LAND COVER AND LAND USE CHANGES REFLECTING THE ENVIRONMENTAL IMPACTS OF LOCAL DECLINING ECONOMIES. CASE-STUDY: SOUTH-WEST DEVELOPMENT REGION. ROMANIA

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Key-words: land cover and use changes, transitional dynamics, South-West Development Region, agriculture, deforestation.

Changements dans la couverture et l'utilisation du terrain réfléchissant impacts des pays en déclin économique local. Etude de cas: la Région Roumaine de Développement Sud-Ouest. Les changements dans la couverture et l'utilisation du terrain, les modifications des circuits de l'énergie et les changements climatiques sont constituants des «changements globaux», terme incluant tous les impacts humains sous les complexes des systèmes socio-écologiques. La plupart des auteurs faite une connexion entre la pression sous l'environnement et les forces socio-économiques, considérant que le processus de transition économique et la conscience environnementale réduite produisent problèmes environnementaux sérieux. Cette recherche s'agit de l'investigation des impacts environnementaux par les dynamiques de transition dans longues périodes réfléchies par des changements dans la couverture et utilisation du terrain dans la région de développement roumaine sud-ouest, en connexion avec le déclin post-socialiste de l'économie, aggravé par le fait que beaucoup des villes ont perdu leur fonction industrielle. La méthodologie est basée sur l'allocation de des changements dans la couverture et utilisation du terrain indiquées par les données CORINE entre 1990–2000 et 2000–2006 aux dynamiques de transition spécifique, calculant la surface affectée par chaque type, et utilisant le kriging commun pour trouvant les zones le plus affectées. Les résultats indiquent que le plus importantes dynamiques sont le forestage (afforestation ou reforestation), abandon et développement de l'agriculture, déforestation et urbanisation pour la première période, et le forestage (afforestation ou reforestation), déforestation, abandon de l'agriculture et urbanisation pendant la deuxième. Donné que la colonisation naturelle des parcelles agricoles abandonnées par la végétation forestière pourrait être erronément classifiée comme foretage, les causes majeurs peuvent être attribuées au déclin de l'économie, soutenant l'hypothèse de travail.

1. INTRODUCTION

A consistent part of the environmental literature is devoted to explaining environmental issues through poverty, or at least connecting them (Reichel-Dolmatoff, 1982; Rozelle *et al*., 1997; Jehan, Umana, 2003), particularly in developing countries with low environmental awareness (Leonard, David, 1981; Ianoş *et al*., 2009), or which do not use resources as sustainable means to reduce poverty (Hope *et al*., 2005). However, a consistent part of these studies developed an in-depth conceptual refinement of the underlying causes of poverty and/or their relationship to the environmental issues. Some studies were focused on territorial disparities, which pinpointed problem areas (Ancuţa, 2010; Ianoş *et al*., 2013). Many studies were devoted to mapping poverty (Sandu, 2003, 2005, 2011).

Other studies established typologies using different concepts; weak urban polarization areas were introduced by the National Spatial Plan of the settlement network, approved in 2001, and defined as "*areas distanced from cities at least 25–30 km., requiring priority actions for developing the settlements providing inter-communal services*"; the concept was rarely used in the literature (Ancuţa, 2010; Drăghici *et al*., 2011; Soare, 2012; Vâlceanu, 2013). provided a first theoretical definition –

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"*areas characterized by economic and demographic stagnation or regress, which must be supporting by consolidating the territorial role and functions of human settlements with a favorable geographic position, a certain economic foundation, and well-developed administrative, cultural and education infrastructures*". Another concept is 'deeply disadvantaged area' (Braghină *et al*., 2008; Ianoş, 2001; Ianoş, Heller, 2006; Ianoş *et al*., 2009, 2010; Şerban, Ianoş, 2012; Turnock, 2005), defined by the Romanian Strategy for Territorial Development based on the spatial contiguity of at least 5 administrative units, an average development index at least 25% smaller than the one of the integrating area or 75% below the one of the region of development, values of core indicators close to the national or macro-regional minimum, and regional impact over all neighboring units. Four classes were identified using the criteria above: weakly polarized area without inner discontinuities, uni-polar rural area with slight inner discontinuities, bi- or multi-polar rural area with inner discontinuities, and deeply rural, not polarized area. The newest concept in this series, although insufficiently crystallized, is 'restrictive environment', the output of a joint action of natural and anthropogenic factors, impeding development and consequently calling for active spatial planning solutions aimed at boosting economic development and increasing life quality (Cocheci, 2014a, b); however, a set of criteria for individualizing such environments has not been developed so far.

Among the methods used to assess environmental changes, spatial analyses based on land cover and use data, particularly the CORINE Land Cover database provided by the European Agency, were preferred because of their association with other anthropogenic impacts forming the global changes (Dale, 1997; Dale *et al*., 2011), but also for the availability of data (Petrişor *et al*., 2010, 2014), despite of limitations including misclassification or changes of the classification schemes, or resolutions from one period to another (Jansen, 2007; Pelorosso *et al*., 2009; Verburg *et al*., 2011; Petrişor *et al*., 2014). Several studies used CORINE data to look at land cover and land use changes in Romania. The study by Petrişor (2012a) assessed all types of changes during the two periods covered by the data by transitional dynamic, using a different classification. The results underlined the importance of several antagonistic phenomena, affecting forests (afforestation and reforestation vs. deforestation), agriculture (agricultural development vs. agricultural abandonment) and urban areas (urbanization vs. urban restructuring), showing their connection with the economic transition lacking control over the development process (development and decline occurred in different places, instead of boosting development of a declining area). A similar study by Petrişor *et al*. (2014) covered, at a more detailed scale, the North-East Development Region, using a different classification; the findings, explained by socio-economic issues specific to the region, indicated urbanization, afforestation and reforestation vs. deforestation, and development vs. abandonment of agriculture as main drivers of change, reconfirming that spatial development was uncontrolled, as in other developing countries. Three studies were focused on urban processes: Petrişor *et al*. (2010) analyzed three phenomena affecting urban areas during 1990–2000 – urban development, restructuring, and de-urbanization, pinpointing areas mostly affected by each phenomenon individually. Ianoş *et al*. (2011) connected the urbanization process to a decrease in the level of primary eco-energy (*i.e.*, initial energy of a territorial system before the conscious intervention of man over its structures), at two spatial scales. Petrişor (2012b) carried out a national analysis aimed at assessing the extent of urbanization during 1990–2000 and 2000–2006 and found out that, given since the small share of urban settlements within the whole territory, the true extent of the phenomenon can be determined only comparing urban growth to the urban area. Overall, the three studies show that socio-economic drivers are the main drivers of land cover and use changes, especially in developing economies (Popovici *et al*., 2013).

The study area was constantly seen as one of the most disadvantaged Romanian regions from an economic standpoint. Some authors consider that the decline is due to the cities that lost their industrial function (Ianoş, 2000); particularly mining resulted into a loss of the environmental potential (Braghină *et al*., 2010, 2011) which could have been valued through tourism (Buhociu *et al*., 2013;

Stan *et al*., 2013). Among the phenomena that affect the environment and prevent the development of agriculture, the exposure of some areas to aridity and drought phenomena of the area seems to have the greatest impact (Marinică, Chimişliu, 2008; Vlăduţ, 2010; Corneanu *et al*., 2012; Bălteanu *et al*., 2013; Peptenatu *et al*., 2013; Prăvălie *et al*., 2013, 2014).

2. DATA AND METHODS

The methodology used in this study is an alteration of methodologies used in previous studies (Petrişor *et al*., 2010; Ianoş *et al*., 2011; Petrişor, 2012a, b; Petrişor *et al*., 2014). The method assigns changes to specific transitional dynamics. Several data sets, described in Table 1, were used for the analyses. Whenever needed, data were clipped by the Romanian boundaries and projected unto Stereo 1970 (EPSG 31700/ Dealul Piscului 1970 datum), the coordinate reference system used in Romania. For raster data, each cell was reduced to each geometrical center using the X-Tools extension of ArcView GIS 3.X, and centers were interpolated using the Geostatistical Analyst of ArcGIS 9.X via ordinary kriging.

Table 1

Data used in the study

Feature	Provider	Period, characteristics	URL
Land cover and use changes	European Environment Agency	1990–2000	http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-changes-clc1990-clc2000-100-m-version-12-2009
Land cover and use changes	European Environment Agency	2000–2006	http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-3
Elevation	Consultative Group on International Agricultural Research of the Consortium for Spatial Information	Raster cells of approximately 90 m × 90 m	http://srtm.csi.cgiar.org/SELECTION/inputCoord.asp
Biogeographical regions	European Environment Agency		http://www.eea.europa.eu/data-and-maps/data/biogeographical-regions-europe-1
Ecological regions	European Environment Agency		http://www.eea.europa.eu/data-and-maps/data/digital-map-of-european-ecological-regions
Soil	European Soil Database (ESDB) (Panagos *et al*., 2012)	Food and Agriculture Organization of the United Nations 1990 classification – level 1	http://eusoils.jrc.ec.europa.eu/esdb_archive/ESDB/Index.htm
Natural protected areas	Ministry of the Environment and Climate Change	Only those of national and international interest - IUCN I-V, Natura 2000	http://www.mmediu.ro/beta/domenii/protectia-naturii-2/arii-naturale-protejate/

Transitional dynamics were assessed based on the status of each parcel in the beginning and ending period. Separate analyses were run for 1990–2000 and 2000–2006. Changes were classified as land cover changes (LC) if the level 1 class differs between the two periods and land use changes (LU) if only the third level changed. The main transitional dynamics were defined as:

1. Abandonment of agriculture: LU change of class 1 agricultural parcels into an inferior use (e.g., crops to agricultural land with significant areas of natural vegetation)

2. Development of agriculture: LU change of class 1 agricultural parcels into a better use (e.g., agricultural land with significant areas of natural vegetation to crops) or LC change of other class (except for forested or natural) into agricultural land (e.g., urban to agricultural)

3. Deforestation: LC transformation of forested parcels into other classes (e.g. forest to built up) or LU transformation to an inferior use (e.g. coniferous forest to transitional woodland/ shrubs)

4. Afforestation or reforestation: Dutcă and Abrudan (2010) define afforestation as change of other land uses into forest, or increase of the canopy coverage over 10% threshold through plantations or natural regeneration, and reforestation as re-establishment of forests after a temporary condition decreasing the canopy coverage below 10% due to an anthropogenic or natural phenomenon. In this study, afforestation and reforestation were defined as an LC transformation from other classes into forests or LU transformations within the forest/ natural class to a better use (e.g., transitional woodland/ shrubs to coniferous forest), including the colonization of abandoned agricultural land by forest vegetation (Petrişor *et al*., 2014).

5. Urbanization/suburbanization: LC change of other classes (not forest) into urban (e.g., agricultural to urban) and LU changes within the urban class

However, not all of these changes were considered. The analyses were confined to the most important types, which through the spatial distribution (number of parcels affected and their area) allowed for depicting a certain spatial distribution through spatial interpolation. The maps were obtained by: (1) overlaying the distribution of transitional dynamics against other layers of information (elevation, biogeographical and ecological regions, soils, natural protected areas); (2) using the Geostatistical Analyst of ArcGIS to interpolate via ordinary kriging the centers of parcels affected by each transitional dynamics category by their size. The centers were obtained using the X-Tools extension of ArcView 3.X. The resulting contours, reflecting the intensity of each transitional dynamic, were overlaid against other layers or information or simply mapped.

3. RESULTS AND DISCUSSION

The results are presented in two sets of maps. Figs. 1–6 display the transitional dynamics reflected by land cover and use within the South-West Development Region during 1990–2000 (figures labeled "a") and 2000–2006 (labeled "b"), mapped against elevation (Fig. 1), natural protected areas (Fig. 2), biogeographical regions (Fig. 3), ecological regions (Fig. 4), soil types (Fig. 5) and types of human settlement (Fig. 6).

The first 4 groups of maps (Figs. 1–4) are easy to interpret if noticing that most changes occurred in the mountain areas, situated at higher elevations, in the alpine biogeographical region and ecological regions specific to the mountain areas, with large areas protected through inclusion in natural protected areas. In addition to them, the results show that urbanization occurs in the Sub-Carpathian hill region (average elevation), where most urban settlements are located, and the development of agriculture is characteristic of the plain area (low elevation), where the natural conditions favor it. When looking at the relationship with the natural protected areas, the results indicate a pressure of urbanization in the adjacent areas, evidence of deforestation and the abandonment of agriculture, most likely as a consequence of the protection status of some areas (Andam *et al*., 2010; Anthony, Szabo, 2011; Frys, Nienaber, 2011). The analysis of the location of transitional dynamics by the types of settlements reveals contradictory patterns; during 1990–2000, agricultural development characterizes the southern part of the region, and its north during the next period. Agricultural abandonment is characteristic of the south, most likely in relationship to the aridization process (Păltineanu *et al.*, 2007a, b, 2009; Marinică, Chimişliu, 2008; Vlăduţ, 2010; Dragotă *et al.*, 2011; Corneanu *et al*., 2012; Bălteanu *et al*., 2013; Peptenatu *et al*., 2013; Prăvălie *et al*., 2013, 2014). Last but not least, while urban sprawl, through urbanization and suburbanization, is expected to occur close to the important urban centers (Grigorescu *et al*., 2012), it is not the only transitional impact in these areas; most likely, the others are a consequence of urbanization. Finally,

when looking at the relationship with the soils, two phenomena are noticeable: the forestation of riverbeds and the abandonment of agriculture on soils prone to desertification, most likely as a consequence of aridization.

The magnitude of these phenomena is explained in Table 2. The table shows, for each transitional dynamic, the total area affected during the two periods, displaying the row values (in km^2) and the relative importance, as share of the total area affected by changes. The results show that for all periods the most important drivers of change were forestation, deforestation and urbanization, and during 1990–2000 the abandonment and development of agriculture. Overall, these results reconfirm the national findings (Petrişor, 2012a; Petrişor *et al*., 2010).

Table 2

Main transitional dynamics affecting South-West Development Region during 1990–2006 based on CORINE data on land cover and use

Transitional dynamics	1990–2000		2000–2006	
	Area (km^2)	Area (% total)	Area (km^2)	Area (% total)
Agricultural abandonment	59.21	19.36	3.25	7.87
Agricultural development	41.59	13.60	0.16	0.38
Aridization	4.75	1.55		
Deforestation	40.03	13.09	12.95	31.29
Floods	9.31	3.04		
Forestation	119.55	39.08	13.04	31.52
Unknown	0.55	0.18		
Urbanization/Suburbanization	30.89	10.10	11.97	28.94

The next set of maps displays the results of kriging-based analyses looking at the spatial distribution of the main transitional dynamics: agricultural abandonment (Fig. 7) and development (Fig. 8) during 1990–2000 and urbanization during the two periods, 1990–2000 (figures labeled "a") and 2000–2006 (labeled "b"), mapped against natural protected areas (Fig. 9) and types of human settlement (Fig. 10). Fig. 7 and Fig. 8 provide evidence for the "compensatory development", documented by previous studies (Petrişor, 2012a; Petrişor *et al*., 2010, 2014), meaning that the development of agriculture occurs through a land cover change indicating the expansion over other systems (natural), instead of boosting agricultural development of abandoned areas, which are declining. Also, the results provide additional evidence for the abandonment of agriculture in areas prone to aridity and drought phenomena. The analysis of urbanization shows that the process does not occur only around important settlements, and confirms an additional pressure against the mountain areas, which constitute a priority for European conservation policies due to their ecological vulnerability and fragility (Borsdorf, Braun, 2008), and against natural protected areas, rising questions on the effectiveness of their protection or declaration (Iojă *et al*., 2010; Knorn *et al*., 2012).

An important research question tackled with the relationship between socio-economic transformations and the main drivers of land cover and use changes – forestation, deforestation, urbanization, abandonment and development of agriculture. A first remark is that, except for urbanization, all the other drivers acted in pairs formed by opposing phenomena. This is a clear indication of the fact that switching from a centrally planned economy to a democratic, decentralized system resulted in uncorrelated actions with antagonistic effects. For example, agriculture could be developed, in theory, on the parcels that were abandoned. In reality, the explanation consists in the change of ownership; declining agriculture occurred on property restituted to the next generations of those who owned the land. As a consequence of forced urbanization during the communist time, one of the social transformations was a migration of young rural people towards the cities. Those who succeeded entering the possession of the land owned by their parents or grandparents lost the connection with agriculture, and were unable to use the land for agriculture. Similarly, many people who were

restituted forested land did not have a use for it, but saw it as a possibility of obtaining rapidly a profit by cutting the forests off and selling the wood (Roman, 2009). In opposition to these changes, most of the 'beneficial' ones (i.e. forestation, development of agriculture) occurred on land owned by the local or central government.

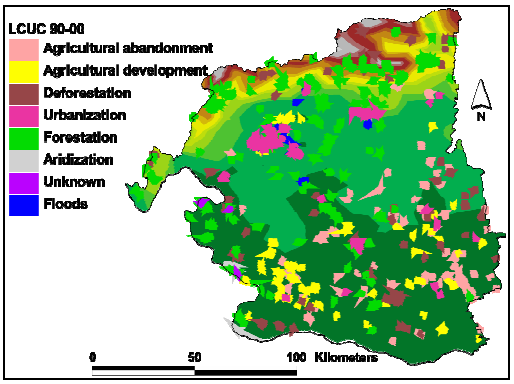

Fig. 1a – Main transitional dynamics by elevation in the South-West Development Region (1990–2000).

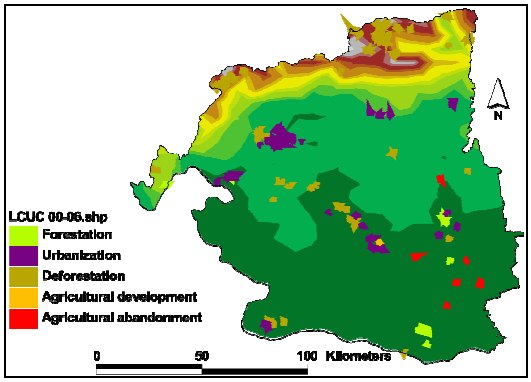

Fig. 1b – Main transitional dynamics by elevation in the South-West Development Region (2000–2006).

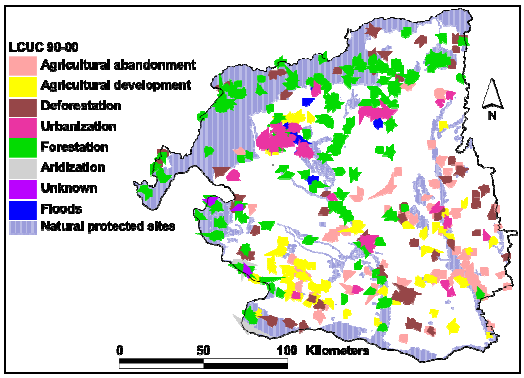

Fig. 2a – Main transitional dynamics and natural protected areas in the South-West Development Region (1990–2000).

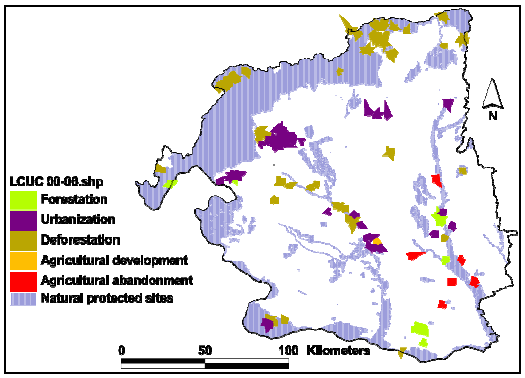

Fig. 2b – Main transitional dynamics and natural protected areas in the South-West Development Region (2000–2006).

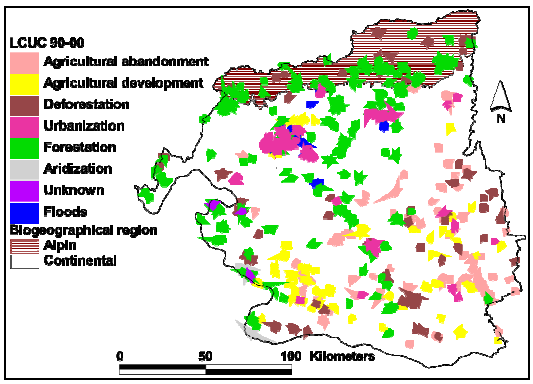

Fig. 3a – Main transitional dynamics by biogeographical region in the South-West Development Region (1990–2000).

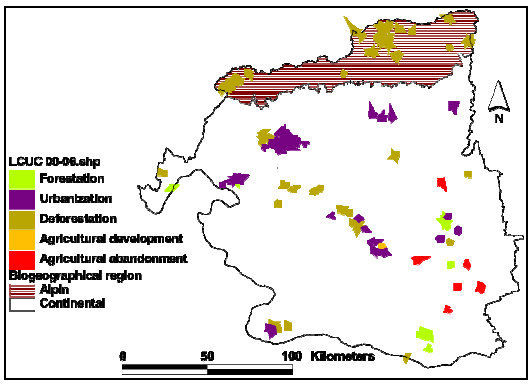

Fig. 3b – Main transitional dynamics by biogeographical region in the South-West Development Region (2000–2006).

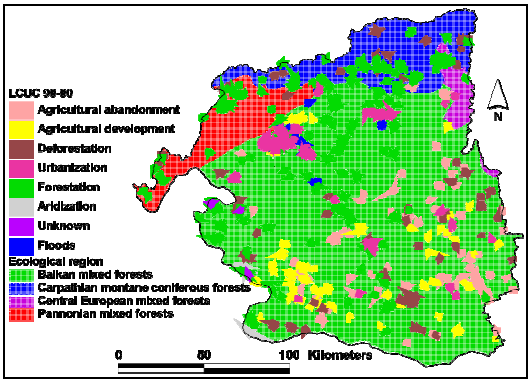

Fig. 4a – Main transitional dynamics by ecological region in the Romanian southwestern region of development (1990–2000).

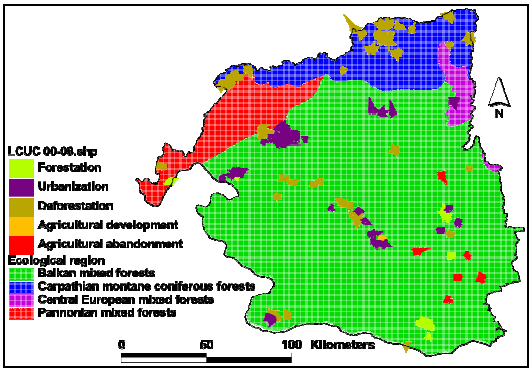

Fig. 4b – Main transitional dynamics by ecological region in the Romanian southwestern region of development (2000–2006).

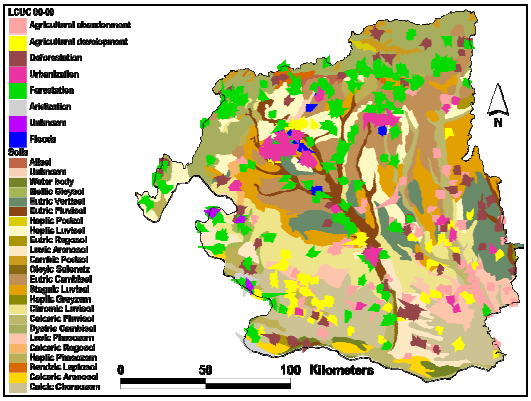

Fig. 5a – Main transitional dynamics by soil type in the South-West Development Region (1990–2000).

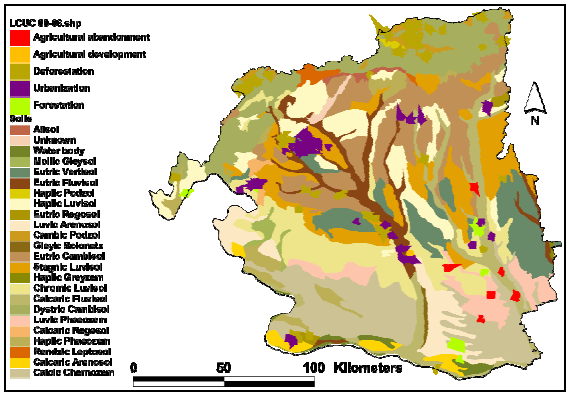

Fig. 5b – Main transitional dynamics by soil type in the South-West Development Region (2000–2006).

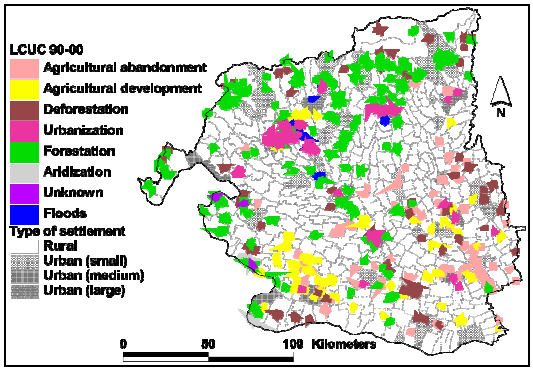

Fig. 6a – Main transitional dynamics by type of human settlement in the South-West Development Region (1990–2000).

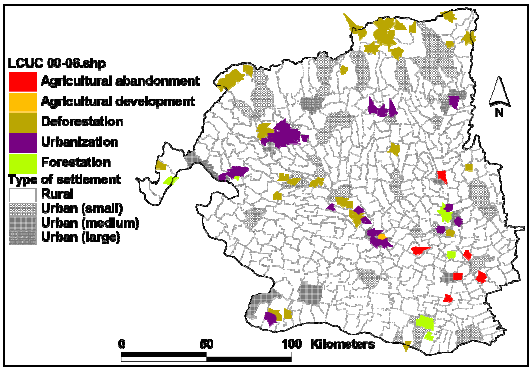

Fig. 6b – Main transitional dynamics by type of human settlement in the South-West Development Region (2000–2006).

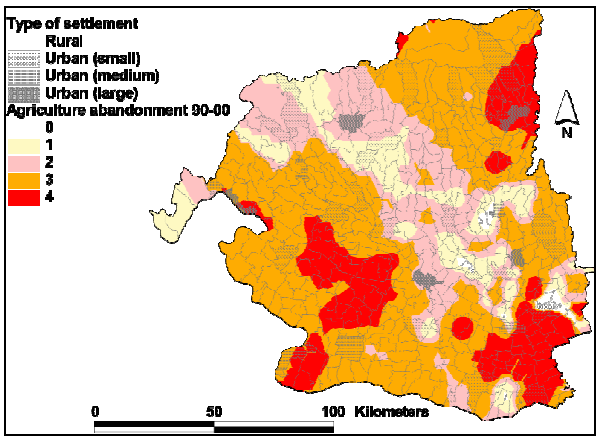

Fig. 7 – Agricultural abandonment in the South-West Development Region (1990–2000).

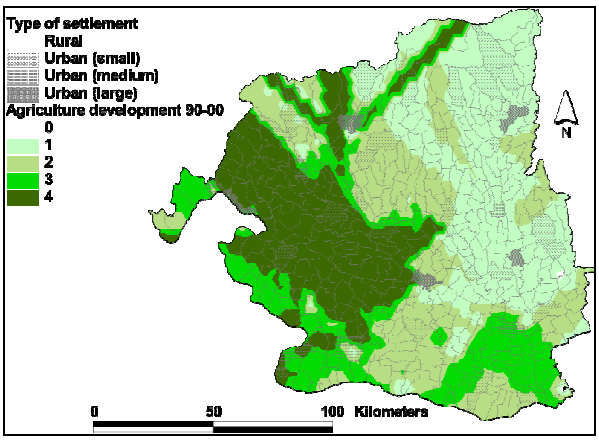

Fig. 8 – Agricultural development in the South-West Development Region (1990–2000).

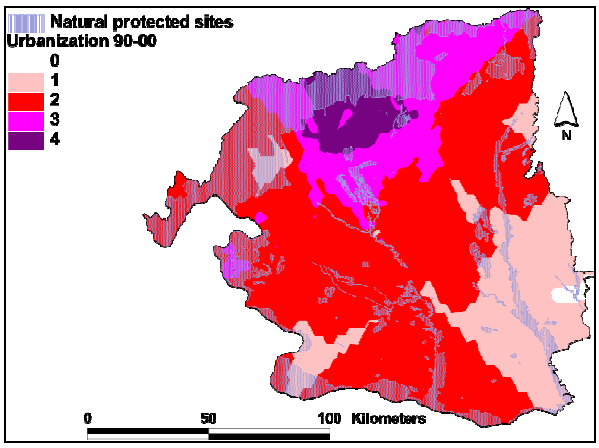

Fig. 9a – Urbanization and protected areas in the South-West Development Region (1990–2000).

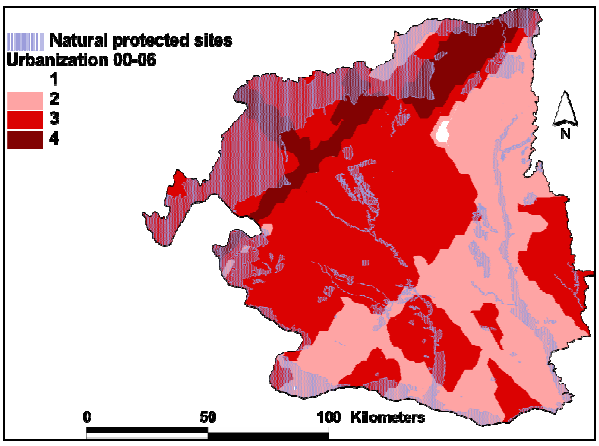

Fig. 9b – Urbanization and protected areas in the South-West Development Region (2000–2006).

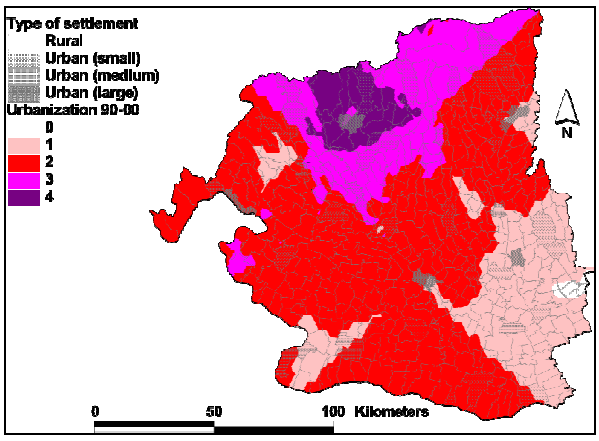

Fig. 10a – Urbanization by type of human settlement in the South-West Development Region (1990–2000).

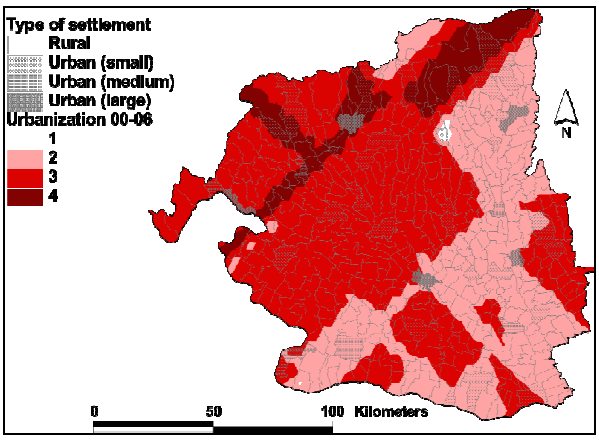

Fig. 10b – Urbanization by type of human settlement in the South-West Development Region (2000–2006).

4. CONCLUSIONS

The objective of the study was to assess the main drivers of environmental change reflected by transitional dynamics using land cover and use data in a particular region of Romania, in relation to its socio-economic particularities. Although the study was carried out over a particular region, it reconfirmed the previous national findings, identifying urban sprawl, deforestation and abandonment of agriculture as the main drivers of change.

Furthermore, the results reconfirmed the potential impact of these phenomena on natural protected sites and sensitive regions (such as the areas prone to aridity and drought, and alpine regions). From a theoretical perspective, the study underlined the deleterious effects of uncontrolled development induced by the restructuring economy, and provided additional evidence for the impact of economic underdevelopment associated with low environmental awareness, especially through the analyses focused on the deforestation and abandonment of agriculture.

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