SPATIAL ECOLOGICAL, BIOGEOGRAPHICAL AND LANDFORM DISTRIBUTION OF 2006-2012 LAND COVER AND USE CHANGES IN ROMANIA

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Abstract. Land cover and use changes are an important form of environmental impact, with socio-economic determinants in the declining economies. Since satellite imagery-derived geospatial data can be used in conjunction with GIS to explore the spatial distribution of changes, this study aims to explore it in relationship to the biogeographical and ecological regions and landforms. The result, based on geo-statistical analyses of CORINE data, simply show the consequences of an unplanned development: forests are cut from the mountain and hill region, but their regeneration occurs only in the hills; floods occur in the floodplain, agriculture is abandoned in the steppe, and urbanization dominates the plain regions.

Keywords: CORINE, biogeographical regions, ecological regions, landforms, elevation, impact assessment.

Rezumat. Distribuţia spaţială a modificărilor acoperirii şi utilizării terenului din perioada 2006-2012 în România pe regiuni biogeografice şi ecologice şi forme de relief. Modificările acoperirii şi utilizării terenului reprezintă o formă importantă de impact asupra mediului, determinată în ţările în curs de dezvoltare de factori socio-economici. Având în vedere că datele geo-spaţiale derivate din imagini satelitare pot fi utilizate împreună cu sistemele informaţionale geografice pentru analiza exploratorie a distribuţiei spaţiale a acestor schimbări, studiul de faţă îşi propune analiza lor în relaţie cu regiunile biogeografice şi ecologice şi formele de relief. Rezultatele, obţinute prin utilizarea unor analize geo-statistice pe baza datelor CORINE, arată consecinţele unei dezvoltări neplanificate: pădurile sunt tăiate în zonele de deal şi de munte, dar se regenerează doar în zonele de deal; în lunci au loc inundaţii, culturile agricole sunt abandonate în zona de stepă, iar regiunile de câmpie sunt intens urbanizate.

Cuvinte cheie: CORINE, regiuni biogeografice, regiuni ecologice, forme de relief, altitudine, evaluarea impactului.

INTRODUCTION

The recent advances in the theory of the environmental impact assessment of human activities include introducing the concept of ‘global changes’ (DALE, 1997; DALE et al., 2011) in order to coin all man-induced changes affecting our global environment: land cover and use changes, climate changes, and alterations of the energy flows. The three changes are related (DALE, 1997; DALE et al., 2011; IANOŞ et al., 2011; PETRIŞOR, 2012c), but the connections are hardly assessable from a quantitative perspective because not all of them benefit upon the existence of data resulted from a continuous monitoring.

This study is focused on land cover and use changes, because they are easy to assess, especially at regional scales, using satellite imagery data in conjunction with the Geographical Information Systems (PETRIŞOR, 2016). These data were an output of the program CORINE (Coordinated Information on the European Environment) (DE LIMA, 2005), available from the European Environment Agency for the periods 1990-2000 and 2000-2006 and Copernicus (2006-2012). Moreover, land cover and use changes reflect socio-economic issues through their underlying transitional dynamics (PETRIŞOR et al., 2010; 2014).

In particular, land cover and use changes are able to reflect the consequences of sprawl, characteristic to man dominated systems. More exactly, as a consequence of socio-economic development, man-dominated systems are sprawling over the natural ones, simplifying and fragmenting them (RAZIN & ROSENTRAUB, 2000; FERNÁNDEZ-JURICIC & JOKIMÄKI, 2001; MARZLUFF & EWING, 2001; JONGMAN, 2002; MELLES et al., 2003; HABERL et al., 2009; PETRIŞOR & SÂRBU, 2010; TUDOR et al., 2013; PETRIŞOR et al., 2016). The two phenomena differ; fragmentation refers to a patched or leap-frog land development, while dispersion refers to the expansion of a city from its core (SCHNEIDER & WOODCOCK, 2008). However, the consequences are similar; the sprawl process results into land cover and use changes (RAZIN & ROSENTRAUB, 2000; GRIMM et al., 2008), and is more prominent around cities than in agricultural areas (MARZLUFF & EWING, 2001). Other consequences include reducing the global resilience (ANDERSSON et al., 2014), fragmenting the habitats (MCMAHON, 2000), decreasing the areal of natural species (MCKINNEY, 2008), altering the ecosystem functions, increasing exposure to other impacts (MARZLUFF & EWING, 2001; GIBB & HOCHULI, 2002) and contributing to the loss of biodiversity (BENEDICT & MCMAHON, 2001; GIBB & HOCHULI, 2002; LUCK & WU, 2002; POELMANS & VAN ROMPAEY, 2009).

The effects of land cover and use changes can be assessed from two related perspectives: alteration of the green infrastructure and reduction of ecosystem services. The green infrastructure is a “network of open space, woodlands, wildlife habitat, parks and other natural areas, which sustain clean air, water, and natural resources and enrich their citizens’ quality of life” (MCMAHON, 2000). It consists of ecological corridors, urban areas, industrial parks, suburban areas, sustainable drain systems, and coastal areas (BENEDICT & MCMAHON, 2001; GILL et al., 2007; TZOULAS et al., 2007). The green infrastructure provides ecological services (MCMAHON, 2000; PAULEIT et al., 2005; TAYLOR LOVELL & TAYLOR, 2013), can help cities adapting to climate changes (GILL et al., 2007; MELL, 2008), and contributes to ecosystem health by preserving biodiversity (TZOULAS et al., 2007), ultimately relating to human health (CAMERON et al., 2012). Ecosystem services are the benefits offered by ecosystems to the human society: supply, regulation, cultural, and support (BOLUND & HUNHAMMAR, 1999; ZAKRI & WATSON, 2003; WATSON & ZAKRI, 2005; ERNSTSON et al., 2010; YOUNG, 2010; CILLIERS et al., 2013). They have biophysical, health, environmental justice, economic, social, cultural, and insurance value (PATAKI et al., 2011; GÓMEZ-BAGGETHUN & BARTON, 2013; GÓMEZ-BAGGETHUN et al., 2013), and can reduce global pollution and help adapting to the effects of climate change (LA GRECA et al., 2011). The quality of ecosystem services reflects their normal functioning, as yield depends on the carrying capacity (IANOŞ et al., 2009). However, they depend on biodiversity and ecosystem health (NIEMELÄ et al., 2010; YOUNG, 2010). Urban ecosystem services and ecological infrastructure can help reconnecting cities and people to the biosphere (WICKHAM et al., 2010; GÓMEZ-BAGGETHUN et al., 2013).

Several similar studies carried out in Romania at different spatial scales (IANOŞ et al., 2011; PETRIŞOR, 2012a, b, c; 2015a, b; PETRIŞOR & PETRIŞOR, 2015; PETRIŞOR et al., 2010; 2014), with different aims, focuses and methodologies, but all aimed at pinpointing the main transitional dynamics characteristic to Romania as a transition country. The findings consisted of few antagonistic phenomena: development and abandonment of agriculture, deforestation and forestation – consisting of afforestation, reforestation (DUTCĂ & ABRUDAN, 2010), and colonization of abandoned agricultural land by forest vegetation (AGNOLETTI et al., 2011; PETRIŞOR et al., 2014), urbanization and other less prominent causes, such as the construction of dams, draughts etc., which are in general characteristic to transition economies.

The present study aims to assess the spatial distribution of the most recent changes from an environmental perspective, in relationship with the biogeographical and ecological regions, which are the spatial expression of biological diversity (PETRIŞOR, 2008; 2014).

DATA AND METHODS

The study used several datasets, freely available from European and international sources, presented in Table 1. Data were processed by re-projecting and sub-sampling subsets for Romania, clipping, and ultimately computing areas using the X-Tools extension of ArcView GIS 3.X. The analyses aimed to assess the distribution of different transitional dynamics by the biogeographical and ecological regions and landforms by computing their total areas.

Landforms were classified based on their elevation, similar to the study by PETRIŞOR (2010): floodplain - 0 to less than 20 m, plain - 0 to less than 200 m, hill or plateau - 200 to less than 900 m, and mountain - over 900 m.

The following classes of transitional dynamics were defined, using a methodology combining the previous ones (IANOŞ et al., 2011; PETRIŞOR, 2012a, b, c; 2015a, b; PETRIŞOR & PETRIŞOR, 2015; PETRIŞOR et al., 2010; 2014):

1. Urbanization – refers to urban development within the cities, manifested through changes at the third level of level 1 ‘urban’ class, but also to the transformation of other level 1 classes into ‘urban’
2. Forestation – defined by joining afforestation, reforestation, and colonization of abandoned agricultural land by forest vegetation, forestation is reflected by a level 1 transformation of other classes into ‘forest’ (CORINE classes 311 – coniferous forests, 312 – broadleaved forests, 313- mixed forests) (DE LIMA, 2005), but also by transformations of the ‘natural’ level 1 classes indicating the regeneration of forests
3. Deforestation – defined as a transformation of ‘forests’ (see above) into other ‘natural’ level 1 classes
4. Development of agriculture – includes the level 1 transformation of other classes into ‘agricultural’ and level 3 transformations within the ‘agricultural’ classes indicating the development of agriculture
5. Abandonment of agriculture – refers to level 3 transformations within the ‘agricultural’ classes indicating the abandonment of agriculture
6. Floods – includes the level 1 transformation of other classes into ‘wetlands’ or ‘waters’.

Table 1. Specifications on the data used in the study: dataset, provider, URL, remarks and transformations.

Dataset	Provider	URL	Remarks	Transformation
Land cover and use changes data	Copernicus Land Monitoring Services	http://land.copernicus.eu/pan-european/corine-land-cover/lcc-2006-2012/view	ArcView GIS 3.X	Project into Stereo 1970, subsample for Romania
Biogeographical regions	European Environment Agency data services	http://dataservice.eea.europa.eu/dataservice/metadetails.asp?id=308	ArcView GIS 3.X; 2001 data	Project into Stereo 1970, subsample for Romania
Ecological regions	European Environment Agency	http://www.eea.europa.eu/data-and-maps/data/digital-map-of-european-ecological-regions	ArcView GIS 3.X	Project into Stereo 1970, subsample for Romania
Landform	Consultative Group on International Agricultural Research – Consortium for Spatial Information	http://srtm.csi.cgiar.org/SELECTION/inputCoord.asp	Digital Elevation Model (DEM); Nearly 90 m × 90 m resolution	Import into Arc GIS, then export to ArcView GIS 3.X, project into Stereo 1970, subsample for Romania

RESULTS AND DISCUSSION

The study aimed to assess the spatial distribution of land cover and use changes occurred in Romania during 2006-2012 by the biogeographical regions (Fig. 1), ecological regions (Fig. 2), and landforms (Fig. 3). For each figure, the assessment is carried out from a double perspective: (1) are certain transitional dynamics dominant in certain biogeographical regions, ecological regions, or landforms? and (2) which are the transitional dynamics characteristic to each biogeographical region, ecological region, or landform?

Figure 1 indicates that several transitional dynamics are strongly associated with some biogeographical regions; for the continental region, the main transitional dynamics are the development of agriculture, forestation, and urbanization; for the alpine region, the main transitional dynamic is deforestation (consistent with the results of PETRIŞOR, 2015b); and for the steppic region, the main transitional dynamics are other causes, floods, and the abandonment of agricultural land (the last finding is consistent with REY BENAYAS et al., 2007; KUEMMERLE et al., 2008; PETRIŞOR, 2015a). From the other perspective, there is a strong connection between deforestations and the alpine region.

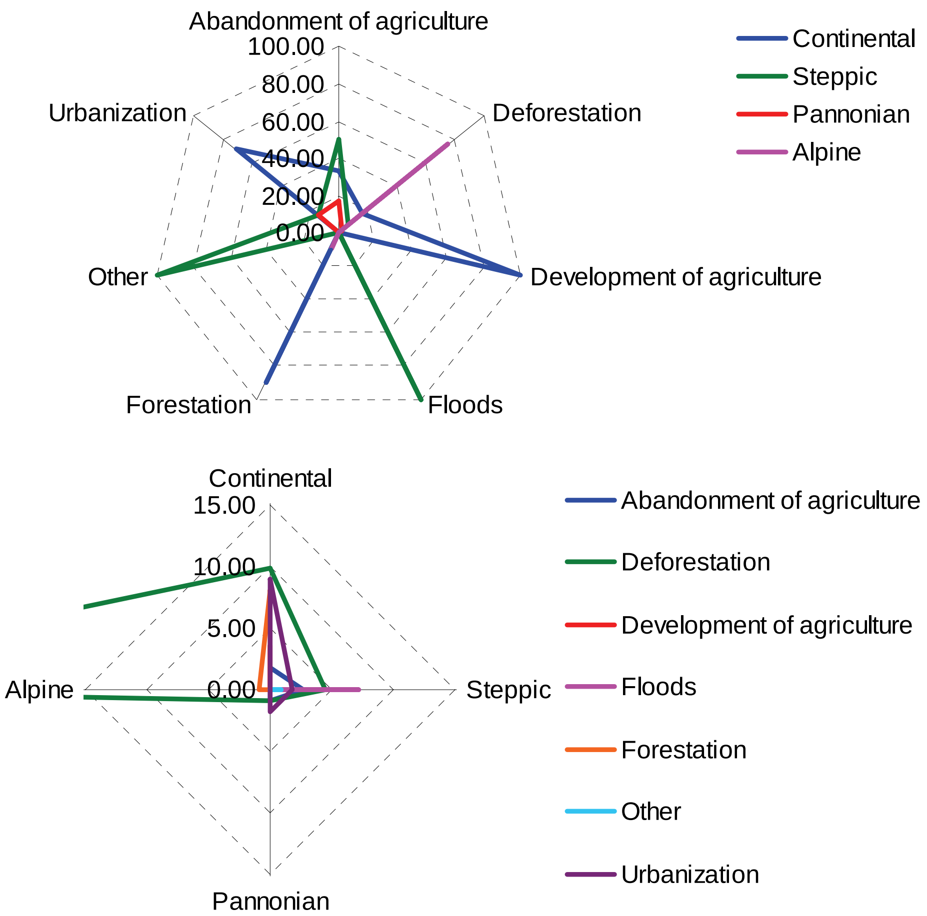

Figure 1. Spatial distribution of land cover and use changes in Romania during 2006-2012 by the biogeographical region, based on CORINE data. The analyses are carried from a double perspective: transitional dynamics by biogeographical region (top) and biogeographical regions by transitional dynamics (bottom).

Figure 2 shows that the abandonment of agriculture and floods are characteristic to the Pontic steppe, deforestation and forestation to the Carpathian montane coniferous forests, abandonment of agriculture, urbanization and forestation to the Pannonian mixed forests, development of agriculture and urbanization to the Balkan mixed forests, and other transitional dynamics to the central European mixed forests. From the other perspective, most deforestation occurred in the region of the Carpathian montane coniferous forests and fewer in the Pannonian mixed forests, and floods are associated to the Pontic steppe.

The results presented in Figure 3 indicate that the transitional dynamics characteristic to the plain are urbanization, development of agriculture and ‘others’. Floods are characteristic to the plain, deforestation to the mountain regions, and forestation to the hills. From the other perspective, the most important associations are between mountains and hills and deforestation, floods and the floodplain, forestation to the fills, and urbanization to the plain.

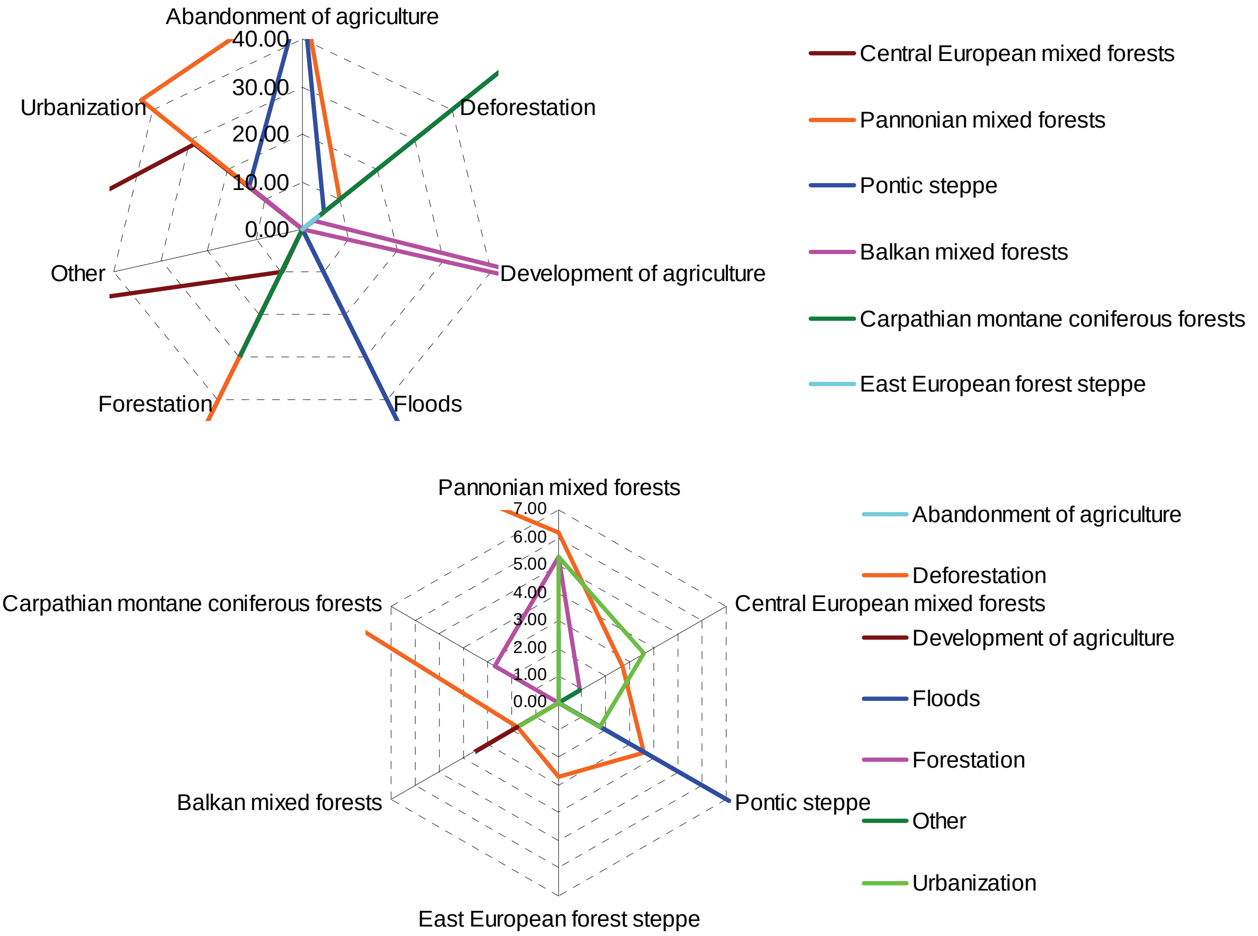

Figure 2. Spatial distribution of land cover and use changes in Romania during 2006-2012 by the ecological region, based on CORINE data. The analyses are carried from a double perspective: transitional dynamics by ecological region (top) and ecological regions by transitional dynamics (bottom).

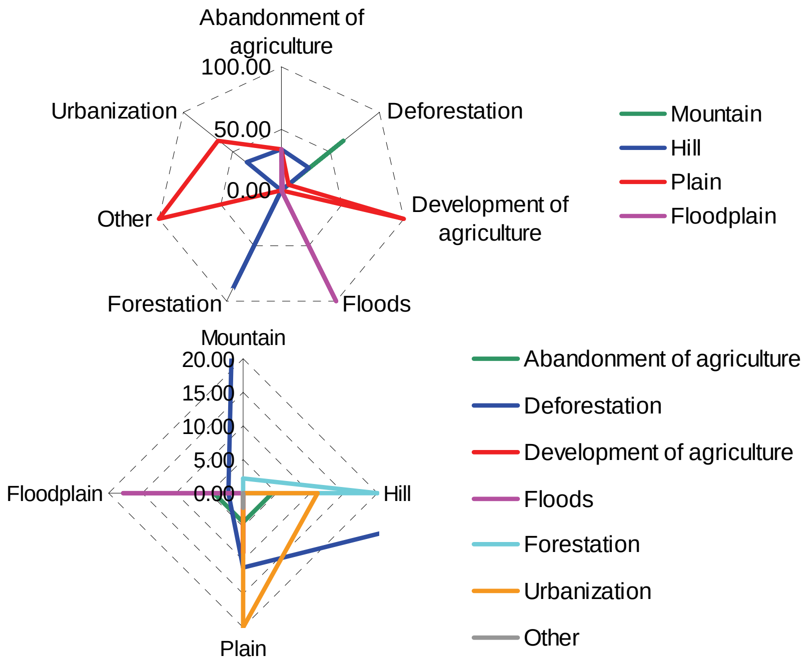

Figure 3. Spatial distribution of land cover and use changes in Romania during 2006-2012 by the landform (defined by elevation), based on CORINE data. The analyses are carried from a double perspective: transitional dynamics by landform (top) and landforms by transitional dynamics (bottom).

The study is subject to limitations characteristic to CORINE data, including misclassification, changes in the classification schemes, and different resolutions from one period to another (JANSEN, 2007; PELOROSSO et al., 2011; VERBURG et al., 2011; PETRIŞOR et al., 2010, 2014), and also to the ones originating in the classification of landforms based on elevation only (for example, Dobrudja mountains would be classified as 'hills' due to their height).

CONCLUSION

The findings of this study are consistent with the previous ones and suggest the lack of planning for development. The main transitional dynamics indicates that negative phenomena are not countered; for example, deforestation occurs in the mountains and hill region, but reforestation only in the latter; as a consequence, floods occur in the plain. The plain areas, situated in the continental region, are under the pressure of urbanization. The steppe, affected by the effects of climate changes, is characterized by the abandonment of agriculture, but the causal relationship of the two cannot be inferred from these data only.

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