


Recent land cover and use in Romania: A conservation perspective

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Abstract: The study of land cover and use changes is important for sustainability, given that they are part of the global changes affecting our environment. In order to understand the mechanisms determining them, land cover and use changes must be studied based on their associated transitional dynamics. The present research aims to look at the most recent land cover and use changes from Romania, chosen as an example for post-socialist transitions. The methodology was based on applying geo-spatial analyses to data on land cover and use changes and natural protected areas. The results indicate that the most prominent transitional dynamics are deforestations and abandonment of cropland, rooted in the post-socialist property restitution. Furthermore, the study identified transitional dynamics indicating the human pressure within the natural protected areas, including urbanization, development of agriculture, and deforestation. Although subject to limitations bound to the use of CORINE data, the findings are important for understanding the environmental impact of socio-economic drivers, and provide additional evidence for the fact that emerging economies tend to sacrifice the environment during the economic crises.

1. Introduction

The importance of studying land cover and use changes (LCUCs) has been stressed out repeatedly, in relationship to sustainability (Verburg et al., 1999; Lambin et al., 2000; Foley et al., 2005); as part of the 'global changes' (Dale, 2011; Faeth and Hanson, 2016), LCUCs measure the human pressure against the environment (Elias et al., 2012). From this perspective, their extent might have a direct association with the human footprint (Chambers et al., 2000; Petrișor, 2016b). LCUCs are also associated with the 'transitional dynamics' (Lambin and Meyfroidt, 2010), which are in fact their socio-economic drivers. The transitional dynamics represent the conversion of a given land cover/use (or their sets) into another land cover/use (Petrișor et al., 2014, 2020); some of them are ascertained based on the initial use (e.g., deforestation), others by the final one (e.g., urbanization). Comparative studies carried out across Europe have pinpointed differences between the West and the East (Kupková et al., 2013). Moreover, the intensity and dominance of transitional dynamics varies in time for the same place (Baumann et al., 2011).

For this reason, and also given the potential use of land cover and use data in other sectors, such as planning (Grădinaru et al., 2017; Ianoș et al., 2017; Coheci et al.,

2019; Popa and Enache, 2019), the European Union established several programs, one replacing the other, for collecting data to monitor LCUCs across the continent (Petrișor et al., 2010; Hagenauer and Helbich, 2012; Petrișor and Petrișor, 2015; Bielecka and Jenerowicz, 2019). The main output consists of the CORINE data, updated each 6 years. The period is suitable for monitoring long-term transitional dynamics at national and regional scales (Petrișor and Petrișor, 2015).

Transition economies are true 'laboratories' for examining the transitional dynamics (Kuemmerle et al., 2006, 2007, 2008, 2009; Hostert et al., 2008, 2011; Müller and Munroe, 2008; Müller et al., 2009; Sikor et al., 2009; Václavík and Rogan, 2009; Bălțeanu et al., 2010; Dragotă et al., 2011; Grigorescu et al., 2012a, b; Knorn et al., 2012; Kupková et al., 2013; Popovici et al., 2013, 2018; Prishchepov et al., 2013; Dumitrașcu et al., 2014; Bičík et al., 2015; Vanonckelen and Van Rompaey, 2015; Andronache et al., 2016; Ianoș et al., 2016; Drăghici et al., 2017; Pintilii et al., 2017; Grigorescu et al., 2018; Kucsicsa and Dumitrică, 2019; Ianoș and Jones, 2019; Kucsicsa et al., 2019). The often disruptive processes associated with shifts of the global policies, such as the EU accession, results into important changes of the trends associated with the transitional dynamics (Kuemmerle et al., 2006, 2007, 2008, 2009; Hostert et al., 2008, 2011; Müller and Munroe, 2008; Müller et al., 2009; Sikor et al., 2009; Václavík and Rogan, 2009; Kupková et al., 2013; Prishchepov et al., 2013; Bičík et al., 2015; Vanonckelen and Van Rompaey, 2015). Romania is a good example (Kuemmerle et al., 2008, 2009; Hostert et al., 2008; Müller et al., 2009; Bălțeanu et al., 2010; Dragotă et al., 2011; Ianoș et al., 2011; Grigorescu et al., 2012a, b; Knorn et al., 2012; Petrișor, 2012a, b, 2015a, b, 2016a, 2017, 2018; Popovici et al., 2013, 2018; Dumitrașcu et al., 2014; Petrișor and Petrișor, 2015, 2017a, 2018; Vanonckelen and Van Rompaey, 2015; Petrișor et al., 2010, 2014; Andronache et al., 2016; Ianoș et al., 2016; Stan and Vintilă, 2016; Drăghici et al., 2017; Pintilii et al., 2017; Grigorescu et al., 2018; Kucsicsa and Dumitrică, 2019; Kucsicsa et al., 2019); while the first transitional dynamics assessed based on the use of CORINE indicated the effects of property restitution (abandonment of restituted cropland and deforestation of restituted forests), the next periods indicate the real estate boom and then the effects of the economic crisis (Munteanu and Servilo, 2013). A characteristic of Romania is the unplanned development (or planning for short term), visible through pairs of antagonistic transitional dynamics (development or growth vs. decline or loss) acting together in different areas during the same period (Petrișor, 2012a, b, 2015a, b, 2016a, 2017; Petrișor et al., 2010, 2014).

One of the requirements associated with the accession to the EU was the creation of networks of protected areas, by expanding the existing ones and creating new sites (Stăncioiu et al., 2010; Kati et al., 2015; Vanonckelen and Van Rompaey, 2015). The process was done at a very fast past pace, often with a poor substantiation (Petrișor, 2018), resulting into a lawsuit against Romania from the EU (Cojocariu et al., 2010). Different studies indicated that the Romanian natural protected areas cover preferentially critical areas, such as the mountains (Petrișor and Petrișor, 2017a) and wetlands (Petrișor, 2010). However, the protection status was not always enforced (Petrișor, 2018). Its enforcement resulted into the regeneration of forests over the former agricultural areas (Blakesley, 2006; Agnoletti et al., 2011; Van Uytvanck, 2009; Petrișor

et al., 2014). However, this phenomenon is characteristic to other countries as well (Agnolletti et al., 2011; Blakesley, 2006; Müller et al., 2008; Sikor et al., 2009; Van Uytvanck, 2009; Prishchepov et al., 2013). In Romania, its particularity is the occurrence in natural protected areas, but also in the cropland areas abandoned after being restituted to their owners (Müller et al., 2009; Popovici et al., 2018). Normally the protection status implies the lack of any other LCUCs than those resulted from the colonization of protected areas by nature, but previous studies have indicated the presence of other LCUCs in non-protected areas too (Petrișor and Petrișor, 2017b).

Starting from this background, the present study aims to: (1) look at the most recent (2012-2018) LCUCs in Romania, by analyzing their spatial distribution over the Romanian regions of development in connection to the associated transitional dynamics, and (2) assess whether these LCUCs show different patterns within the natural protected areas.

2. Data and methods

The study used two data sets. 2012-2018 data on LCUCs is provided free of charge through the Copernicus Land Monitoring Services (<https://land.copernicus.eu/pan-european/corine-land-cover/lcc-2012-2018/view>). The data has a spatial resolution of 5 hectares and comes into an ArcGIS format. In order to use the data, it was converted to ArcView GIS 3.X format, sub-sampled for Romania, and re-projected unto Stereo 1970. Data on the Romanian natural protected areas is freely available from the Romanian Ministry of Environmental Protection through their dedicated Internet page (<http://www.mmediu.ro/beta/domenii/protectia-naturii-2/arii-naturale-protejate/>). The data comes already in an ArcView GIS 3.X format, using the Stereo 1970 projection. Data on the Romanian regions of development comes from the free Geo-Spatial Portal; the limits were derived from the county limits (http://www.geo-spatial.org/file_download/29525), a file provided in an ArcView GIS 3.X format, using the Stereo 1970 projection.

The classification scheme used to ascertain the transitional dynamics corresponding to each LCUC combines those defined by the previous studies (Ianoș *et al.*, 2011; Petrișor, 2012a, b, 2015a, b, 2016a, 2017, 2018; Petrișor and Petrișor, 2015, 2017a, 2018; Petrișor *et al.*, 2010, 2014, 2020), completing them; in more details, the definitions of the transitional dynamics are presented below:

1. Urbanization is a change of natural, agricultural, wetland or water zones in urban ones or changes within the urban areas showing that the city developed;
2. Forestation is defined based on 'forests', corresponding to CORINE classes 3.1.1 (coniferous forests), 3.1.2 (broadleaved forests), and 3.1.3 (mixed forests); the term includes two phenomena, i.e. afforestation and reforestation (Dutcă and Abrudan, 2010), which are the change of urban, agricultural, wetland or water areas into 'forests'. The colonization of abandoned cropland by forest vegetation (Garcia-Ruiz et al., 1996; Blakesley, 2006; Kuemmerle et al., 2006; Václavík and

- Rogan, 2009; Van Uytvanck, 2009; Agnoletti et al., 2011; Petrișor et al., 2014), and changes of other natural categories into forests are included;
3. Deforestation is the change of 'forests' into other natural classes;
 4. The development of agriculture is a process including the change of urban, natural, wetland or water areas into agricultural parcels, and inner changes of the agricultural areas suggesting that the agriculture develops;
 5. The abandonment of agriculture is defined as a change of agricultural areas suggesting the decline or abandonment of agriculture;
 6. Floods include the changes of urban, agricultural, or natural areas into wetlands or waters, and the transformation of wetlands into waters;
 7. Drought is a process implying the change of wetlands or waters into urban, agricultural, or natural areas, or the change of waters into wetlands.

The methodology consisted of spatial analyses carried out in ArcView 3.X: overlaying the data sets, intersecting them, performing computations in Microsoft Excel 2003 based on the attributes, and computations performed using the X-Tools extension of ArcView 3.X.

3. Results and discussion

The spatial distribution of LCUCs occurred in Romania during 2012-2018 by transitional dynamics and region of development are displayed in Fig. 1. The image exaggerates the actual size of the areas affected by changes for a better visualization of their location.

The results confirm previous findings: the deforestations continue in the mountains situated at the border of the North-East, Center and North-West regions of development (Kuemmerle et al., 2007; Hostert et al., 2008; Müller and Munroe, 2008; Stăncioiu et al., 2010; Dutcă and Abrudan, 2010; Knorn et al., 2012; Dumitrașcu et al., 2014; Petrișor, 2012a, 2013, 2015b; Petrișor et al., 2014; Kupková et al., 2013; Petrișor, 2015b; Vanonckelen and Van Rompaey, 2015; Andronache et al., 2016; Drăghici et al., 2016, 2017; Pintilii et al., 2016, 2017; Popovici et al., 2018; Kucsicsa and Dumitrică, 2019; Kucsicsa et al., 2019).

Urbanization is more prominent in the south (Bucharest-Ilfov and South regions of development), but also around other large urban centers (Cluj-Napoca, Brașov, and Timișoara), since previous study showed that the urbanization of developing countries occurs in the metropolitan areas (Pauchard et al., 2006; Václavík and Rogan, 2009; Grigorescu et al., 2012a, b; Petrișor, 2012b, 2017a, b; Kupková et al., 2013; Ianoș et al., 2016). However, the urbanization of the Romanian seashore (Petrișor, 2012a; Petrișor et al., 2010) seems to have stopped.

Another interesting finding is the presence of forestation centers, in the mountains situated in the western part of the country. Most likely, this result sustains the effectiveness of in-situ protection, indicating the regeneration of forests when husbandry ceased due to the protection measures (Garcia-Ruiz et al., 1996; Blakesley, 2006; Kuemmerle et al., 2006; Václavík and Rogan, 2009; Van Uytvanck, 2009; Agnoletti et al., 2011; Petrișor et al., 2014).

Last but not least, other hotspots indicate the abandonment of agriculture in the north-west of the country, most probably due to the massive emigration and loss of working population during the economic crisis (Müller and Munroe, 2008; Müller et al., 2009; Sikor et al., 2009; Prishchepov et al., 2013; Petrișor et al., 2014), and its

development in the center (Popovici et al., 2018). An interesting phenomenon was the transformation of 'urban' land into agricultural land, attributable mostly to developing agriculture on abandoned construction sites rather than to urban agriculture, which in Romania is in its beginning stages (Enache and Popa, 2015; Panagopoulos et al., 2018); a proof is a similar transformation of urban land into forest, most likely due to the colonization of abandoned constructions sites by forest vegetation.

Apart from the hotspots, the very presence of some transitional dynamics is interesting. Floods reoccur and affect important areas, similar to the period 2000-2006 (Petrișor et al., 2010; Petrișor, 2012a). In addition to them, droughts are present; their simple presence might be an indication of the effects of climate changes (Petrișor, 2012c). It is also noteworthy mentioning that droughts tend to affect few, but large areas (Table 1).

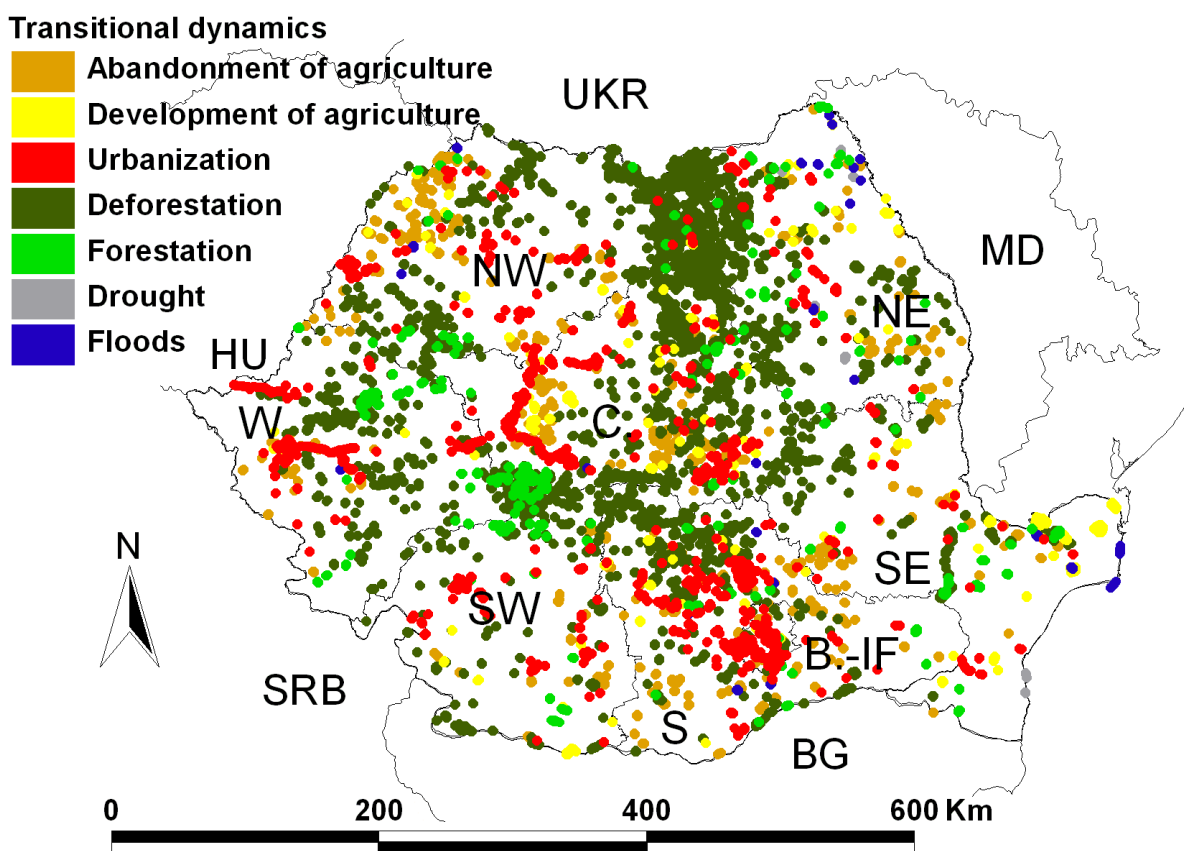


Figure 1. LCUCs in Romania by transitional dynamics and region of development (2012-2018). The contours of areas affected by changes were exaggerated for a better visualization of their location.

The numeric analysis of LCUCs occurred in Romania during 2012-2018 by transitional dynamics and region of development is presented in Tables 1 and 2. The first table presents the overall influence of the main drivers in Romania. In order to provide an overall estimate of the fragmentation of land determined by each transitional dynamic, the table presents also the number of parcels affected. The second table includes areas affected by each transitional dynamics and region of development expressed as row values, and share of the total area of each region.

The findings in Table 1 suggest some important trends. Overall, deforestations and the abandonment of agriculture were the more prominent transitional dynamics in terms of the total area affected. As mentioned before, droughts affected large areas, even if fewer in number. Similarly, the development of agriculture has the largest average parcel

size, suggesting that the development occurred in an organized way, probably through the association of farmers (Simulescu and Zamfir, 2015).

On the opposite size, urbanization affected many small parcels; the results must be interpreted in relationship to the relatively small size of Romanian cities, expressed as share of the total area (Petrișor, 2012b). Another transitional dynamic with a similar pattern is deforestation. Most likely, the results indicate illegal deforestations, occurring on many small parcels.

Table 1. LCUCs occurred in Romania during 2012-2018 by transitional dynamics. The table shows, in addition to the total area affected by each transitional dynamic, the number of parcels affected, as an indicator of the fragmentation of land determined by LCUCs.

<i>Transitional dynamic</i>	<i>Area</i>	<i>National share</i>	<i>No. parcels</i>	<i>Average size/parcel</i>
<i>Abandonment of agriculture</i>	248	0.10	508	0.49
<i>Deforestation</i>	678	0.28	2408	0.28
<i>Development of agriculture</i>	160	0.07	164	0.98
<i>Drought</i>	5	0.00	8	0.61
<i>Floods</i>	14	0.01	31	0.44
<i>Forestation</i>	102	0.04	238	0.43
<i>Urbanization</i>	193	0.08	976	0.20

Last but not least, the relatively small size of parcels affected by forestation suggests that the phenomenon occurred naturally, either by the regeneration of forests after the ceasing of husbandry in the natural protected areas, or colonization of abandoned cropland by forest vegetation (Garcia-Ruiz et al., 1996; Blakesley, 2006; Kuemmerle et al., 2006; Václavík and Rogan, 2009; Van Uytvanck, 2009; Agnoletti et al., 2011; Petrișor et al., 2014).

Table 2. LCUCs occurred in Romania during 2012-2018 by transitional dynamics and region of development. Gray shading indicate that the respective transitional dynamic was not identified or affected less than 0.01 of the area of the region.

<i>Region of development</i>	<i>Transitional dynamic</i>													
	<i>Abandonment of agriculture</i>		<i>Deforestation</i>		<i>Development of agriculture</i>		<i>Drought</i>		<i>Floods</i>		<i>Forestation</i>		<i>Urbanization</i>	
	<i>Area</i>	<i>%</i>	<i>Area</i>	<i>%</i>	<i>Area</i>	<i>%</i>	<i>Area</i>	<i>%</i>	<i>Area</i>	<i>%</i>	<i>Area</i>	<i>%</i>	<i>Area</i>	<i>%</i>
<i>Bucharest-Ilfov</i>	17	0.91	4	0.25	1	0.07	0	0.00	0	0.00	1	0.05	24	1.33
<i>Center</i>	56	0.16	177	0.52	21	0.06	0	0.00	0	0.00	26	0.08	45	0.13
<i>North-East</i>	23	0.06	195	0.53	7	0.02	2	0.01	2	0.01	14	0.04	10	0.03
<i>North-West</i>	46	0.13	88	0.26	5	0.01	0	0.00	2	0.01	5	0.01	24	0.07
<i>South</i>	49	0.14	84	0.24	6	0.02	0	0.00	2	0.01	8	0.02	35	0.10
<i>South-East</i>	34	0.09	39	0.11	106	0.30	1	0.00	5	0.01	18	0.05	7	0.02
<i>South-West</i>	14	0.05	39	0.13	12	0.04	0	0.00	0	0.00	15	0.05	15	0.05
<i>West</i>	9	0.03	49	0.15	1	0.00	0	0.00	1	0.00	14	0.05	32	0.10

These findings are sustained by the detailed analysis presented in Table 2. The results confirm that floods and drought, even if present during the period, were present

only in some regions of development. The most important changes occurred in Bucharest-Ilfov, due to urbanization (1.33% of the area) and abandonment of agriculture (0.91%). Apart from these, the findings are a simple confirmation of those indicated by Fig. 1.

Table 3 displays the LCUCs occurred within the Romanian natural protected areas during 2012-2018 by their associated transitional dynamics.

The findings in Table 3 confirm the previous results, showing that LCUCs occurred within the natural protected areas, although they shouldn't (Petrișor, 2018). Most important, some of them are consequences of activities which certainly violate the protection status – deforestations, development of agriculture, and urbanization. Deforestation occurred in absolutely all types of protected areas, and the shares of areas affected by it are among the highest (0.61% of the total area of natural parks, 0.51% in SCIs, and 0.47% in SPAs). Urbanization occurred in the protected wetlands (Ramsar), Natura 2000 sites (SCIs, SPAs, and SACs), and in the 'other' areas, affecting small shares. The development of agriculture occurred in the protected wetlands (Ramsar – 0.84% of the total area), some Natura 2000 sites (SCIs and SPAs), and in the Biosphere reserves (1.39%) and UNESCO sites (0.75%). Most likely, the latest are strong evidence for the illegal agricultural activities taking place within the limits of Danube Delta Biosphere Reserve (Damian, 2011), since these are the highest shares. The other drivers, indicating natural phenomena after the ceasing of the human activities, had a lesser impact.

Table 3. LCUCs occurred in Romania during 2012-2018 within the natural protected areas by transitional dynamics and region of development. Gray shading indicate that the respective transitional dynamic was not identified or affected less than 0.01 of the area.

Type of natural protected area	Transitional dynamic													
	Abandonment of agriculture		Deforestation		Development of agriculture		Drought		Floods		Forestation		Urbanization	
	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%
Biosphere reserve	0	0.00	6	0.09	92	1.39	2	0.03	6	0.08	5	0.08	0	0.00
UNESCO	0	0.00	1	0.02	23	0.75	2	0.07	1	0.03	0	0.00	0	0.00
National park	0	0.00	6	0.18	0	0.00	0	0.00	0	0.00	2	0.07	0	0.00
Natural park	0	0.01	47	0.61	0	0.00	1	0.01	8	0.10	0	0.00	0	0.00
Ramsar	1	0.01	26	0.24	92	0.84	2	0.02	6	0.06	12	0.11	1	0.01
SCI	25	0.05	236	0.51	95	0.20	3	0.01	7	0.02	50	0.11	6	0.01
SPA	30	0.08	183	0.47	110	0.28	4	0.01	7	0.02	43	0.11	7	0.02
SAC	0	0.00	2	0.12	0	0.00	0	0.00	0	0.00	1	0.07	0	0.00
Natural reserve	1	0.21	0	0.09	0	0.00	0	0.00	0	0.02	0	0.00	0	0.00
Other	0	0.01	9	0.33	0	0.00	0	0.01	1	0.02	1	0.04	0	0.01

In summary, the results show that the most important transitional dynamics are deforestations and the abandonment of cropland. Deforestations are most likely illegal, occurring on many small parcels. Both transitional dynamics are characteristic to Eastern-European countries undergoing the post-socialist property restitution (Kuemmerle et al., 2006, 2007; Hostert et al., 2008; Müller and Munroe, 2008; Václavík and Rogan, 2009; Stăncioiu et al., 2010; Dutcă and Abrudan, 2010; Knorn et al., 2012; Dumitrașcu et al., 2014; Petrișor, 2012a, 2013, 2015b; Petrișor et al., 2014; Kupková et

al., 2013; Petrișor, 2015b; Vanonckelen and Van Rompaey, 2015; Andronache et al., 2016; Drăghici et al., 2016, 2017; Pintilii et al., 2016, 2017; Popovici et al., 2018; Kucsicsa and Dumitrică, 2019; Kucsicsa et al., 2019). Most important, deforestations were also found within the natural protected areas, along with other transitional dynamics indicating the human pressure (urbanization and development of agriculture). Apart from rising serious questions on the effectiveness of protection, these findings indicate that developing economies, particularly in a post-socialist culture, sacrifice the long-term interests related to the protection of the environment for a short-term profit (Ianoș et al., 2009, 2012).

It must also be stressed out that this study is subject to potential limitations associated to the use of CORINE data, including misclassification errors (Jansen, 2007; Pelorosso et al., 2011; Verburg et al., 2011; Petrișor et al., 2010, 2014). However, such findings might only influence slightly the figures, but the findings remain valid, as indicated by their consistence with previous studies carried out in Romania and in other Eastern-European countries.

4. Conclusions

Starting from the importance of studying land cover and use changes in relationship to their associated transitional dynamics for ensuring a sustainable development, this study aimed to look at the most recent land cover and use changes in Romania and its natural protected areas, by the means of geo-spatial analysis. The results indicate that the most important transitional dynamics are deforestations and the abandonment of cropland, which are a consequence of the post-socialist property restitution and were found in other Eastern-European countries. Furthermore, the study found evidence for transitional dynamics indicating the human pressure within the natural protected areas, including urbanization, development of agriculture, and deforestation. Although the study is subject to limitations related to the use of CORINE data, the findings are important for understanding the environmental impact of socio-economic drivers, and provide additional evidence for the fact that emerging economies tend to sacrifice the environment during the economic crises.

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