasslands, the decrease of surface was due to their transition to the category of deciduous forests (1366 ha) and as a result of the expansion of non-agricultural areas (612 ha), and the increase of surface comes from the categories of pastures (14819 ha), complex crops (4323 ha) and shrub vegetation (1418 ha).

In addition to the statistical data, the analysis of the changes illustrated by maps, allows the identification of the areas in which the changes took place and thus the punctual and concrete intervention is possible.

BIBLIOGRAPHY

AGENŢIA NAŢIONALĂ DE CADASTRU ŞI PUBLICITATE IMOBILIARĂ (ANCPI) – baza de date geospaţiale - https://geoportal.ancpi.ro/portal/home/

ARCGIS DOCUMENTATION: https://desktop.arcgis.com/en/documentation/

BAKKER, J.P., BERENDSE, F., 1999 - Constraints in the restoration of ecological diversity in grassland and heathland communities. Trends in Ecology and Evolution 14, 63–68.

BĂLTEANU, D., POPOVICI, E.A., 2010 - Land use changes and land degradation in post-socialist Romania. Rev Roumaine de Géogr/Romanian J Geogr, vol. 54, no. 2, pp: 95–105

BÂRLIBA, C., COJOCARIU, L., 2010 - The Selective distribution of pasture surfaces situated on administrative territory of Nadrag, Timis County, Research Journal of Agricultural Science, vol. 42, no. 1, pp: 340-347

BELL, L.W., MOORE, A.D., 2012 - Integrated crop-livestock systems in Australian agriculture: Trends, drivers and implications. Agricultural Systems, 111 (1): 1-12. doi.org/10.1016/j.agsy.2012.04.003

BROOM, D.M., GALINDO, F.M., MURGUEITIO, E., 2013 - Sustainable, efficient livestock production with high biodiversity and good welfare for animals. Proceedings of the Royal Society B: Biological Sciences, 280 (1771): 2013-2025, doi: 10.1098/rspb.2013.2025

CEGIELSKA, K., NOSZCZYK, T., KUKULSKA, A., SZYLAR, M., HERNIK, J., DIXON-GOUGH, R., JOMBACH, S., VALÁNSZKI, I., KOVÁCS, K.F,. 2018 - Land use and land cover changes in post-socialist countries: Some observations from Hungary and Poland. Land Use Policy, vol. 78, pp: 1–18

COJOCARIU, L., COPĂCEAN, L., HORABLAGA, M.N., 2015 - Grassland delineation and representation through remote sensing techniques, Romanian, Journal Of Grasslands And Forage Crops, vol. 12, pp: 17

COJOCARIU, L., BORDEAN, D.M., COPĂCEAN, L., HOANCEA, L., 2018 - Evaluation of the biodiversity protection degree in Romanian Banat by geomatic methods, International Multidisciplinary Scientific GeoConference: SGEM 18 (5.1), pp. 369-376

COJOCARIU, L., COPĂCEAN, L., POPESCU, C., 2019 - Conservation of grassland habitats biodiversity in the context of sustainable development of mountain area of Romania, Appl. Ecol. Environ. Res, Vol.17, 2019, pp: 8877-8894

COPĂCEAN, L., ZISU, I., MAZĂRE, V., COJOCARIU, L, 2019 - Analysis of land use changes and their influence on soil features. Case study: Secaș village, Timiș County (Romania), PESD, VOL. 13, no. 2, DOI: 10.2478/pesd-2019-0032

DUDA, M.M., IMBREA, F. 2012 - Condiţionarea şi păstrarea produselor agricole, Editura Universitară

EASTMAN J.R., 2012, Idrisi Selva Tutorial, Manual Version 17, Clark University, http://uhulag.mendelu.cz/files/pagesdata/eng/gis/idrisi_selva_tutorial.pdf

EASTMAN J.R., 2016, TerrSet – Geospatial Monitoring and Modeling System, Manual, Clark University, https://clarklabs.org/wp-content/uploads/2016/10/Terrset-Manual.pdf

EUROPEAN ENVIRONMENT AGENCY (EEA), 2017 - Digital Elevation Model (DEM) with spatial resolution at 25 m, Produced using Copernicus data and information funded by the European Union - EU-DEM layers; owned by the Enterprise and Industry DG and the European

Commission:https://www.eea.europa.eu/data-and-maps/data/copernicus-land-monitoring-service-eu-dem

EUROPEAN ENVIRONMENT AGENCY (EEA - CLC) (1990 - 2018): Corine Land Cover Database (CLC), 2006, 2018 Edition - https://land.copernicus.eu/pan-european/corine-land-cover

FU, K., CHEN, X.P., LIU, Q.G., 2007 - Grassland resources degradation of the loess plateau based on remote sensing and GIS. IEEE International Geoscience and Remote Sensing Symposium. DOI:10.1109/igarss.2007.4423590

GEOGRAFIA ROMÂNIEI 1992, VOL. II, Edit. Academiei Române, Bucureşti

GEOSPATIAL - ROMÂNIA: seturi de date vectoriale generale, http://geo-spatial.org/vechi/download/romania-seturi-vectoriale

GHOSH, S., SEN, K.K., RANA, U., 1996 - Application of GIS for land-use/land-cover change analysis in a mountainous terrain. J Indian Soc Remote Sens, vol. 24, pp: 193–202. https://doi.org/10.1007/BF03007332

HANGANU, J., CONSTANTINESCU, A., 2015 - Land cover changes in Romania based on Corine Land Cover inventory 1990–2012. Rev. Roum. Géogr. Rom. Journ. Geogr, vol. 59, pp: 111–116

HE, C., ZHANG, Q., LI, Y., LI, X., SHI, P., 2005 - Zoning grassland protection area using remote sensing and cellular automata modeling – A case study in Xilingol steppe grassland in northern China. Journal of Arid Environments, 63(4), 814–826. DOI:10.1016/j.jaridenv.2005.03.028

HOANCEA, L., COPACEAN, L., BORDEAN, D.M., COJOCARIU, L., 2017 - Analysis of pasture vegetation in the west of Romania in correlation with pastoral traditions, SGEM 2017 Conference Proceedings, 2017, Vol. 17, Issue 52, pp: 33-40, DOI: 10.5593/sgem2017/52/S20.005; https://sgem.org/sgemlib/spip.php?article10413

IMBREA, I., PRODAN, M., NICOLIN, A., BUTNARIU, M., IMBREA, F., 2010 - Valorising Thymus glabrescens Willd. from the Aninei mountains, Research Journal of Agricultural Science, Vol.42, nr.2, pp.260-263

INSTITUTUL NAŢIONAL DE STATISTICĂ (INS): http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table

JOSE, S., 2009 - Agroforestry for ecosystem services and environmental benefits: an overview, Agroforest Systems, 76: 1–10. doi.org/10.1007/s10457-009-9229-7

KHOSHNOOD MOTLAGH, S., SADODDIN, A., HAGHNEGAHDAR, A., RAZAVI, S., SALMANMAHINY, A., GHORBANI, K., 2021 - Analysis and prediction of land cover changes using the land change modeler (LCM) in a semiarid river basin, Iran. Land Degradation & Development, 32(10), 3092– 3105. https://doi.org/10.1002/ldr.3969

MEHRABI, A., KHABAZI, M., ALMODARESI, S.A., NOHESARA, M., DERAKHSHANI, R., 2019 - Land Use Changes Monitoring over 30 Years and Prediction of Future Changes Using Multi-Temporal Landsat Imagery and the Land Change Modeler Tools in Rafsanjan City (Iran). Sustainable Development of Mountain Territories, T.11. №1(39), SSRN: https://ssrn.com/abstract=3405670

MISHRA, V., RAI, P., MOHAN, K., 2014 - Prediction of land use changes based on Land Change Modeler (LCM) using remote sensing: A case study of Muzaffarpur (Bihar), India, Journal of the Geographical Institute "Jovan Cvijic", SASA, Volume 64, Issue 1, Pages: 111-127

MOISUC, A. COJOCARIU, L., SAMFIRA, I.., 1997 - Rezultate privind îmbunătăţire pajiştilor din Vestul ţării, Lucrări Ştiinţifice, vol. 29, pp 151-154

MOISUC, A., COJOCARIU, L., SAMFIRA, I., 1998 – Rezultate preliminare privind îmbunătăţire pajiştilor din Vestul ţării, Lucrări Ştiinţifice, vol. 30, pp 237-244

POPOVICI, E.A., BĂLTEANU, D., KUCSICSA, G., 2013 - Assessment of changes in land-use and land-cover pattern in Romania using Corine land cover database. Carpath. J. Earth Environ. Sci, vol. 8, pp: 195–208

POSEA, GR., 2005 - Geomorfologia României, Ed. Fundaţiei „România de Mâine”, Bucureşti, 2005

PRAKASAM, C., 2010 - Land use and land cover change detection through remote sensing approach: A case study of Kodaikanal taluk, Tamil nadu,INTERNATIONAL JOURNAL OF GEOMATICS AND GEOSCIENCES Volume 1, No 2.

ROBINSON, R.A., SUTHERLAND, W., 2002 - Post-war changes in arable farming and biodiversity in Great Britain, J. Appl. Ecol. 39 (2002) 157–176

RUSU, R., 2007 - Organizarea spaţiului geografic în Banat, Ed. Mirton, Timişoara

SHALABY, A., TATEISHI, R., 2007 - Remote sensing and GIS for mapping and monitoring land cover and land-use changes in the Northwestern coastal zone of Egypt, Applied Geography Vol. 27, Issue 1, pp. 28-41, https://doi.org/10.1016/j.apgeog.2006.09.0

SIMON, M., POPESCU, C.A., COPĂCEAN, L., COJOCARIU, L., 2017 - CAD and GIS techniques in georeferencing maps for the identification and mapping of meadows in Arad county, Research Journal of Agricultural Science, vol. 49, no. 4, pp: 276-283

SIMON, M., COPĂCEAN, L., COJOCARIU, L., 2018 - U.A.V. technology for the detection of spatio-temporal changes of the useful area for forage of grassland, Research Journal of Agriculture Science, 50(4), 332-341

SMITH, R.S., SHIEL, R.S., BARDGETT, R.D., MILLWARD, D., CORKHILL, P., ROLPH, G., HOBBS, P.J., PEACOCK, S., 2003 - Soil microbial community, fertility, vegetation and diversity as targets in the restoration management of a meadow grassland. Journal of Applied Ecology 40, 51–64

STENSEKE M.. 2006 - Biodiversity and the local context: linking semi-natural grasslands and their future use to social aspects, Environmental Science & Policy. 9:350–359

TARANTINO, CRISTINA, ADAMO, MARIA, LUCAS, R., BLONDA, PALMA, 2016 - Detection of changes in semi-natural grasslands by cross correlation analysis with WorldView-2 images and new Landsat 8 data, Remote Sensing of Environment, Volume 175, 15, Pages 65-72, https://doi.org/10.1016/j.rse.2015.12.031

VIDICAN, R., CARLIER, L., ROTAR, I., MĂLINAŞ, A., 2020 - Exploitation and Management of Low Input Grassland Systems, Bulletin of the University of Agricultural Sciences & Veterinary Medicine Cluj-Napoca. Agriculture, Vol. 77, 1, pp 49- 56, DOI:10.15835/buasvmcn-agr: 2019.0031

VOGT, MAB., 2021 - Agricultural wilding: rewilding for agricultural landscapes through an increase in wild productive systems, J Environ Manage. Apr 15;284:112050, doi: 10.1016/j.jenvman.2021

WANG, J., JIAO, Y., WANG, L., XIAO, H., 2003 - Dynamic monitoring of grassland degradation with remote sensing and the strategy of ecological restoration in Shandan County of Heihe Basin. Ecosystems Dynamics, Ecosystem-Society Interactions, and Remote Sensing Applications for Semi-Arid and Arid Land. DOI:10.1117/12.465684

WANG, R.J., YANG, L.W., 2011 - Valuate of Soil Conservation of Grassland Ecosystem with GIS and Remote Sensing Technology. Advanced Materials Research, 365, 115–118. DOI:10.4028/www.scientific.net/amr.365.115

ZARE, M., PANAGOPOULOS, T., LOURES, L,. 2017 - Simulating the impacts of future land use change on soil erosion in the Kasilian watershed Iran. Land Use Policy, volume 67, p. 558 – 72