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LAND USE CHANGES IN THE BORDER ZONE. A CASE STUDY OF THE POLISH-BELARUSIAN BORDER IN THE VILLAGE OF MILENKOWCE

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ABSTRACT

Motives: The study was motivated by the changes in land use in the border village of Milenkowce in the period of 1975–2021, as recorded in the cadastre (Land and Buildings Register) and visualized on orthophotomaps. The territory of the northeastern border area and the problem of agricultural land abandonment have been addressed by only a few researchers to date.
Aim: The aim of this study was to perform a quantitative and qualitative analysis of land use changes as well as changes in the regulations on land use data acquisition and storage.
Results: The study demonstrated that the Land and Buildings Register (EGiB) regulations did not affect the land use groups and subgroups registered in the cadastral records. The changes in land use in the border village of Milenkowce were minor and mainly involved an increase in forest area at the expense of agricultural land. The spatial pattern of land use changes, measured by the Morans'I Global index, revealed no statistically significant clustering or dispersion.

Keywords: land use, border zone, land and buildings register, farmland abandonment, spatial pattern

INTRODUCTION

The land use concept semantically refers to the purposes for which the land is utilized, e.g., agricultural or recreational use. However, in practice it is often impossible to distinguish land use and land cover due to the plasticity of their definitions (e.g. forest (Björk & Skånes, 2016)). That is why land use and land cover are often used interchangeably (Bielecka & Jenerowicz, 2019) by academics, public authorities, and practitioners. Over recent decades, significant changes in land use have been noted worldwide due to increasing human interference with the environment. Regardless of the type and duration of human activity in the physical environment, anthropogenic impacts usually first appear in the form of changes in land use and land cover (LULC). In particular, vegetation changes may generate landscape fragmentation (Gabriele et al., 2023), soil erosion (Zorn & Komac, 2009) and other phenomena. Land use change analyses are described and discussed in a plethora of research papers focusing on, *inter alia*, mountain ecosystems (Kaim et al., 2016; Kurowska et al., 2020), metropolitan areas (Tokarczyk-Dorociak et al., 2018), coastal zones (Bielecka et al., 2020), riparian zones (Clerici et al., 2014), and wetlands and dryland (Anand & Oinam, 2020). Only few of these publications refer to the border zone, especially the eastern one, where changes

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in land use depend on the relationship between border states, their economic conditions, and the border type. Proniewski (2014) described the structure of Podlasie's spatial determinants, highlighting low economic potential, low investment expenditures, especially on innovation, poor infrastructure and transport potential, and emphasising human capital as the main driving force of the province. Czerny et al. (2016) described the peripherality of the border areas of the Lublin Province, and Bański et al. (2010) discussed the influence of the state border on the directions of socio-economic development in the eastern part of Lublin Province. Border regions along Poland's eastern border, which since 2004 has also been the border of the European Union and the Schengen area, are condemned to isolation, which affects their socio-economic development. This situation also occurred earlier before the collapse of the Soviet Union and the political transformation in Poland (Bański et al., 2010). The Polish border of the current European Union is a typical sub-sequential border, created secondary to land use forms (Komornicki, 2008).

Our research intends to fill this gap by examining the spatiotemporal characteristics of land use changes in the village of Milenkowce, located in the north-western part of the Polish-Belarusian border zone, over the past five decades, specifically, from 1975 to 2022. The study aims to address the following research questions:

Q1 – How has land use changed in Milenkowce during the specified time period? Is the spatial pattern of land use change clustered, dispersed or random? Are there any discernible trends in land use changes within the village and municipality where the village is located?

Q2 – How do the changes in the official land use registration regulations in the cadastre affect the observed land use?

LITERATURE REVIEW

The studies on global environmental change point out that land use change (LUC) is the largest contributor to environmental change. However, it must be emphasised that the links between land use and global change have not yet been sufficiently explored and understood. This is mainly due to insufficient knowledge of global and regional changes in land use. The relationship between land use and human activity is reciprocal. The land use definition claims that the land is directly shaped by human activity as it reflects the use and functions of a territory as they have been and effectively still are in real life. Research conducted for at least three decades has shown that changes in land use lead to anthropogenic alterations and modification of the earth's surface, thus affecting all its ecological functions (Kaim et al., 2016; Steffen et al., 2007). Understanding the impacts of land use change is essential for mitigating the consequences of human-environment interactions, so changes should be identified and quantified through multiple multi-scale case studies and finally summarized regionally and globally. Scientists quote population growth as the main driver of LUC, which upsurges agricultural land and intensifies food production that is a major factor in climate change, including desertification or excessive rainfall (AbdelRahman, 2023; Gabriele et al., 2023).

Widespread access to remote sensing data has ushered the current era of continuous mapping and monitoring of land use and land cover. With the development of satellite technology, the thematic scope of the information acquired and the level of detail increased (Bielecka & Ciolkosz, 2008). Remote sensing data have now become the main source of data for mapping land use and land cover at global, regional, and local levels. Other sources of information on land cover and land use are maps, in particular topographic maps, and public registers. It is worth mentioning that the most truthful and reliable information on land use comes from field surveys. However, due to the time-consuming and costly nature of these surveys, such mapping is usually limited to small areas. Among many types of LUC agricultural land abandonment (ALA) is a well-known process that occurs in many regions of the word, especially where agricultural activity meets several constrains, namely environmental, socio-demographic, and political

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(Janus & Bozek, 2019). Agricultural land abandonment has been observed along Poland's eastern border for several decades.

A valuable source of information is the cadastre, i.e. the Register of Land and Buildings in Poland (thereafter referred as EGiB). The land use information collected in the said Register comes from field surveys or is obtained from the interpretation of aerial images. However, looking at the cadastre in Poland historically, one may notice that the method of recording land use has changed several times. The changes concerned the number of land use levels, groups and subgroups, nomenclature of land use classes and their definitions. This process was described in detail by Matuk (2023), who outlined its political context and ultimately concluded that the political changes in 1989 did not affect the details of land use registration in the cadastre. However, the designations of land use classes have changed, which interferes with further harmonization of Polish resources with the INSPIRE (Infrastructure for Spatial Information in Europe) data specification (Stańczuk-Gławniczek, 2018). Noszczyk and Hernik (2017) noted that the reliability and usability of cadastral data is influenced by the way in which land and buildings registers are maintained. An active approach guarantees continuous data updating and high usability. A passive solution results in delays in data updating and thus leads to unreliability. Mika (2020) argued that modernisation of the Land and Buildings Register is a tool for improving the land management and administration process. The reliability of cadastral data was also studied by Kocur-Bera and Frąszczak (2021), who found that discrepancies between the cadastre and the state on the ground range from 30% to 80%. In summary, the authors concluded that only comprehensive data modernisation, using modern technology, could mitigate such discrepancies.

MATERIALS AND METHODS

Study area and material

Milenkowce is a village located in the Podlaskie Province, Sokółka county, Kuźnica municipality (see Fig. 1). The village includes two colonies, Sterpejki and Zajzdra, which are integral parts of it. According to the National Census of Population and Housing in 2021, the population of Milenkowce village is 42. The village accounts for 1.1% of the total population of the municipality. From 1998 to 2021, the population of the village decreased by approximately 42.5%. The age dependency ratio in Milenkowce is 110, which is significantly higher than the ratio for the Podlaskie Province (68) and the ratio for the entire country of Poland (70). In 2002, there were 20 households in Milenkowce, of which 10 were single-person households (GUS, 2021).

Fig. 1. Milenkowce, the study area location
Source: Geoportal 2022, www.geoportal.gov.pl.

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The cadastre in Podlaskie was created from scratch in the years 1957–1962. Busko & Meusz (2014) stated that the documents used in its creation came from land consolidation plans from 1935–1936, aerial photographs at a scale of 1: 5,000, and field measurements in the towns of Łomża and Augustów in 1936–1937 and 1949 respectively. Based on materials stored in Cadastre and Real Estate Department in Sokółka it is known that EGiB in Milenkowce was established in 1956 on the basis of the Decree of February 2, 1955 on the Land and Buildings Register (Dz.U. 1955, item 6). Before the planned land consolidation, land ownership was regulated i.e. Land Title Deeds were issued (1975–1977). The EGiB was modernised in 2017, and since then the register has been maintained in the digital form.

The following data were used to conduct the study:

1. The cadastral map at a scale of 1:5,000 from 1975 in the analogue form, prepared by the Provincial Office of Geodesy and Agricultural Land in Białystok, ref. no. geodetic resource 1449-166/75.
2. EGiB data from the year 2022, received from the District Surveying and Cartographic Documentation Centre, Geodesy, Cadastre and Real Estate Department in Sokółka.
3. Aerial orthoimagery from the years 2002, 2010, 2016, and 2022 available online at geoportal.gov.pl, maintained by the Head Office of Geodesy and Cartography (Geoportal, 2022).
4. Population statistical data from Local Data Bank, maintained by the Central Statistical Office (GUS, 2022).

METHODS

The hypothesis of this research states that land use along the Polish-Belarusian border zone, due to the closed nature of the border, is slowly changing, which is manifested as an increase in forest area at the expense of abandoned agricultural areas, whereas the aim of the research is to analyse land use between 1975 and 2022 and to examine the impact of changes in official regulations on land use registration in the EGiB. The study was conducted in three consecutive steps, data collecting and pre-processing, data analysis and synthesis, and finally results documentation. The initial data processing consisted in converting the EGiB 1975 analogue map into a digital vector file using the QGIS 3.32 software and digitizing land use, in particular agricultural land, forests and shrubs, and the total area of remaining land use classes (built-up, roads, water, ecological (if applicable)), in the years 1975, 2002, 2010, 2016, 2021. All land use vector files were uploaded into QGIS (Fig. 2).

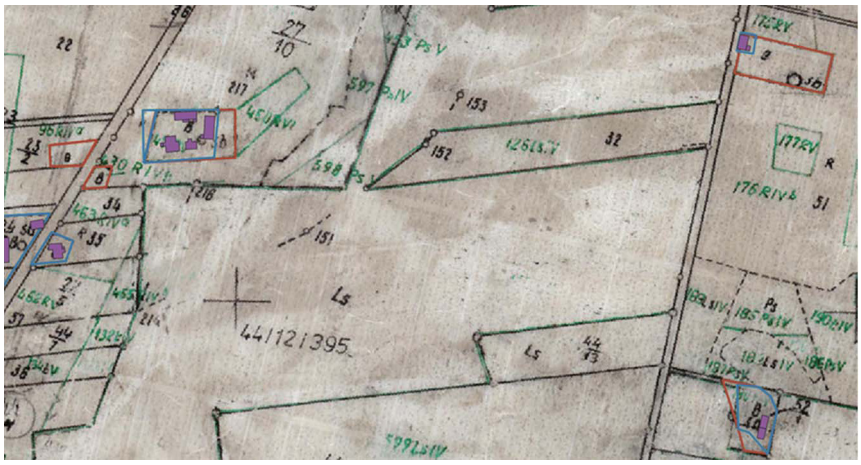

Fig. 2. Preview on land use, Milenkowce village. The green lines present the land use in 1975, the brown lines – in 2010, and the blue one in the year 2021

Source: own study, based on cadastral map from 1975 form the Provincial Office of Geodesy and Agricultural Land in Białystok.

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In the analysis and synthesis of the data, the area of agricultural, forest, and other land use classes was calculated and compared by year, not only for the village of Milenkowce, but also for the municipality in which it is located. The spatial pattern of land use changes was examined using Global Moran'I inferential statistics. The statistics begin by identifying a null hypothesis, namely complete spatial randomness (CSR), for the location of features or their attribute values. The z-scores (standard deviation) and p-values (significance level) returned by the Global Moran'I tools indicate whether or not the null hypothesis could be rejected. P-values are typically 90, 95 or 99 per cent. High or low (negative) z-scores associated with very small p-values are generally in the tails of the distribution and indicate that the null hypothesis can be rejected. Finally, the results were documented in the form of tables, charts, and a description of land use changes.

RESULTS

Land use changes in Milenkowce: patterns and trends

Milenkowce is a typical agroforestry village with a dominant share of forest in the land use structure (61% of the total village area). Agricultural land accounts for 34.4% and urbanised land for as little as 7.5%. Changes in land use over the analysed period were small. The area of agricultural land in 2021 decreased by 16 ha compared to 1975. The area covered by forest and scrub was the smallest in 2002 and the largest in 2016, at 248.1 and 264.2 ha respectively. The areas of other types of land use remained the same (see Chart 1, Fig. 3). There was also no clear trend in the changes in the area of land and forest. The forest area is increasing according to a second-degree polynomial trend with an R-squared coefficient

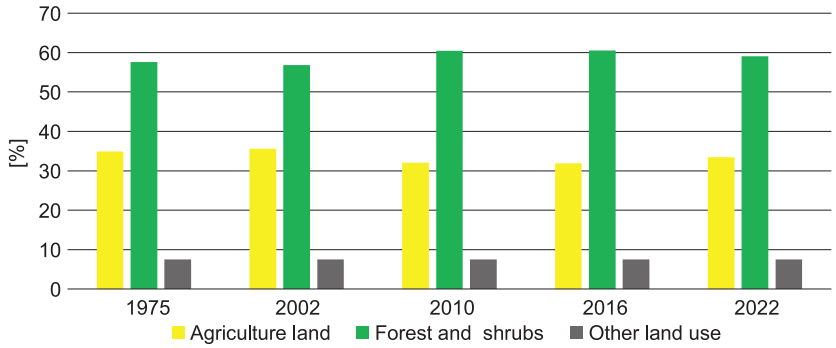

Chart 1. Changes in land use, Milenkowce
Source: own elaboration.

Fig. 3. Afforestation, left – 2002, right – 2022
Source: own study.

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of determination of 0.57, while the agricultural area is decreasing at the same rate ($R^2 = 0.56$).

The Global Moran's I statistic reveals that the spatial pattern of land use changes in Milenkowce is random. Both the z-scores (standard deviation) and p-values (probability), in general negative (see Table 1), indicate that the null hypothesis on complete spatial randomness cannot be rejected.

The structure of land use in the Kuźnica municipality has not changed much either. Between 2017 and 2022, a slow reduction in the area of agricultural land by approx. 20 ha was observed (Chart 2).

Kuźnica municipality is also an agricultural and forest land, agriculture accounts for 63% of the municipality's area, forests for about 29%. Anthropogenic land (settlements and transport network)

Table 1. Global Moran'I statistics

Period	Moran's Index	Expected Index	Variance	z- score	p-value	Numer of changes
1971–2002	0.1775	-0.0556	0.0208	1.6153	0.1063	18
2002–2010	-0.0263	-0.0333	0.0119	0.0648	0.9483	30
2010–2016	-0.1332	-0.0385	0.0320	-0.5297	0.596	26
2016–2022	-0.0206	-0.0196	0.0012	-0.0276	0.978	52
1971–2022	-0.0271	-0.0256	0.0088	-0.0154	0.988	40

Source: own elaboration.

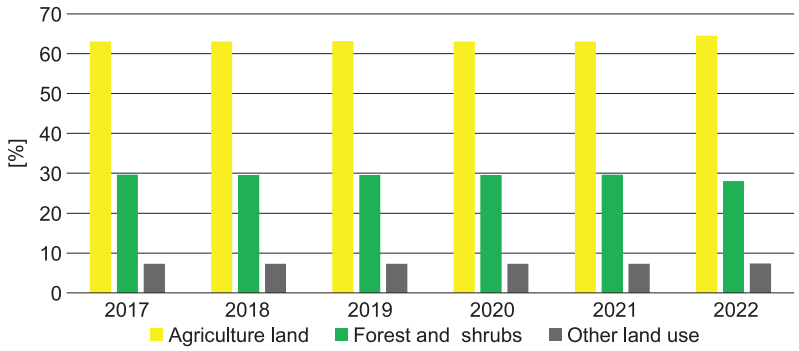

Chart 2. Changes in land use, Kuźnica municipality
Source: own elaboration.

Fig. 4. Kuźnica municipality, sand excavation areas
Source: own elaboration.

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covers only 8%. In 2017, an increase in agricultural land by 200 ha was observed, an average of 33.6 ha per year with the second-degree polynomial trend with R-squared coefficient of determination of 0.76. This was made possible by reclamation of sand and gravel excavation pits, some of which (around 1.2%) were converted into meadows and pastures (see Fig. 3). The forested area decreased slightly by 0.5% (211 ha) according to second degree polynomial trend, with the R-squared coefficient of determination of 0.76.

Land use registration regulations

Since 1975, five ministerial regulations were in force in Poland regarding the Land and Buildings Register, namely:

1. Ordinance of the two Ministers of Agriculture and Public Utilities of February 20 1969 on the land registry (Zarządzenie Ministrów Rolnictwa i Gospodarki Komunalnej z dnia 20 lutego 1969 r. w sprawie ewidencji gruntów (M.P. 1969, item. 98)).
2. Regulation of the Ministry of Spatial Planning and Construction and of the Ministry of Agriculture and Food of December 17 1996 on the EGiB (Rozporządzenie Ministrów Gospodarki Przestrzennej i Budownictwa oraz Rolnictwa i Gospodarki Żywnościowej z dnia 17 grudnia 1996 r. (Dz.U. 1996, item 813)).
3. Regulation of the Minister for Regional Development and Construction of March 29 2001 on the EGIB (Rozporządzenie Ministra Rozwoju Regionalnego i Budownictwa z dnia 29 marca 2001 r. (Dz.U. 2001, item 454)).
4. Regulation of the Minister of Administration and Digitisation on 29 November 2013 (Rozporządzenie Ministra Rozwoju Regionalnego i Budownictwa z dnia 29 marca 2001 r. (Dz.U. 2013, item 1551) amending the EGIB Regulation (Dz.U. 2001, item 454)).
5. Regulation of the Minister of Development, Labour and Technology of July 27, 2021 on the register of land and buildings (Rozporządzenie Ministra Rozwoju, Pracy i Technologii z dnia 27 lipca 2021 r. (Dz.U. 2021, item 1390)).

The legal regulations mentioned above include the division of land use into groups and subgroups, the letter designation in the EGIB register and the definition of land use. The analysis showed that the number of land use groups changed in the regulations in force at different times, with the lowest number of register groups in the 2021 regulation and the highest in the 1969 regulation. All acts list (1) agricultural land, (2) forest trees and shrubs, (3) water, (4) built-up and urbanised land, and (5) remaining lands, which were further subdivided into three to eight subgroups. Thus, in the 2021 Regulation, ecological land use was removed and wasteland was included in agricultural land. Mining and extraction lands, which had been separated as a separate registration group in the 1969 Regulation, was included in urbanised areas in subsequent legislation. The names of land use classes have also changed. i.e. the 2001 Regulation changed "forest land" into "forest and shrub". Notwithstanding, the land use definitions in the first, most general group of registrations, have also remained unchanged. The definition of forest in the above-mentioned regulations is consistent with the definition of forest in the Forest Act (Ustawa z dnia 28 września 1991 r. o lasach). At the same time, agricultural land is defined by enumerating and providing the characteristics of subgroups included in the agricultural land registration group according to the 2001 Regulation (Rozporządzenie Ministra Rozwoju Regionalnego i Budownictwa z dnia 29 marca 2001 r). It is worth mentioning that according to Regulation (EU) 1307/2013 the definition of agricultural *land means any area taken up by arable land, permanent grassland and permanent pasture, or permanent crops*.

Two regulations are crucial for the analyses carried out, namely the one from 1969, according to which land and building records were kept for Milenkowce in 1975–2001, and the one from the year 2001, according to which the land use was updated in 2017, during the modernisation of EGiB. Changes in the names, designations, and definitions of land use groups are summarized in Table 2.

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Table 2. Changes in land use groups in the EGiB regulations from 1969 and 2001

Land use group	Land use group name (designations)	Type of changes
Forest land	forest (Ls) land covered with trees and bushes (Lz)	Change of land use group, the subgroup name, and the description of land Lz use
Ecological land use	ecological land use (e.g. E-Ls)	Indication where the ecological use was established
Water	sea waters (Wm), inland waterways (Wp) standing inland water (Ws)	Changed group name (water and land under water)
Other land use	other land use (Tr)	No changes

Source: own elaboration.

DISCUSSION

The peripheral regions on the eastern border, one of which is the Podlaskie Province, had to face many barriers that hindered their development. Researchers (Bański & Janicki, 2013; Janus & Bozek, 2019; Prishchepov et al., 2012) in particular highlighted the near-border locations, which were afflicted by unfavourable demographic processes that ultimately led to the abandonment of agricultural farms. Bański and Janicki (2013) also emphasised that, following the fall of the Soviet Union, more positive experiences of development associated with the opening of the border became apparent. However, Poland's accession to the European Union (EU) and the Schengen area limited the flows of people and goods once more (Janus & Bozek, 2019) thus hindering the development of regions along the eastern border. Van der Zanden et al. (2017) noted that the EU Common Agricultural Policy is leading to an acute abandonment of agricultural land and it is expected that the area of abandoned agricultural land in Europe could reach even 212,000 ha by 2040. Based on multiple case studies, Veldkamp and Lambin (2001) found that drivers of land use change are scale dependent, i.e. that different drivers are more important at the detailed (local) scale than at the regional or global scale. At the farm or village scale, social and accessibility variables are the main determinants of land use, at the small regional scale topography and agro-climatic potential are the main determinants, while at the regional to national scale climatic variables as well as macro-economic and demographic factors seem to drive land use. The most frequently discussed factor influencing land use change at the village and municipality level is local legislation (Wnęk et al., 2021), in particular local spatial development plans and plans for the protection against hazards (i.e. flood hazard zones).

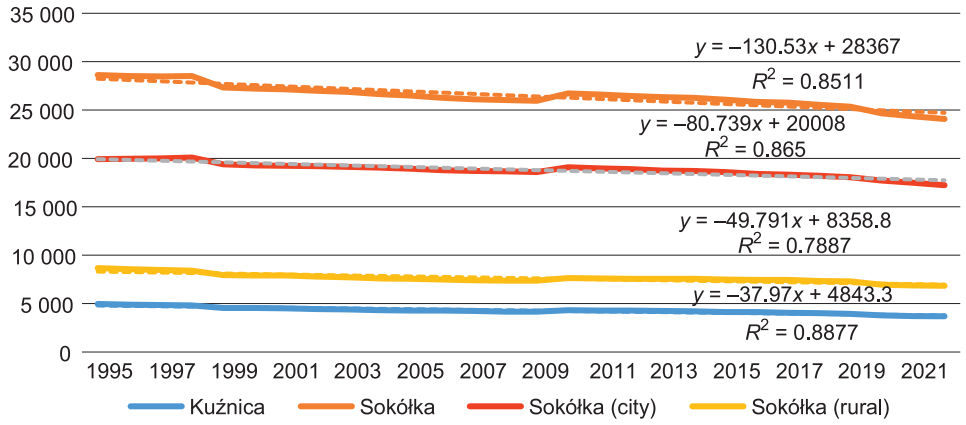

Chart 3. Population trends
Source: own study.

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Sroka et al. (2019) divided the determinants of land use change into five groups, namely (1) socio-economic (e.g. migration, urbanisation, number of enterprises, agriculture income); (2) location (e.g. proximity to settlements, roads, municipality centres); (3) environmental (e.g. altitude, slope, soil fertility); (4) farm characteristics (e.g. low income, unfavourable farm structure); and (5) institutional, in particular agricultural policy at any level of administration. The groups identified by Sroka et al. (2019) match the statement of Veldkamp and Lambin (2001), so factors related to farm characteristics affect land use at a local level, while the others influence it most often at a regional, national or global level.

Human potential, especially population, is no less important. In the municipality of Kuźnica and the county of Sokółka, the population has been steadily decreasing since 1995. As can be seen in Chart 3, the decline in the rural part of Sokółka county has been more pronounced in agricultural areas.

According to Śleszyński et al. (2017), population decline is an important factor in the economic development of north-eastern municipalities, it determines the quality of life and correlates with problem areas. A similar opinion was expressed by Bański and Janicki (2013), Bański et al. (2010), and Czerny et al. (2016). Our research is also in line with the results of Abdel-Rahman (2023) found in the meta-analysis of land use in Egypt and India. Moreover, as noted by Busko and Meusz (2014), the modernisation of EGiB differs from province to province and strongly depends on the historical regions of Poland. Our results confirm this statement, as the EGiB in Kuźnica, the former region of the Russian cadastre, was maintained in analogue form until 2017.

CONCLUSIONS

In order to understand trends in land use change and spatial patterns in the Belarusian borderlands, we examined 46 years of land use change in the village of Milenkowce and the municipality of Kuźnica, paying particular attention to structural and social aspects. The study shows that the EGiB regulations do not affect the land use groups and subgroups registered in the cadastral records. The changes in land use in the border village of Milenkowce were small and mainly concerned the increase of forest against agricultural land. The spatial pattern of land use changes, measured by the Morans'I Global index, did not reveal any statistically significant clustering or dispersion. Moreover, remote sensing data, especially aerial orthoimages, are very important data sources for updating land use according to the EGiB regulations and technical specifications.

This research contributes to the discussion on changes in land use and changes in legislation on the cadastre, in particular land use, which is very important in the context of joint EU projects on agriculture and access to high quality data.

Author contributions: O.M. and E.B. have approved the final version of the article. Authors contributed to this work as follows: O.M. and E.B developed the concept and designed the study, O.M. collected the data, O.M. and E.B analysed and interpreted the data, O.M. and E.B prepared the draft of the article, O.M. and E.B revised the article critically for important intellectual content.

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