Land Use Policy 78 (2018) 1–18

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

Land use and land cover changes in post-socialist countries: Some observations from Hungary and Poland

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ARTICLE INFO

Keywords:
Land change analysis
Land use/land cover
Corine Land Cover
Statistical analysis
Spatial data
Synergistic comparison
Trend analyses

ABSTRACT

This study has analysed changes in land use and land cover (LUCC) in two post-socialist countries – Hungary and Poland, based upon cadastral data, statistical data, and CORINE Land Cover data. This is a new approach aimed to perform a synergy analysis carried out in accordance with the 'top-down' principle, i.e. from the level of countries (in the case of land use) to the level of provinces/counties (land cover). This approach facilitates more reliable results. The authors analysed LUCC in northern Hungary (the Pest County) and southern Poland (the Małopolska Province) using GIS and statistical methods. The main aim of the research was to identify and assess the ongoing LUCC changes and compare them in the assumed field of research. The results indicate the existence of a trend in each time series. A downward trend was revealed for agricultural land in Hungary and Poland as well as for uncultivated land in Hungary. An upward trend was found in other variables (uncultivated land in Poland and forest land in both countries). Changes in land cover in the Pest County and the Małopolska Province (in 2000 and 2012) show a decrease in agricultural areas and an increase in artificial surfaces, forest and semi-natural areas with the change in Poland being more intensive than that in Hungary.

1. Introduction

Land use and land cover changes (LUCC) have become an important issue in studies on global environmental changes in recent years (Fan et al., 2017). Land use and cover are considered primary factors affecting ecosystems (Foley et al., 2005; Verburg et al., 2009) and landscape values (Sallay and Jombach, 2011). This has resulted in LUCC's increasing global academic attention. The research was focused on the methodology of comparisons using GIS methods (Bewket and Abebe, 2013), fuzzy sets, and landscape metrics (Szabó et al., 2016), but also on forging a new approach to combining ecological, geographical, and social anthropological data in the study of LUCC (Kumpula et al., 2011). Scientists presented a study that employs a high-resolution land use change model to downscale land use changes from macro-scale models to the landscape level (Verburg, 2006) to provide salient suggestions for future land-use change analysis (Deng and Li, 2016).

Studies on LUCC are a key element in understanding the relations and interactions between anthropogenic factors and the natural environment (Gaitanis et al., 2015; Kanianska et al., 2014). Both of these factors affect the LUCC to a greater or lesser degree. The current change trends are dominated by general degradation of the environment (Feranec et al., 2010; Koellner and Scholz, 2008) and substantial fragmentation of the landscape (Bogoliubova and Tymków, 2014). Numerous studies globally note the rapid pace of LUCC resulting from the population growth (Lambin et al., 2001), intensive land use (Lambin et al., 2003; Matson et al., 1997), and loss of natural areas (Falcucci et al., 2007; Lepers et al., 2005).

It is particularly important to appreciate LUCC since the knowledge of its importance is indispensable for the investigation of wider transformations in the global environment (Fan et al., 2017), climate changes, food security, biodiversity, climate adaptation (Kazak, 2018), mitigation policies (Meiyappan et al., 2014), and also to promote environmental sustainability (Gaitanis et al., 2015; Kazak et al., 2017). It should be noted that in many cases the changes are adverse ones such as the development of valuable natural areas or setting aside of high-quality agricultural land (Mackiewicz and Karalus-Wiatr, 2017). Hence,

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https://doi.org/10.1016/j.landusepol.2018.06.017
Received 25 April 2018; Received in revised form 14 June 2018; Accepted 14 June 2018
0264-8377/

constantly changing land use is the primary cause of land cover change (Gaitanis et al., 2015). Land use change is the oldest anthropogenic environmental intervention and is referred to as an aspect of 'the global change'. Such change as, for example, the conversion of forest land into a different type of land has been considered a climate change factor (Gaitanis et al., 2015) or a significant factor of landscape value loss (Sallay et al., 2012).

LUCC affects the landscapes of Europe (Verburg et al., 2006) and modern analysis techniques, based on the synergistic application of scientific theories and tools, increase the LUCC monitoring capacity (Verburg et al., 2009). The universal introduction of computers, advances in computing technology, and remote sensing techniques resulted in the general use of digital materials in LUCC studies focusing, for example, on urban and agglomeration growth processes (Cheng and Masser, 2003; Jat et al., 2008) or on areas threatened by human pressure (Cegielska et al., 2017a; Salata et al., 2016). Raw data for such investigation may be aerial photographs analysed using GIS technologies (Foody, 1996), which provide a comprehensive approach when combined with additional spatial reference material (Gajos and Sierka, 2011). A synergistic statistical and spatial analysis, with a properly prepared and managed data base, opens the possibility of quantification and characterisation of the intensity of investigated phenomena (Jombach and Sallay, 2011) and constant monitoring of ongoing changes (Jat et al., 2008; Kollányi et al., 2012). The data may further help analyse spatiotemporal dynamics of the phenomena in long-term studies (Cao et al., 2017).

Studies on local LUCC require that their results be set in a broader context since local case studies are not always representative of larger areas and conversely, large-scale studies present only general LUCC trends (Verburg et al., 2006). Hence, synergistic analyses that combine the national and regional levels give more reliable results (Verburg et al., 2009).

In this paper, the authors are interested in a synergistic study on LUCC in Hungary and Poland using cadastral data, statistical data, and CORINE Land Cover data. The authors employed statistical and GIS methods to analyse data for areas in northern Hungary (the Pest County) and southern Poland (the Małopolskie Province) and investigate the following research questions:

1 How has the land use and land cover changed in Hungary and Poland during the considered period?
2 Are the changes in the land use and land cover similar in the studied area of Hungary and Poland?
3 What do the similarities or differences identified in the research stem from?

2. Materials and methodology

2.1. Study area

The surveys were performed in the area of the Pest County (Hungary) and Małopolskie Province (Poland) (Fig. 1).

After the Second World War, Hungary and Poland were under the influence of the USSR where centrally-planned economy and nationalisation were the norm. At that time, Eastern Europe and East-Central Europe faced significant political and economic changes (Griffiths et al., 2013; Kuemmerle et al., 2006). Hungary and Poland transited from socialist planning to market-oriented economy following the collapse of the USSR, which resulted in substantial changes in the political, social, and economic environment (Bicik et al., 2001; Csaki, 2000). Two factors that justify the comparison of changes in LUCC in the two countries include the date of the accession to the European Union (2004) and socio-political transformation in 1989.

The current system in place in Poland was introduced in 1999 and is based on three tiers of administration: tier 1 – provinces (*województwo* in Polish); tier 2 – districts (*powiat*); and tier 3 – municipalities (*gmina*). The case study for Poland was the area of 15,183 km^2 of the Małopolskie Province located in southern Poland (Statistical Office in Kraków 2016). The Małopolskie Province is an interesting study area thanks to its varied topography (Hernik, 2011; Janus and Taszakowski, 2018), hydrology and geology (Drzewiecki et al., 2014), and land use types (Busko and Szafranska, 2018). Whilst northern Małopolska is dominated by agricultural land, the central part of the province (including the Kraków area) is more urbanised and the southern area is dominated by forests (Noszczyk et al., 2017). This region is also strategic due to its substantial historical, cultural, and tourist values (UMWM, 2010). A summary of changes in this area was prepared both for the whole province and for individual tier 2 units of 22 districts (Fig. 1b).

The spatial and settlement structure of Hungary is established in the Constitution. It subdivides the area of the country into the capital, counties (*megye* in Hungarian), towns and villages. Counties are territorial units consisting of settlement-level units.

The study area in Hungary was the Pest County with the City of Budapest located in northern central Hungary with the total surface area of 7574 km^2 (as of 2016). The area is characterised by diverse landscape conditions. It is situated at the crossing of several major landscape units of Hungary where, in a wider surrounding, the Great-Plain meets the North Hungarian Mountains and Transdanubian Mountains. In spite of the fact that the Pest County represents the economic centre of the country, the main transportation corridors cross the country here. Twelve percent of the county's territory belongs to nature reserves including two national parks and eleven nature preserves. The spatial structure of Hungary is extremely centralized. The Pest County represents 7,4% of the country's territory inhabited by one-third of the population. Almost 50% of the GDP is produced (Regional Development Concept of Pest county, 2014) here. The administrative borders encompass 187 settlements including 40 towns. Since 1990, there has been a strong suburbanization pressure especially in the 1990s (Sallay et al., 2012), which slowed down since the second part of the 2000s (Egyedné Gergely, 2014).

In order to facilitate a better comparison with districts in the Małopolskie Province, the Pest County was replaced with settlement-level units, 22 micro-regions (Fig. 1a).

2.2. Data

2.2.1. Cadastral and statistical data

The statistical analysis of LUC in Hungary and Poland involved six variables presented in Table 1. The first three variables (X_1–X_3) were for Hungary and variables X_4–X_6 concerned Poland. The analysed period was 2002–2016, which was mainly due to the availability of data after territorial subdivision reform in Poland (Noszczyk et al., 2017).

Uncultivated land in Hungary (X_3) is the total of the surface areas of unused agricultural areas and other areas such as buildings and structures, farm yards, parks and ornamental gardens, roads and side ditches, ponds, quarries, waste land, etc. required for the operation of holding (HCSO, 2017). Whereas uncultivated land in Poland (X_6) is the total surface area of developed and urbanised land, wasteland, ecological sites, and land under water. Statistical characteristics of all the variables are shown in Table 2.

For most variables, the mean is less than the median, which indicates that the empirical distribution is asymmetric. Additionally, the variability of all variables is low, which is confirmed by the low value of the standard deviation as compared to the mean and the very low value of the coefficient of variation (Table 2).