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DYNAMICS OF THE ENVIRONMENTAL TRANSFORMATION PROCESSES DURING 1990 – 2006 IN ROMANIA REFLECTED BY LAND COVER AND USE CHANGES

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Key words: territorial system, land management, environmental deterioration, uncontrolled development, anthropization, CORINE.

Abstract. The relationship between the natural and anthropic components of territorial systems or complexes of coupled socio-economic and natural systems is changing in time under the effect of socio-economic and political drivers. One way of looking at it is through the changes of land cover and use, which are connected also to the dynamics of the eco-energies during the anthropization process. The aim of this paper is to perform an analysis of long-term land cover and use changes of the Romanian territory, hypothesizing that the transition period, with its more or less benefic economic periods, was characterized by an uncontrolled development resulting in important environmental impacts. The results confirm the hypothesis and underline several phenomena; some of them are antagonistic (decline and development of agriculture, deforestation and afforestation or reforestation), and others, such as urbanization, seem to occur mainly in one direction. The most affected areas are the limit of North-East and Center regions (due to deforestations) and the area around Bucharest and the shoreline (due to urbanization).

Introduction

Two Earth sciences – ecology and geography – have developed a systemic approach to define their object of study. While describing the same spatial reality, ecologists called it "ecological system" (Botnariuc and Vădineanu, 1982; Vădineanu, 1998, 2004) and geographers, "territorial system" (Ianoş, 2000). An extensive review of the literature on the two concepts has indicated that correspondences can easily be made between them based on the spatial scale (Petrişor, 2011). In addition, their structure is similar and it consists of natural and anthropic elements (Petrişor and Sârbu, 2010).

These conceptual considerations naturally lead to the question: provided that a system (ecological or territorial) is spatially delimited (Vădineanu, 1998), what is

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the relationship of the natural and anthropic subsystems? Vădineanu (1998) shows that man-dominated systems tend to expand over the natural ones, transforming and simplifying them; this process is called anthropization. Ianoş (2000) believes that the transformation can be appreciated through the consumption of primary eco-energies, defined as the "initial energy of a territorial system before the intervention of man as a conscious factor in its structure". If a key feature of systems, diversity, is also accounted for, biodiversity tends to decrease during the process, while geodiversity, equivalent to eco-diversity, increases (Petrişor and Sârbu, 2010).

While conceptually clear, these processes lack a methodology for assessing the transformation rate. It is far easier to look at the physical changes, reflected by the modifications of land cover and use. According to Jensen (2000), land cover represents a description of what is actually there from a biophysical viewpoint, and land use identifies how human communities utilize what lies on the surface of the Earth. In an even more pragmatic sense, the United States use the two-level Anderson's classification (Anderson *et al*., 1976); the first level reflects land cover and the second land use. The European Union utilizes the three-level CORINE classification (de Lima, 2005). While the first one reflects land cover, the second and third correspond to a more or less detailed description of land use in man-dominated systems or typology of natural systems (Petrişor *et al*., 2010).

Previous research over the Romanian territory, using CORINE data and focused on urban systems, has indicated that socioeconomic and political issues are the most important drivers of the changing relationship between natural and man-dominated systems, reflected by land cover and use changes (Petrişor *et al*., 2010). At the same time, micro-scale analyses have shown that the spatial distribution of land cover and use changes is tightly related to the one of eco-energies (Ianoş *et al*., 2011).

Nevertheless, the use of CORINE data is subject to several limitations. First, the analysis of an entire continent using a unitary methodology makes such inventories possible only at large intervals of time and the available data describe a past situation; we can only rely on 1990 data, 2000 data made available in 2004 and 2006 data made available in 2010. While the data have the advantage of being free of charge, the analysis of small territorial units reveals errors due to misclassification. To overcome these limitations, the present study is carried out at the scale of the national territory and of the regions of development, which also change slower (Vădineanu, 2004). From the territorial standpoint, land cover and use changes reflected by CORINE data are appropriate for analyzing changes in the higher levels of the Nomenclature of Units for Territorial Statistics (NUTS) hierarchy (Petrişor, 2008).

The concept of sustainable development has been defined by Brundtland (1987) as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". However, in interpreting its definition, it is important to find a balance between its traditional pillars – economic, social and environmental (Bugge and Watters, 2003), to which a fourth cultural one was added in 2004 (Iliescu, 2005). The relationship between the pillars is often a conflict, especially in developing countries. For example, the literature often cites what Indira Ghandi said at the United Nations in 1972 Stockholm meeting: "poverty is the worst form of pollution" (Iliescu, 2005).

From this perspective, Romania offers an interesting case study. The long transition period resulted into a decline of the large industrial units, which led to a decrease of pollution (O'Brien, 2005). Moreover, the decline of the communist intensive and extensive agriculture and its transformation into a subsistence activity (Iorgulescu Polimeni and Polimeni, 2007) should be more visible and reflected by land cover and use changes. Similarly, deforestations due to the change of ownership from the state to people who reclaimed their property (Roman, 2009) ought to be reflected by land cover and use changes. Last but not least, the real estate boom has been visible through the magnitude of urbanization phenomena (Petrişor *et al.*, 2010).

The aim of this study is to analyze long term environmental modifications of the Romanian territory and its subunits reflected by land cover and use changes, hypothesizing that the transition to an open market economy was an uncontrolled process with serious negative environmental consequences visible at the spatial scale of the entire country.

1. Data and methods

The CORINE data used in the study were made available free of charge by the European Environment Agency. Two data sets were used to reflect changes occurred between 1990-2000 (available on the Internet at the address http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-1990) and 2000-2006 (http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-2000). Data are available in a shape format, used by the Geographical Information Systems (GIS). Nevertheless, a few changes are required. First, the projection needs to be changed from Lambert Azimuthal Equal Area used in the European Union to Stereo 1970 used in Romania. Also, a subset clipped by the administrative borders of Romania was derived and further split by the limits of the regions of development. Two different sets were used for the two periods.

The analysis consisted of identifying each change according on its code and filling in the information for two fields. The type of change was either "land cover", if the code changed its first digit, and "land use", otherwise. The

underlying cause was determined case-specifically, relying mainly on the final code.

For the man-dominated systems, the term "urbanization" was used for land cover changes resulting into the transformation of areas belonging to other classes (natural, agricultural, wetland or water) into urban areas; unlike Petrişor *et al*. (2010), we used the same term for land use changes within the urban areas indicating the completion of construction works or densification of constructions.

For the natural areas, of particular interest were the forests. While the transformation of forests into transitional areas was ascribed to deforestations, the reverse could be due to two phenomena, which cannot be distinguished without knowing the concrete field reality: afforestation is the conversion from other land-uses into forest, or the increase of the canopy covers above the 10% threshold, achieved through plantations or natural regeneration, while reforestation is the re-establishment of forest formations after a temporary condition with less than 10% canopy cover due to human-induced or natural perturbations (Dutcă and Abrudan, 2010).

In a similar way, two antagonistic phenomena were the development or decline of agriculture. The first was defined as either a land cover change of other areas into agricultural ones or conversions due to a clear interest in agriculture, such as the conversion of pastures into orchards or permanent crops, while the second phenomenon was its opposite.

3. Results and discussion

The changes are mapped in Fig. 1 and 2. The two images exaggerate the magnitude of changes for a better visualization.

Similar to the conclusions of Ianoş *et al*. (2011), it can easily be seen that the area most affected by land use changes during 1990-2000 covers the Oriental Carpathians. This is mainly due to deforestations. Other important areas are the surroundings of Bucharest and the sea shore area covered by resorts, where increased land cover changes are due to the increase of urbanization (Petrişor *et al*., 2010). The pattern is similar during the next period.

The overall situation of the changes according to their causes is displayed in Fig. 3. For both periods, the image depicts all changes, and land cover and use changes separately. It can easily be seen that for the first period deforestations and their opposite, afforestation or reforestation, as well as the other two antagonistic phenomena, the decline and development of agriculture, make up most of land cover and use changes.

Nevertheless, when looking at land cover changes, urbanization is the most important driver, while the two antagonistic phenomena affecting agriculture and forests are reflected by land use changes. The latter two phenomena have a more

profound cause, as they represent the consequence of the activities generated by the decision to retrocede properties and changes of ownership resulted from decentralization. These remarks sustain our hypotheses according to which the effects of these activities against the environment were negative and dramatic.

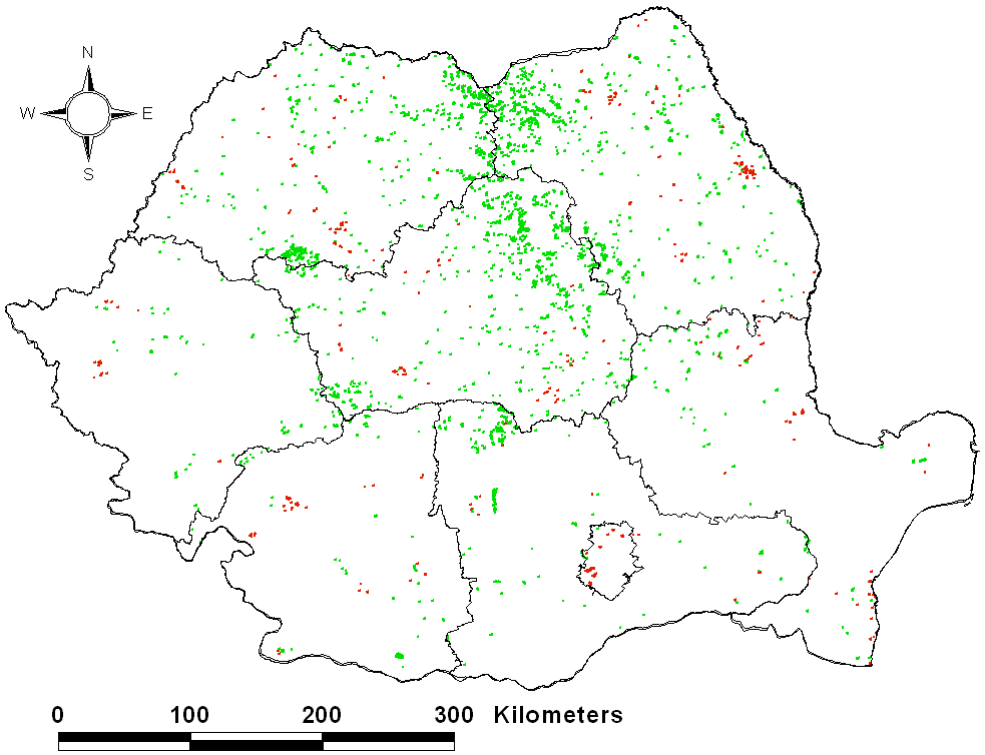


Fig. 1 - Land cover and use changes in Romania between 1990-2000. Land use changes appear in green and land cover changes in red. The sizes of the areas affected by land cover and use changes are exaggerated to allow for a better visualization

The second period is characterized more by deforestations, which have a high share in all changes. They dominate land use changes, while land cover changes depict the real estate boom. The latest cannot be seen in the overall changes, as the areas affected have a small share compared to the huge percentage covered by agricultural and natural areas of the Romanian territory. The second cause of land

use changes during this period is the decline of agriculture, documented by Bordânc (2008).

The spatial distribution of changes by region of development is shown in Fig. 4. The image looks at the area (hectares) affected by changes. Nevertheless, the actual area is not the best measure in this case, as Bucharest-Ilfov, even though the smallest region, is also the most dynamic, including the land cover and use changes. For this reason, the area affected by changes was compared to the total surface of the region, and the results are displayed in Fig. 5.

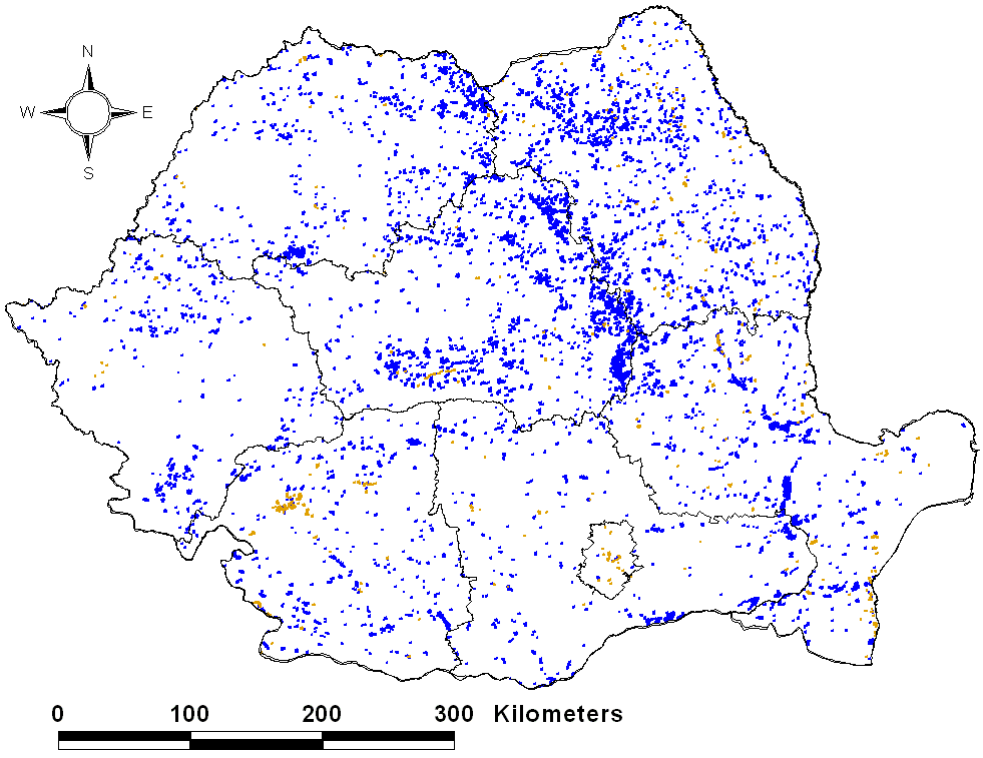


Fig. 2 - Land cover and use changes in Romania during 2000-2006. Land use changes appear in blue and land cover changes in orange. The sizes of areas affected by land cover and use changes are exaggerated to allow for a better visualization

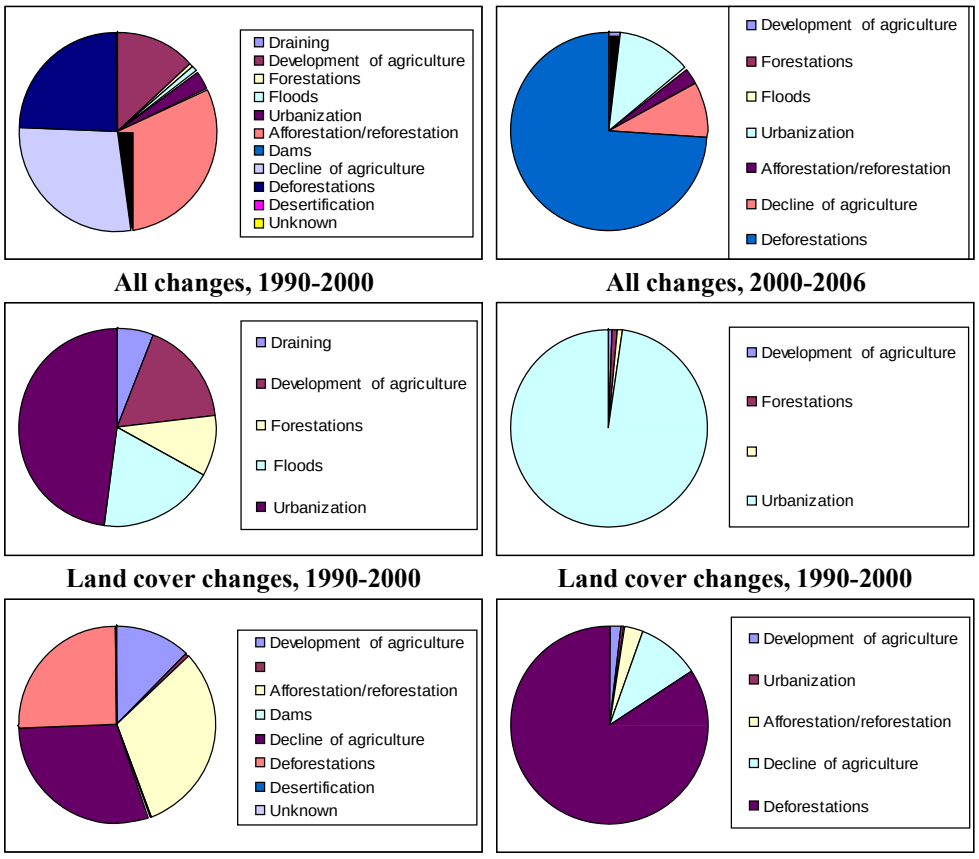


Fig. 3 - Land cover and use changes in Romania during 1990-2006 by underlying cause.

The results indicate that the North-East and Center regions were mostly affected during both periods; the changes are due to deforestations (Roman, 2009). During 1990-2000, another affected region is the South-East. Some of the phenomena responsible for it are the decline of agriculture, but also the urbanization of the coastal area (Petrişor *et al*., 2010). De-urbanization of cities that lost their industrial function is responsible for important land cover changes in the South-West region (Petrişor *et al*., 2010). When accounting for the area of the region, the only ones affected by important changes in both periods are the Center and North-East; again, this is due to the massive deforestations. They are followed by the South-East region during the first period, for the already mentioned reasons, and by Bucharest-Ilfov in the second. The explanation is that the strong

urbanization of former agricultural administrative units around Bucharest (Peptenatu *et al*., 2010) reached its peak.

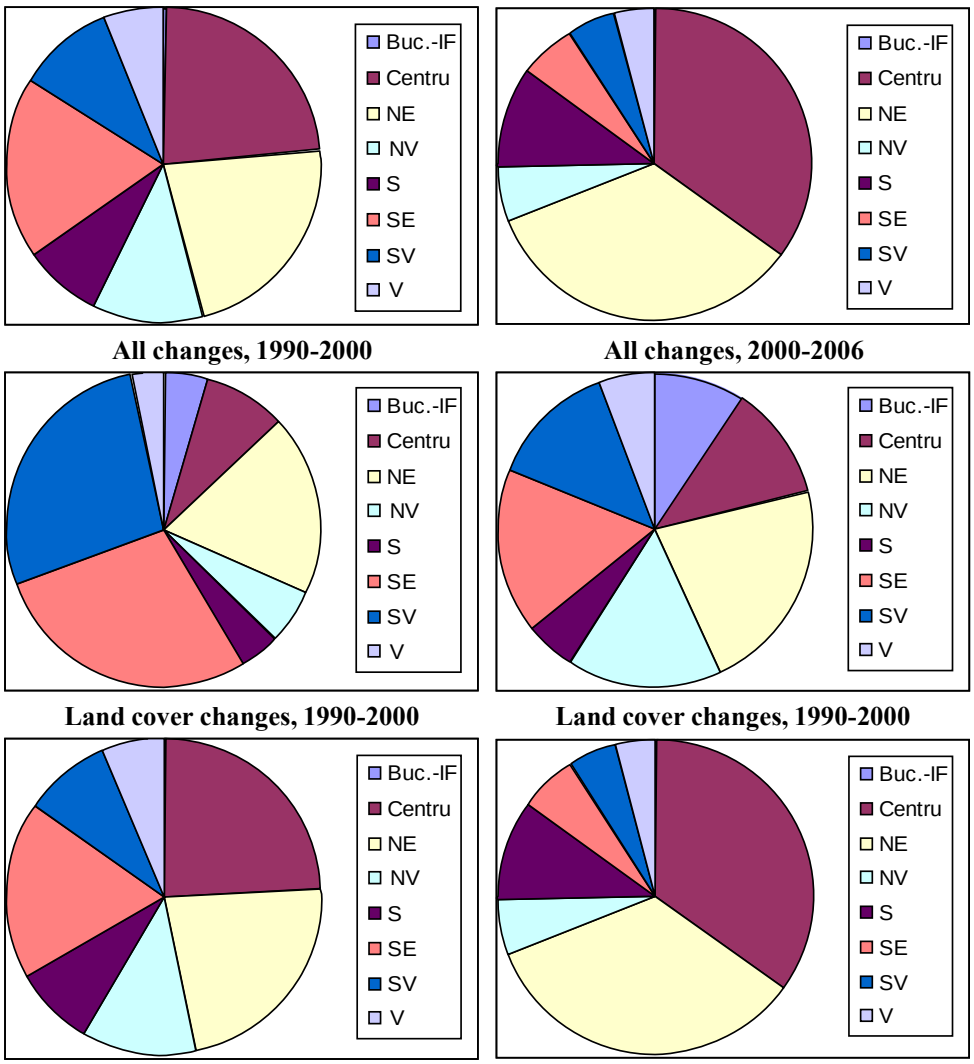
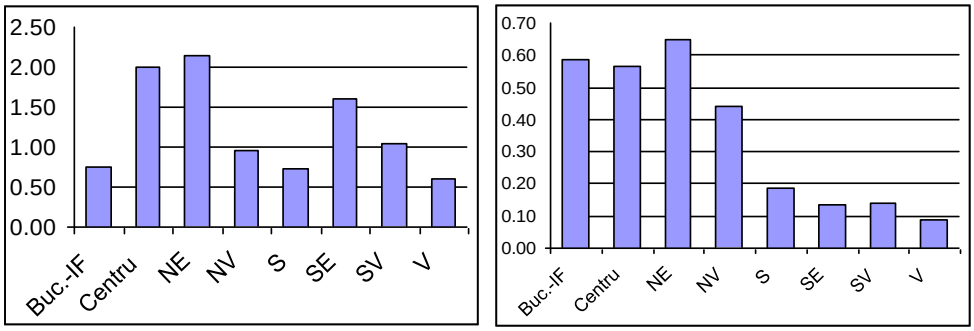


Fig. 4 - Land cover and use changes in Romania during 1990-2006 by region of development (hectares affected by changes).



All changes, 1990-2000 **All changes, 2000-2006**

Fig. 5 - Land cover and use changes in Romania during 1990-2006 by region of development (hectares affected by changes compared to the total area of the region).

Provided that a detailed analysis by region of development, period, type and underlying cause exceeds the aim of this paper, such data are presented only in Table 1 for further references, but not extensively discussed.

Conclusions

The paper aimed to test the hypotheses according to which the transition from communism to democracy and an open market economy results in uncontrolled development, which in its turn is at the core of important environmental impacts, in terms of both nature and magnitude.

The analyses of Romania and its regions of development as a case study support the underlying hypotheses. Several antagonistic phenomena were revealed; their origin is in changes of ownership, most of them resulted from the decision of the government to retrocede the properties, including agricultural land and forests. As a consequence, the decline of agriculture and deforestations affected important parts of the territory, especially the Carpathian massifs situated at the limit of the North-East and Center regions of development, where significant deforestation occurred.

Table 1. Land cover and use changes in the Romanian regions of development by type and underlying cause.

Reg.	Underlying cause	Period	All changes		Land cover		Land use	
		Change	’90-’00	’00-’06	’90-’00	’00-’06	’90-’00	’00-’06
Buch.-Ilfov	Urbanization		884	910	834	910	49	
	Decline of agriculture		275				275	
	Development of agriculture		194				194	
	Deforestations			152				152

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Reg.	Underlying cause	Period	All changes		Land cover		Land use	
		Change	'90-'00	'00-'06	'90-'00	'00-'06	'90-'00	'00-'06
Center	Development of agriculture		30		30			
	Plantation of forests		267		267			
	Floods		859		859			
	Urbanization		314	1110	314	1110		
	Afforestation/reforestation		14994	130			14994	130
	Dams		156				156	
	Decline of agriculture		8240	1250			8240	1250
	Deforestations		31873	17521			31873	17521
	Development of agriculture		14423	159			14423	159
	Unknown		260				260	
NE	Drains		597		597			
	Development of agriculture		10876	385	850	41	10026	345
	Plantation of forests		442		442			
	Floods		423		423			
	Urbanization		1137	2097	1041	2097	96	
	Afforestation/reforestation		20765	256			20765	256
	Decline of agriculture		17288	2705			17288	2705
	Deforestations		17293	15400			17293	15400
	Unknown		44				44	
NV	Development of agriculture		5058	109	433	0	4625	109
	Plantation of forests		85	2	85	2		
	Floods		81		81			
	Urbanization		358	1504	358	1504		
	Afforestation/reforestation		11344	141			11344	141
	Decline of agriculture		4620	1344			4620	1344
	Deforestations		13577	13247			13577	1344
	Unknown		199				199	
S	Development of agriculture		1535	106	105	13	1430	93
	Plantation of forests		21		21			
	Floods		246	12	246	12		
	Urbanization		468	630	404	493	64	137
	Afforestation/reforestation		5507	176			5507	176
	Decline of agriculture		15031	644			15031	644
	Deforestations		1831	4790			1831	4790
	Unknown		174				174	
SE	Development of agriculture		2923	587	967	18	1956	569
	Plantation of forests		866		866			
	Floods		747		747			

Table 1. Land cover and use changes in the Romanian regions of development by type and underlying cause.

Reg.	Underlying cause / Period Change	All changes		Land cover		Land use	
		’90-’00	’00-’06	’90-’00	’00-’06	’90-’00	’00-’06
	Urbanization	3001	1427	2355	1339	647	88
	Afforestation/reforestation	16636	264			16636	264
	Dams	438				438	
	Decline of agriculture	29514	518			29514	518
	Deforestations	3177	1955			3177	1955
	Desertification	102				102	
	Unknown	219				219	
SV	Drains	475		475			
	Development of agriculture	3384	16	542		2842	16
	Plantation of forests	7	72	7	72		
	Floods	931		931			
	Urbanization	3089	1197	2938	1197	151	
	Afforestation/reforestation	11948	1232			11948	1232
	Decline of agriculture	6833	325			6833	325
	Deforestations	3867	1295			3867	1295
	Unknown	55				55	
V	Development of agriculture	1437	53	195		1243	53
	Floods	50	17	50	17		
	Urbanization	351	542	351	542		
	Afforestation/reforestation	9585	8			9585	8
	Decline of agriculture	5020	51			5020	51
	Deforestations	2843	2130			2843	2130
	Unknown	26				26	

At the same time, the real estate boom, more visible after the year 2000, affected the areas around Bucharest and the coastal region, determining significant environmental impacts. Other important phenomena were due to the decline of cities loosing their industrial function.

The lack of control is visible mainly through the fact that antagonistic phenomena occurred simultaneously, increasing the affected area. In a controlled and planned development, involving a wise land management, the development of agriculture would take place exactly in the areas that were actually abandoned after being returned to the owners, who are no longer interested or cannot practice it, instead of requiring the transformation of lands with other destination into agricultural areas.

More importantly, while deforestations are obvious, the antagonistic phenomenon resulting into an increase of the area covered by forests is not

necessarily a planned process (plantation of trees), as it could occur spontaneously through reforestation or by afforestation due to natural regeneration.

Last but not least, urban development appears to take the shape of sprawl as opposed to a controlled process.

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