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ASSESSMENT OF CHANGES IN LAND-USE AND LAND-COVER PATTERN IN ROMANIA USING CORINE LAND COVER DATABASE

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Abstract: Romania has a wide range of landforms, land use and land cover categories being unevenly distribute. However, agricultural land and forest land are prevailing. Important spatial changes related to land use dynamic occurred in the 1990s (transition period) and got momentum after 2000. One of the major changes during the transition period was the expansion of private ownership over agricultural and forest land against the collective and state property that has been characteristic of the previous period. So, the large collective and state farms from the communist period gave way to small, peasant-type family farms, leading to noticeable fragmentation of the agricultural land. As to the land use pattern, two main directions of change have been of interest. Firstly, the intensification and the extensification of the agricultural systems, mostly in the plains and plateaux and secondly, the afforestation and deforestation, largely in the mountains and plateaux have been described. The pack of urbanisation and industrialisation slowed down, yet still on going in the large urban centres as Bucharest, Timișoara, Iași, Constanța, Cluj Napoca etc., and in their neighbourhood. The present study aims to analyse the temporal and spatial changes of the main land use and land cover categories by resorting to CORINE Land Cover (CLC) database, while identifying and looking into the main factors controlling the evolution of land-use/cover change. Insights into the regional level change resulted in studying it by major relief units, namely, the Carpathian Mountains, hills, plateaux and plains, as well as the Danube Delta.

Keywords: Land-use and land-cover changes; CORINE Land Cover database; Romania.

1. INTRODUCTION

Land-use and land-cover changes are central to the interests of the global environmental research, especially in the regions with high dynamics of the social and environmental pressures. This significant cumulative type of change influences and is affected by climate change, loss of biodiversity, and sustainability of human-environment interactions (Lambin et al., 1999; Lambin & Geist, 2006). Over the past decades, land-use and land-cover changes have become a priority research-topic of international projects, given their implications for global environmental change (Turner et al., 1993). The main changes, basically conversion and modification, considered to be cumulative, may have detrimental local and regional environmental effects on soil, vegetation, waters and air, and if cumulating, the quality of these factors at global level could be degraded.

Land-use and land-cover changes can be considered relevant information source on landscape processes (Weber, 2007). Timely detection and precise information about land-use and land-cover changes are extremely important for understanding the relationships and interactions between human and natural phenomena if the management of decision-making is to be improved (Lu et al., 2004). To this end, remote sensing and GIS software are the best methods to study the spatial distribution and evolution of geographical phenomena related to land-use and land-cover changes. CORINE Land Cover database contains useful information for detecting land-use and land cover changes, as well as for constructing land cover account. Land cover represents a concrete set of natural and anthropogenic features, resulting largely from its use (Haines-Young & Weber, 2006) and of being an indivisible part of the landscape (Feranec et al., 2010). Based on GIS processing of the CORINE Land Cover data layer some studies at national, as well as regional level have been achieved (Feranec

et al., 2000, 2006, 2007, 2010; Feranec & Otahel, 2001; Kuemmerle et al., 2006; Otahel et al., 1993, 2002; Willems et al., 2005, etc.).

The fall of the communist regime has led to a series of radical political and socio-economic changes in many Central and East European countries. Transition in the economy meant the replacement of the old centralised system by the free market system (Bălteanu et al., 2004, 2005). In the previous studies on assessing and quantifying land-use and land-cover changes, in the context of post-communist period (Ptáček, 2000; Bičík et al., 2001; Zemek et al., 2005; Kuemmerle et al., 2006; Václavík & Rogan, 2009; Bičík & Jeleček, 2009, Szilassi et al., 2010 etc.), it is generally recognized that the socio-economic and political conditions of the transition period represent the major drivers of these changes. The socio-economic and political changes have affected land use in Romania after 1990 through a restructuring process and basic mutations in the ownership of land increasing the influence of market forces in shaping the rural landscapes. Some of the negative effects of the Act 18/1991 resulted in the excessive fragmentation of farmland and in the marked degradation of production services in agriculture and land quality (Bălteanu & Popovici, 2010). The new land-use system that emerged was by far more vulnerable to extreme environmental perturbations and less resilient (Fraser & Stringer, 2009). Moreover, transition has led to significant changes in the land use/land cover pattern by conversion from one category to another. The wide range of factors responsible for these changes comprises the *political* associated with *economic*, *technological*, *demographic* and *natural* ones. Political and institutional drivers have in time been directly involved in land-use and land-cover change, affecting primarily the regime of property rights and the decision-making systems involved in the management of natural resources (Lambin et al., 2003). In Romania, the four major land reforms enacted in the 19th and 20th centuries (1864, 1918-1921, 1945 and 1991) had decisively influenced subsequent land-use dynamics, access and control of land, as well as social relationships (Bălteanu et al., 2004). The type and amplitude of modifications varied in terms of the socio-economic and political conditions of each period. The general trend consisted in the enlargement of agricultural land and built-up areas to the prejudice of forestland and grassland. The significance of this study consists in the detailed analysis of the land-use/land cover change pattern at national level, few such studies having been performed so far, and the existing ones referring only to regional level (Kuemmerle at al., 2009; Lakes et al., 2009; Müller & Kuemmerle, 2009; Dutca & Abrudan, 2010; Popovici, 2010; Grigorescu et al., 2012; Knorn et al., 2012).

2. STUDY AREA

Romania is situated in the south-eastern part of Central Europe at the contact with Balkan Europe (south of the Lower Danube), and at the crossroads of the major European thoroughfares (Niculescu, 2006). With an area of 238,391 km^2 and 19,042,936 inhabitants (Population Census 2011), Romania ranks among the medium-sized European states, but is the largest country in the south-east of Central Europe. The moderate temperate-continental climate and the varied landforms favour a great diversity of the vegetation cover. The mountains, hills and plateaux are dominantly covered by the forest belt (coniferous and broad-leaved forests), while the alpine and subalpine meadows are developed in the highland. In the plain areas the greatest part of oak forests, steppe and sylvo-steppe vegetation have been replaced by croplands.

Romania is one of the European countries with important land resources (0.68 ha agricultural land and 0.43 ha arable land per capita). In terms of structure, agricultural land represents 61.2% of Romania's area, forest land 28.5%, terrains under water and ponds 3.5%, built-up areas 3.1%, roads and railways 1.6% and degraded and unproductive grounds 2.1% (Romanian Statistical Yearbook 2012). According to CORINE Land Cover database (2006), agricultural areas amounted 58%, forest and semi-natural areas 33%, artificial surfaces 6%, wetlands and water bodies 3% (Fig. 1).

2.1. The geographical distribution of land use and land cover categories

The diversity of natural conditions, as well as the general and regional particularities of a social and economic history, have resulted in land-fund structure with *agricultural terrains* having the highest percentage (over 61%). The agricultural land use categories (*arable, pastures and hayfields, vineyards* and *orchards*) hold different shares in every landform unit. Hence, in the plain regions, below 200 m a.s.l. (the Romanian Plain and the Banat and Crişana Plain) agricultural land represents over 80% of the total, 60-70% in the plateaux and about 54% in the hillsides (the Banat and Crişana Hills and the Subcarpathians). The lowest percentages are found in the mountains (12.1%) and in the Danube Delta (only 23.5% total surface-area) (Fig. 1).

Terrains covered with natural and semi-natural vegetation (forests and natural grassland) represent 33.6% of the national territory. Their distribution is inversely proportional to agricultural land. Thus, the largest forests occur in mountainous and hilly regions (68.7% and 34.8%, respectively of their overall areas). With the decrease of altitude, soils and climatic conditions become more propitious to the development of farming land, forested areas shrinking to 22.5% in the hillsides and to about 6% in the plains.

Land severely modified by man (Artificial land) includes settlements (rural and urban), various agricultural or industrial constructions (nurseries, silos, industrial estates etc.), commercial units, sporting and leisure facilities, roads and railways, mining waste-dumps, household refuse and industrial waste etc. That land occupies 6.3% of the country's territory in all types of landform, covering between 1.15% in the Danube Delta and 9.28% in the hillsides.

Wetlands have the widest spread in the Danube Delta, representing together with water surfaces, over 75% of the Delta area. Other notable wetlands are Balta Mică from Brăila located in the Danube Floodplain, and more than 30 such areas alongside the main big rivers (the floodplains of the Danube, Prut, Siret, Buzău Mureş, the Three Criş Rivers, Someş, Timiş with its tributary the Bega etc.), oligotrophic and eutrophic boggy soils in the Eastern Carpathians, etc.

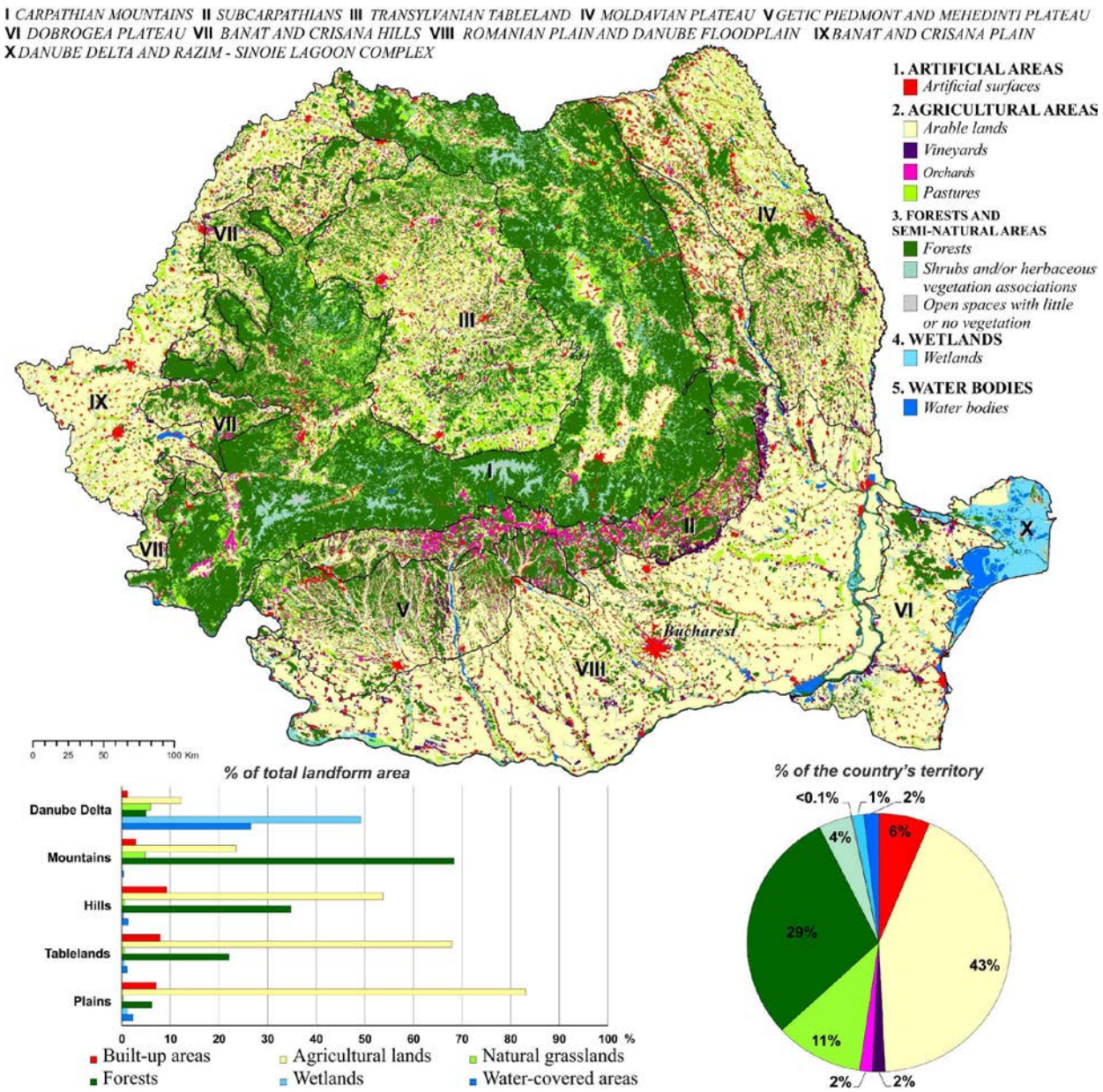

Figure 1. Distribution of the land use and land cover categories by major landform units (CORINE Land Cover, 2006)

3. DATA AND METHODS

There are two major types of land-use and land-cover changes, namely: *conversion* (that is radical changes involving the replacement of one type of land cover by another) (Meyer & Turner II, 1994, Turner & Meyer, 1991), and *modification* (that is, maintaining a certain type of intensive use without changing the terrain's attributes) (Gregorio & Jansen, 2000). The authors of the present paper had in view to identify and analyse the first category of changes in land use and land cover, thus highlighting the main land cover flows (LCF) that took place in Romania over the last two decades. The concept of LC flows was applied in many studies by Stott & Haines-Young (1998), Haines-Young & Weber (2006), Feranec et al. (2000, 2010). The land-cover changes analysed herein represent the result of the main conversion processes that took place between the 15 classes of the second CLC data level (Table no. 1), the losses of initial land cover (consumption) and the making of new land type (formation) (Weber, 2007). According to the previous methodology, seven land-cover flows were identified and analysed: *urbanisation and industrialisation* (conversion from agricultural and natural land to artificial land); *intensification of agriculture* (internal conversion of agriculture from lower-to-higher intensity of use, and also conversion from natural land (32, 33) to agriculture); *extensification of agriculture* (internal conversion of agriculture, transition of classes, associated with higher-to-lower intensity of use); *agricultural land abandonment* (conversion of agricultural land to semi-natural areas); *deforestation* (conversion from forest land to other LU categories); *afforestation* (forest regeneration, transition from agriculture, semi-natural vegetation and wetlands to forests); *water bodies construction and management* (conversion from agriculture and natural lands to water bodies).

3.1. Data

Two sets of spatial data underlie the basic information used in this study:

1) Data on land use and land cover structure and data on land use and land cover changes (classification level 3) elaborated under the CORINE Programme *(European Environment Agency; www.eea.europa.eu);*

2) Data on major landform units *(Romania. Space, Society, Environment, 2006)* used in the regional analysis of land-use changes.

Additionally, statistical data supplied by the National Institute of Statistics (Romanian Statistical Yearbooks 1990-2010; General Agricultural Census 2002, 2010; Agricultural Farm Survey 2005; TEMPO-Online database, etc.), as well as field surveys were taken into consideration.

Changes in the land use and land cover pattern were detected for two relevant time-intervals in Romania (1990-2000 and 2000-2006). The first interval (1990-2000) represents the period of transition to the market economy. The second interval (2000-2006) largely overlaps that of pre-accession to the European Union, when important land-use changes, mainly processes of intensification/extensification of agriculture, deforestation and urbanization took place.

CORINE Land Cover is a database of the European environmental landscape derived from the interpretation of satellite imagery: Landsat -4/5 TM (in a few cases, Landsat MSS) and SPOT 2/3 (for CLC 1990); Landsat -7ETM (for CLC2000) and SPOT4 and/or IRS LISS III images (for CLC 2006) (Bossard et al., 2000; Feranec et al., 2012). The complete classification, nomenclature and methodology are available in the official CORINE portal (http://www.eea.europa.eu/publications). A number of 39 out of the 44 classes in the CLC nomenclature were identified in Romania, and grouped into 15 classes (level 2) (Table 1).

3.2. Data uncertainty

Considering the minimum mapping area (25 ha), the accuracy provided by CORINE Land Cover for identifying a certain type of conversion is not high enough to catch all locations affected by land use/land cover change. Since satellite images are not received within the same period of the year, sometimes a gap of several months existing among them, certain plant species are in different stages, hence they give a distinctive spectral response that may induce possible errors of interpretation (Ursu et al., 2006). Also, the resolution of the satellite images differs over the two time-periods analysed: $\leq$50 m for CLC 1990 and $\geq$25 m for CLC 2000 and CLC 2006. Land-use changes included vast water-covered areas, especially arable terrains, left after the 2005-2006 floods had affected the western part of Romania (Banat-Crisana Plain) and the Danube Floodplain. As a result, confusions may arise in analysing certain land-cover flows (e.g. water bodies construction and management), as well as a certain incertitude in the visual interpretation of satellite images (vectorization accuracy).

Table 1. CORINE Land Cover nomenclature (identified in Romania)

LEVEL 1	LEVEL 2	LEVEL 3
1 Artificial surfaces	11 Urban Fabric	111 Continuous urban fabric 112 Discontinuous urban fabric
	12 Industrial, commercial and transport units	121 Industrial or commercial units 122 Road and rail networks and associated land 123 Port areas 124 Airports
	13 Mine, dump and construction sites	131 Mineral extraction sites 132 Dump sites 133 Construction sites
	14 Artificial, non-agricultural vegetated areas	141 Green urban areas 142 Sport and leisure facilities
2 Agricultural areas	21 Arable land	211 Non-irrigated arable land 212 Permanently irrigated land 213 Rice fields
	22 Permanent crops	221 Vineyards 222 Fruit trees and berry plantations
	23 Pastures	231 Pastures
	24 Heterogeneous agricultural areas	241 Annual crops associated with permanent crops 242 Complex cultivation patterns 243 Land principally occupied by agriculture, with significant areas of natural vegetation 244 Agro-forestry areas
3 Forest and semi-natural areas	31 Forests	311 Broad-leaved forests 312 Coniferous forests 313 Mixed forests
	32 Scrub and/or herbaceous vegetation associations	321 Natural grasslands 322 Moors and heathland 323 Sclerophyllous vegetation 324 Transitional woodland-scrub
	33 Open spaces with little or no vegetation	331 Beaches, dunes, sands 332 Bare rocks 333 Sparsely vegetated areas 334 Burnt areas
4 Wetlands	41 Inland wetlands	411 Inland marshes 412 Peat bogs
	42 Maritime wetlands	421 Salt marshes
5 Water bodies	51 Inland waters	511 Water courses 512 Water bodies
	52 Marine waters	521 Coastal lagoons 523 Sea and ocean

3.3. Description of GIS technique

The analysis has been facilitated by the Geographical Information System (GIS). In this case, land use and land cover changes are developed under ArcMap 9.3 and, additionally, in Excel.

Initially, the land-use changes layer was re-projected from ETRS_1989_LAEA_52N_10E into Stereo-70 system of coordinates, suitable to our study. A number of 126 types of change were identified across Romania during 1990-2000, and 71 over 2000-2006 (CLC classification level 3). Subsequently, these changes were generalised to CLC level 2 (Fig. 2), used to establish the 8 flows previously described. The regional analyses consisted in intersecting the layer of change (generalized form, level 2) with that designating the boundary of major landform units in Romania: mountains, hills, plateaux and lowland areas, as well as the Danube Delta.

The obtained information allowed us to assess changes in space-and-time, identify the types of change, build the matrix of change (flows), evaluate loss-and-gain within each land-use class (level 2), the rate of change and intensity of flows.

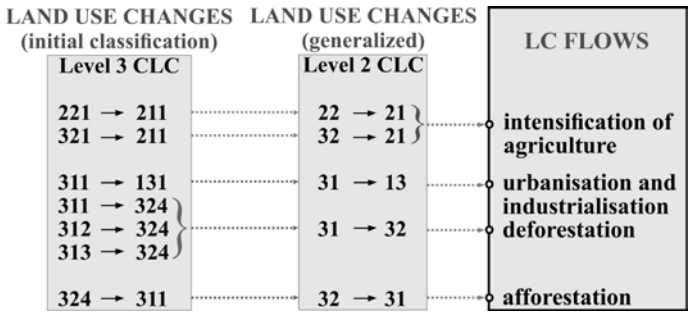

Figure 2. The generalisation of land-use and land cover changes spatial data classification level 3 to level 2

4. RESULTS AND DISCUSSIONS

4.1. Detection of land-use and land cover changes

December 1989 in Romania marked the beginning of a period of transition to the market economy, a new stage in the evolution of agriculture and implicitly in land use (Popescu, 2001). The most important changes of that period appeared in the space dynamics of the main land use/cover categories and their quality, a new type of landed property and land exploitation (Popovici, 2008, 2010).

Two distinct studying periods have been distinguished:

1) The 1990-2003 transition, marked by basic changes in agriculture, when the collective and state property was replaced by private property (Fig. 3), and

2) The post-transition period (2003-to-date), corresponding to Romania's pre- and post-accession to the European Union, associated to several land-use changes connected with the adoption and implementation of the Common Agricultural Policies (CAP).

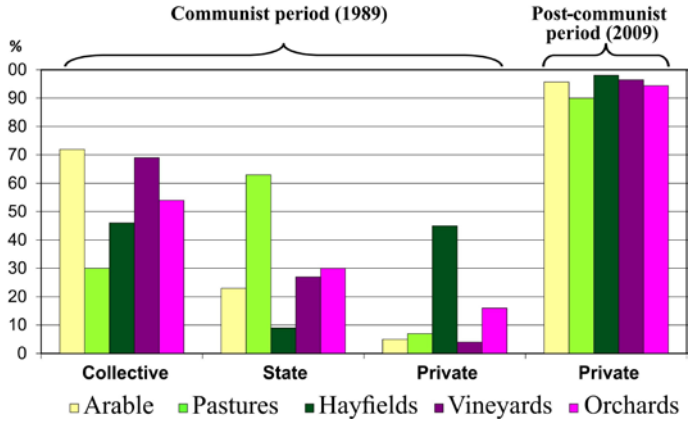

Figure 3. Land fund by categories of use and form

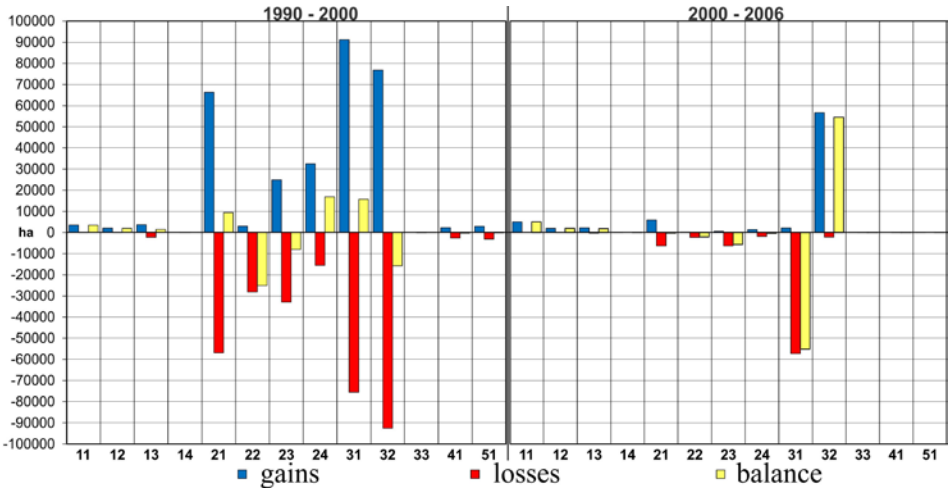

Figure 4. Gains and losses by land-use and land cover categories over the 1990-2000 and 2000-2006 intervals

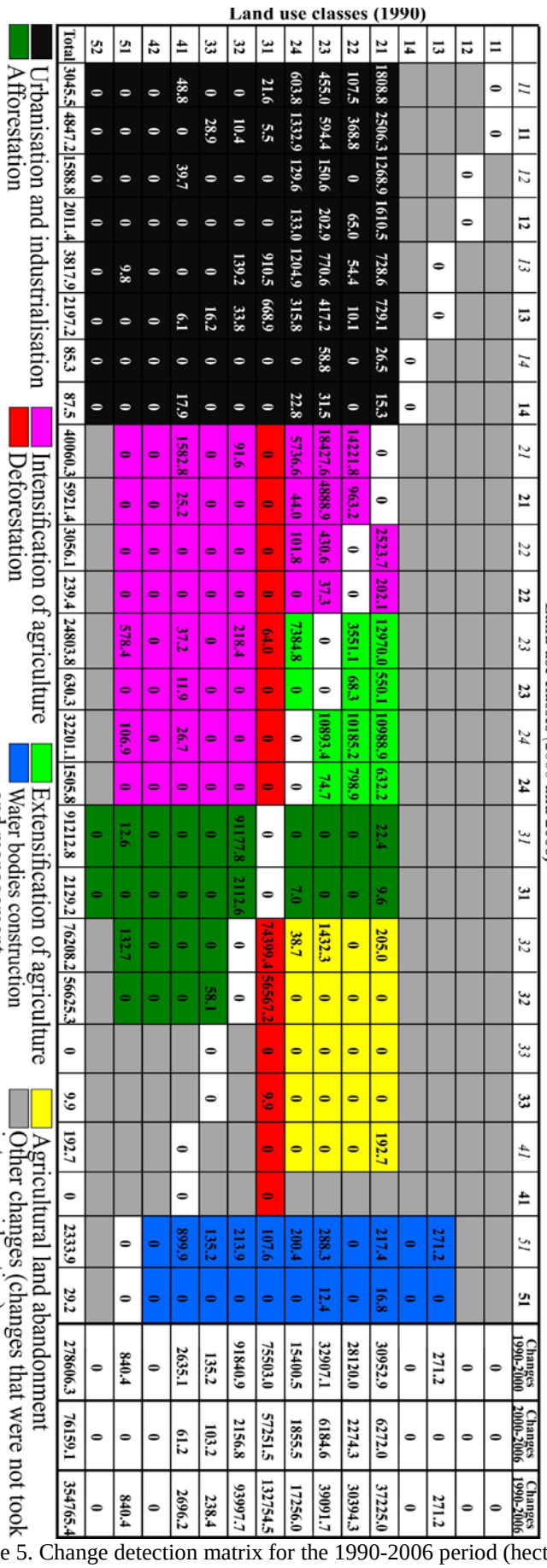

Figure 5. Change detection matrix for the 1990-2006 period (hectares)

The political and socio-economic changes begun in the early 1990s had a strong impact on lands, especially on the quantity and quality of agricultural terrains. Hence, over the 1990-2006 period, a total of 354,765 ha (1.48% of the country's area) underwent changes (Fig. 5), at an annual rate of 0.09%. By 2000, the scale of the phenomenon was higher (279 thousands ha and 0.11% annual rate of change) than after 2000 (76 thousands ha and 0.05% annual rate of change).

Among the land-use categories with a negative record in both study periods (1990-2000 and 2000-2006) were permanent crops (vineyards and orchards), their area shrinking by over 27,099 ha. Then follows the pastures (13,633 ha), open spaces with little or no vegetation (143 ha) and inland marshes (376 ha). On the other hand, the built-up areas, heterogeneous agricultural areas and scrub and/herbaceous vegetation associations have significantly increased (Fig. 4).

In the first period, forests, shrub and/herbaceous vegetation associations and agricultural land use classes (21, 22, 23 and 24) registered major spatial changes, while in the second period it was classes 31 and 32 (forests and shrub and/herbaceous vegetation associations) that had the highest gains and losses (Fig. 4). Looking at the change detection matrix (Fig. 5), the most frequent land use/cover flows in Romania over the 1990-2006 were deforestation, afforestation, extensification and intensification of agriculture (Fig. 6). Processes of urbanisation and industrialisation would develop largely at the expense of the agricultural land-use categories (arable land, heterogeneous agricultural areas, pastures and permanent crops).

Deforestation. The retrocession of forest land contributed to illegal logging, especially active over the past ten years. In 2008, more than 45% of the forest land was in private property. The high number of owners with small forest plots, as well as the uncertainty of maintaining these lands led to massive deforestations (illegal logging), especially on the privately-owned terrains.

In this way, the forested area shrank by up to 39,406 ha. During the first period (1990-2000), gains were higher than losses. The losses were by far greater than gains in the second period (2000-2006) as a result of implementing the Act no.1/11 January 2000 (Fig. 4), when deforestation process represented about 74% of total changed area. Most conversion phenomena involved forest land and transitional woodland-shrub classes. The forested area lost over 130,967 ha in favour of the latter classes and about 1,607 ha in favour of the artificial classes (Fig. 5). Since 2000, natural areas were declared protected and deforestation practices on their territory somehow diminished.

According to CORINE Land Cover database (2006), the forested area of Romanian's national and natural parks amounts 720,495 ha (about 10% of all forest land in this country) mostly in the Carpathian Mountains (8.6% of all of Romania's forests). Since most protected areas had been delimited beginning with the year 2000, the trend of deforestation rate has decreased mostly inside national parks rather than outside their boundaries. Thus, logging in Romania's national and natural parks fell by 36.8% (from 7,637 ha over 1990-2000 to 4,824 ha in 2000-2006) (Fig. 7), and by only 22.6% in unprotected areas (from 66,865 ha to 51,753 ha).

As forested area began shrinking, the quality of land started deteriorating significantly through torrential events, erosion, landslides and the intensification of extreme climatic phenomena: floods, snowstorms and droughts. In the lowland regions, climate change, the systematic destruction of irrigation systems and the cutting of protection forest belts (wind breaks) have facilitated the onset of frequent and lengthy dry periods that had negative effects on crop production, the environment and living conditions, generally.

Afforestation is the second significant process that took place in Romanian during the studied period, it representing over 26% of the total changed area (Fig. 6). The expansion of the forest area is due primarily to natural regeneration, particularly in the mountainous and Subcarpathian regions. This process unfolded largely on deforested terrains, but also on abandoned farm land, pastures in particular which developed in the wake of declining shepherding. The most common type of transition was transitional woodland-shrub to forests (93,290 ha) (Fig. 5).

Artificial reforestation (planting after logging, calamities or establishment of a new forest on degraded lands) took place on small areas, directly depending on financial sources. In the years 1990-2000, 5,200 hectares of degraded land (public state property) were afforested, the cost being covered from the Land Reclamation Fund (Ministry of Environment and Climate Change, 2010). Since 2000, non-reimbursable European funds contributed to tree-planting on over 25,000 ha (2009). Measure 3.5 of the SAPARD Programme (Special Accession Programme for Agriculture and Rural Development) stipulated the funding of afforestation projects. In 2009, Measure 221 of the National Rural Development Programme had in view the First Afforestation of Agricultural Lands.

Farming underwent significant spatial changes either in the land-use agricultural categories (internal conversions) or between these categories and other land-use classes, such as built-up terrains, forest land etc. (Fig. 5). The expansion of private property, the excessive fragmentation of agricultural land, the high percentage of very small subsistence farms, the dismantling of big animal breeding farms and the degradation of production services in agriculture have contributed to the mitigation of cultivated areas, the abandonment of pastures and permanent crops over large surfaces. All these resulted in the enhancing of extensive agriculture, basically conversion from agricultural classes with higher-to-lower intensity of use (ex. arable and permanent crops turned into pastures).

The processes of extensification and intensification of agriculture were analysed only in terms of quantity and not of quality (inputs in agriculture were not taken into consideration). During the post-communist time, the cultivated area decreased from 9.8 million ha in 1989 to 7.8 million ha in 2009 because much of the arable land (11.0 million ha over the 1990-2009 period) remained uncropped (Bălteanu & Popovici 2010).

Extensification of agriculture gets more prominent than intensification, it representing over 16% of the total changed area involving conversion from arable land and permanent crops to pastures and heterogeneous agricultural surfaces. In this period, about 25,141 ha of arable land and 14,604 ha of permanent crops were turned into low-productive classes (23 and 24). The permanent crops area had steadily shrunk mostly through abandonment or clearing after having been recovered by their former owners. At the same time, the new plantations covered usually small, dispersed areas, most of them around peasant households. Also, in the transition period, the conversion of arable land to pastures resulted from the abandonment of the former, particularly in low-productive regions. If arable land stays fallow for several years, it gets covered with vegetation; since identifying them on satellite images is sometimes difficult, they are listed under grassland.

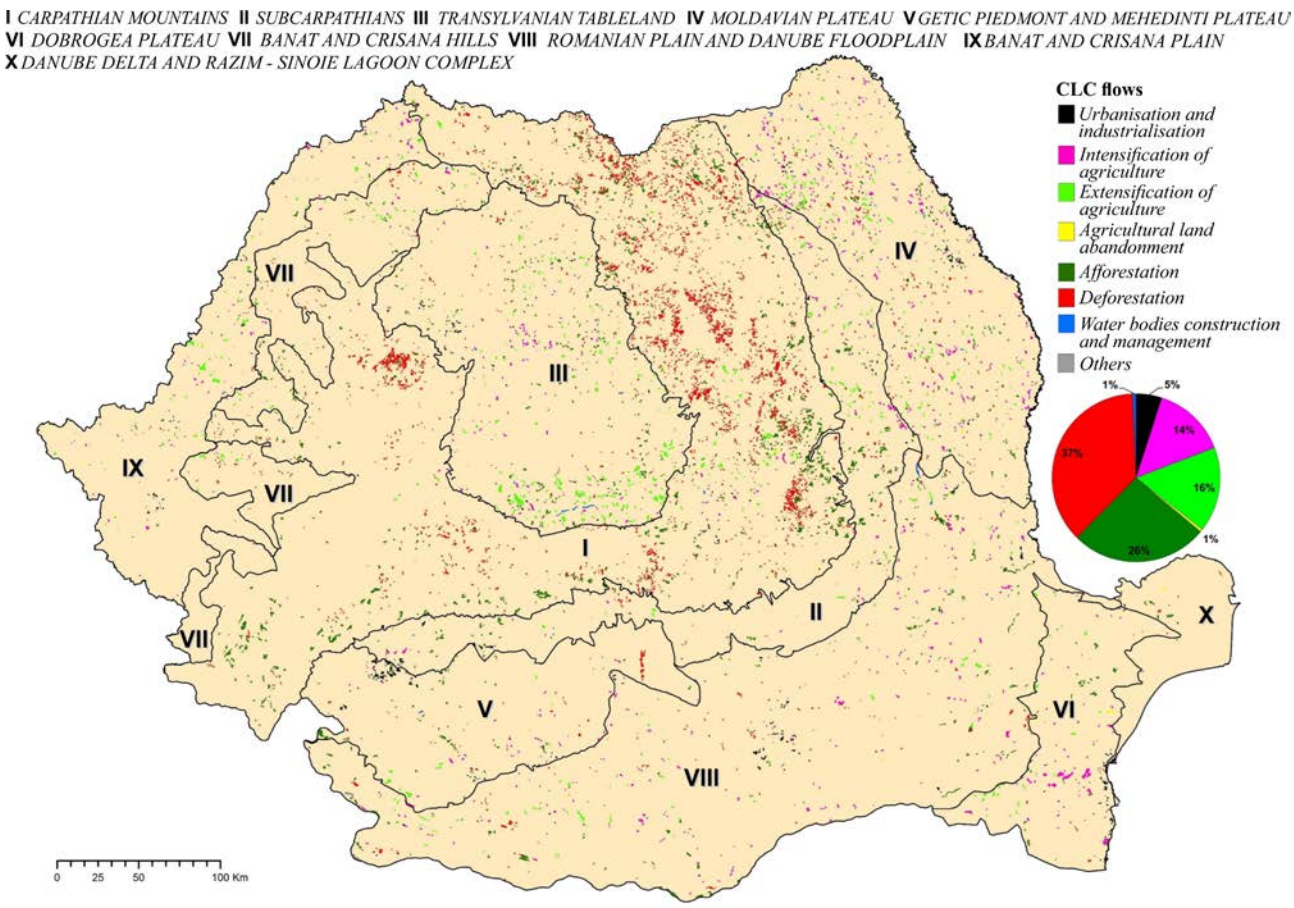

Figure 6. Main land use and land cover flows in Romania over the 1990-2006 period

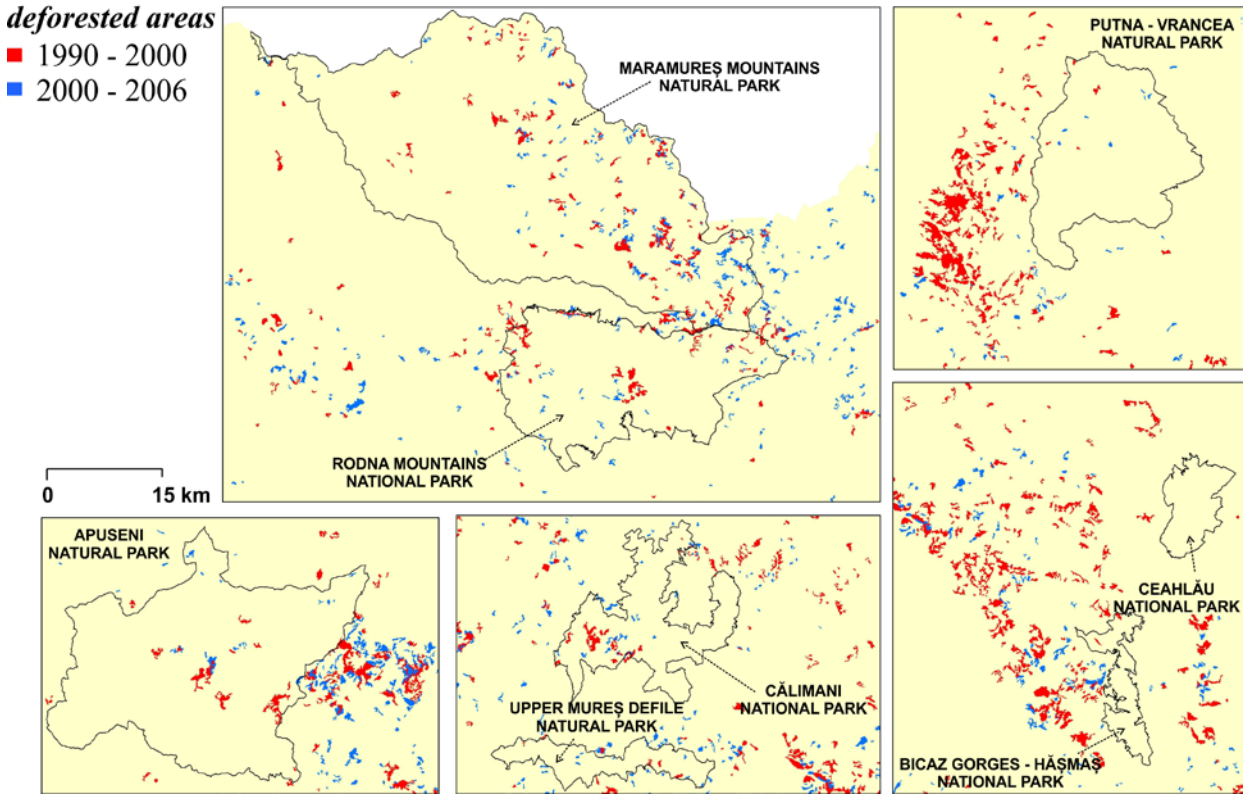

Figure 7. Disparities in the process of deforestation inside and close to a few national and natural parks in Romania during the two studied periods.

Several other causes for abandoning arable land is their high degree of fragmentation, money shortage with the small farmers, the absence of markets to sell the products, few, if any, irrigation systems etc. Pastures and hayfields would expand to the detriment of vineyards and orchards, lose in surface-area in favour of arable land (intensification process), especially in the post-transition period.

Intensification of agriculture represents about 14% of the total changed area (Fig. 6). In Romania's transition period, the intensification of agriculture was more reduced (15.8%) than extensification (20%), because many arable lands and permanent crops had been abandoned. After 2000, the cultivation of land got momentum, intensification process holding a greater share (about 8% of total changed area) than extensification (2.9%), as some arable areas, left fallow in the period of transition, started being re-cropped.

Urbanisation and industrialisation are characteristic of all the large cities of post-communist Romania. Over the 1990-2006 period, artificial surfaces would enlarge by some 17,681 ha (5% of the total change-affected area), especially to the detriment of all agricultural land-use categories (Figs 4, 6). However, intensive urban sprawl (the housing-market boom) in the outlying rural areas got momentum after 2006-2008, when vast expanses of agricultural land were turned mainly into built-up areas: new dwelling complexes, industrial and commercial units (logistic parks, super-markets, etc.), sporting and leisure facilities, etc., essentially altering their spatial and functional structure. The financial crisis of the past five years has also influenced the land-use pattern in the peri-urban areas as many developers slowed down their activity, and the majority of the terrains bought for housing projects were abandoned. Most of these terrains have fertile soils. Looking forward to seeing the boom of the housing-market, certain investors chose to license the land to some farmers and have it re-introduced into the agricultural cycle (vegetables or cereal crops), others preferred abandoning them altogether. The urbanisation process, also connected with the evolution of the main demographic indicators (depleted birth and fertility rates, higher external migration, negative natural balance plus some social problems), reveals a steep demographic decline which will obviously affect the medium-and-long-term land-use pattern. True enough, Romania's population is in general declining numerically. However, some territorial differentiations do exist. Thus, there are regions (e.g. the urban sprawls) in which the population is steadily increasing. Others experience a steep decline such as poorly-developed rural areas. In the former case, the main land-use changes consist in the conversion of farming terrain into built-up areas (Grigorecu et al., 2012), while in the latter case, farming land is abandoned because of poverty, external migration in search for jobs and severe ageing of the rural population.

Agricultural land abandonment was much more obvious in the Subcarpathians and the mountains, regions traditionally engaged in animal husbandry, and once the animal stock was shrinking large pastures and hayfields were abandoned, their place being taken by semi-natural vegetation (class 32). During the 1990-2000, agricultural land lost about 1,675 ha to transitional woodland-shrub class (Fig. 5).

Water bodies construction and management encompassed over 2,363 thousands ha (only 1% of total changed area), out of which 2,333 thou ha affected in the years 1990-2000. What emerged was primarily conversion of agricultural land (706 ha) and wetlands (899 thou ha) to inland waters (class 51) (Fig. 5). However, interpreting these transitional phenomena raises a series of questions, because they refer not only to proper hydrotechnical works, but also to temporarily covered with water by floods.

4.2. Spatial distribution of land-use and land-cover change processes

Looking at the spatial distribution of the main land-use and land-cover change processes one may notice significant disparities both with regard to the two intervals (1990-2000 and 2000-2006) and to the scope-and-breadth of change as well as to the main land-use and land-cover flows within the major landform units. Most conversions from one land use and land cover category to another took place in the Carpathian Mountains, the Romanian Plain, the Moldavian Plateau and the Transylvanian Plateau, less affected being the Danube Delta, the Banat and Crişana Plain and Hills and the Getic Piedmont (Table 2, Fig. 8).

The *1990-2000* interval coincides with the period of transition to the market economy in which agriculture was intensified and extensified within all relief units, less so in the mountain regions where afforestation and deforestation prevailed. Records speaking of over 42% of total changed area, the logged area being of 60,000 ha, that is more than had been replanted. On the other hand, extensive versus intensive agriculture was higher in all the other units excepting the Moldavian Plateau, the Dobrogea Plateau and the Romanian Plain. However, some territorial disparities within one and the same landform unit do exist, e.g. the eastern half

of the Romanian Plain, certain areas in the Moldavian Plateau or in the Transylvanian Plateau. Here, the rate of transition of arable land and permanent crops to pastures was remarkably high, mostly because the poverty, migration abroad of the rural population, severe fragmentation of arable land and droughts frequently raged in the south and south-east of the country.

The *2000-2006* period overlaps Romania's pre-accession to the European Union, so that the total area changed was by far smaller, again comprehensive change being registered in the mountain regions (58.8% of total changed area), next in line coming the Moldavian Plateau (11.4%) and the Romanian Plain (8.8%) (Table 3). Although of lower scope-and-breadth, deforestation was the dominant process in the mountains, hills and plateaux, followed by urbanisation and intensification of agriculture, particularly in the lowlands (Romanian Plain, Banat and Crişana Plain) and the Moldavian Plateau (Figs. 6, 8). As regards the intensification and extensification of agriculture, the former process is undoubtedly the dominant one because the areas left fallow for years on end started being cultivated, a sign that the farming sector was revigorating.

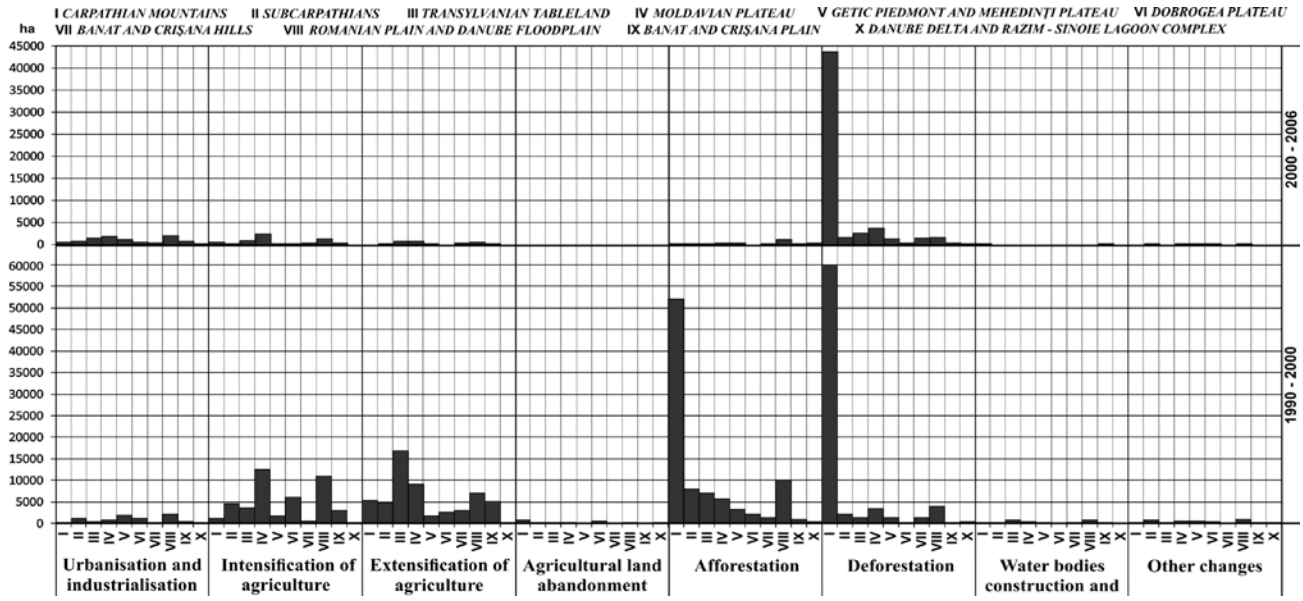

Figure 8. Main land use and land cover flows in Romania by landforms

Table 2. Areas affected by land use and land cover changes

Landform		Landform area (ha)	1990-2000			2000-2006		
			Total changes (ha)	% of landform area	% of total changes	Total changes (ha)	% of landform area	% of total changes
I	Carpathian Mountains	6,628,64	119,747	1.81	42.45	44,855	0.68	58.75
II	Subcarpathians	1,658,94	21,703	1.31	7.69	2,280	0.14	2.98
III	Transylvanian Plateau	2,529,74	29,916	1.18	10.61	5,634	0.22	7.38
IV	Moldavian Plateau	2,295,48	32,639	1.42	11.57	8,702	0.38	11.40
V	Getic Piedmont and Mehedinţi Plateau	1,462,52	10,607	0.73	3.76	2,857	0.20	3.74
VI	Dobrogea Plateau	1,017,16	13,167	1.29	4.67	961	0.09	1.26
VII	Banat and Crişana Hils	1,283,38	6,644	0.52	2.36	2,402	0.19	3.15
VIII	Romanian Plain and Danube Floodplain	4,896,84	36,395	0.74	12.90	6,690	0.14	8.76
IX	Banat and Crişana Plain	1,619,46	10,016	0.62	3.55	1,550	0.10	2.03
XI	Danube Delta and Razim-Sinoie Lagoon Complex	447,012	1,242	0.28	0.44	418	0.09	0.55
	Total		282,076	9.90	100	76347	2.22	100

In the Danube Delta, over 0.28% of the area had been affected by change in the first study period and only 0.09% in the second one (Table 2), the main land cover flows being deforestation (31%) and afforestation (38%). The process of urbanisation affected 10% of the total change area in the first period and 16% in the second one.

5. CONCLUSIONS

The land-use and land-cover changes experienced during the 1990-2006 period were particularly complex both across the country and in the landform units themselves. Since 1991 there were major changes in the type of property over agricultural and forest lands and in the type of farms. The severe fragmentation of farm land, the emergence of numerous individual farms practicing subsistence agriculture, poor services for agriculture (irrigation, fertilisation, mechanisation etc.) contributed to significantly decreasing of the quality and quantity of land-use.

GIS-based assessment of land-use changes over the 1990–2006 period, according to CORINE Land Cover database, highlighted a wide range of modifications in the land-use and land-cover pattern, basically transition from one category of use to another. Firstly, it was the structure of agricultural land that has been mostly affected (from intensive to extensive pattern), in that permanent crops and heterogeneous agricultural areas shrank, while pastures and arable land would expand.

In some regions, arable areas were sharply reduced, being abandoned by their new owners unable to work their plots regained under Land Reform (the Act 18/1991). The same happened to vineyards and orchards, many being abandoned or cleared off. Since 2000, the period of Romania's pre-accession to EU, the situation would change, arable land expanding, while vine-and-fruit areas continued to subside.

It was a time when mountain forests and lowland wind breaks were systematically cut, impairing the quality of land and intensifying extreme climatic phenomena. In the post-communist period, but especially after 2006, urban sprawl got momentum largely in the neighbourhood of the big urban centres. This process entailed the conversion of vast farm land to built-up terrains.

The evolution of the main land-cover flows was distinctively different in each of the two study-periods and in landform units. Thus, extensification and intensification of agriculture prevailed in the plains and plateaux, the first process being more evident over 1990-2000, and the last after 2000. The highest urbanisation rates registered the north-east, south and south-east of the country. The peak deforestation values recorded the Carpathians Mountains, especially the northern half of the Eastern Carpathians, mainly by implementing the "Lupu" Act no.1/11 January 2000.

If certain limitations or uncertainties of CORINE Land Cover database (minimum mapping area is 25 ha) and possible interpretation errors of satellite images are overlooked, this could be a reliable source for monitoring and quantifying spatial and temporal land-use and land-cover changes at national and regional levels, in particular.

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