JOURNAL OF WATER AND LAND DEVELOPMENT
e-ISSN 2083-4535
Polish Academy of Sciences (PAN) Institute of Technology and Life Sciences – National Research Institute (ITP – PIB)

JOURNAL OF WATER AND LAND DEVELOPMENT
DOI: 10.24425/jwld.2022.143724
2022, Special Issue: 92–98

Land use change in suburban zone: European context of urban sprawl

Jan K. Kazak, Magdalena Błasik, Małgorzata Świąder

Wrocław University of Environmental and Life Sciences, Institute of Spatial Management, ul. Grunwaldzka 55, 50-357, Wrocław, Poland

RECEIVED 04.06.2022 ACCEPTED 12.07.2022 AVAILABLE ONLINE 31.12.2022

Abstract: Quantifying and understanding global land use change and its spatial and temporal dynamics is critical to supporting international policy debates. The main area of transformation of spatial structures nowadays are suburban areas of the largest cities. Constant land development and urbanization, including such forms as urban sprawl, influence significant changes in land use. The aim of this study was to analyse a land use change pattern in a selected rural area which is under pressure of spatial development of a regional city. Data used for a land use change detection was based opensource Urban Atlas dataset for 2006, 2012, and 2018, enriched by recent update from 2021 orthophoto map. Spatial analyses presenting statistics of land use change were conducted in QGIS. Besides analysis of land use change, the paper discusses observed spatial patterns also taking into account changing social, environmental and economic conditions and spatial policies influencing land cover complexity. Understanding these dynamics would help better spatial management of real estates for more sustainable land development.

Keywords: land cover, land use change, rural, suburban, urban sprawl

INTRODUCTION

With the increase of human mobility and increased accessibility of more remote locations European metropolitan areas have been rapidly expanding. In Central and Eastern Europe urban expansion has accelerated especially after legal transformation in the beginning of 90. in 20th century. In Polish conditions the speed of converting land into urban areas in the beginning of 21st century was at the level of around 42.5 ha per day which confirms the importance of that issue [Źróbek-Różańska *et al.* 2014]. Quantitative, qualitative, and structural changes in land use that occur in a specific period and space are referred to as urban development. From a center of a city to its outskirts, this development is accompanied by spatial diffusion. Propagation of urban forms of land development on surrounding rural areas (in suburban zone) is commonly called urban sprawl. Suburban zone is a subject to particularly strong investment pressure [Wolny *et al.* 2014], strongly driven by increasing accessibility of more remote locations [Wolny 2016].

Urban sprawl does not have consistent boundaries, making it difficult to define. The land-use patterns of metropolitan areas are constantly changing. Uncontrolled urban sprawl has a negative impact on rural areas and social connections in the surrounding area. The countryside is primarily planned by city dwellers, and future rural development is expected to fulfil metropolitan requirements. Large distances from city centers, single-family home domination, gentrification, and considerable inflows of people from the central city characterize contemporary Polish suburbanization [Solecka *et al.* 2017]. People from core cities, who generally have high salaries, build homes in suburban, agricultural areas to get away from the traffic and stress of daily life that they assign to densely urbanized areas [Tanaś 2014]. This migration is strongly driven by legal and administrative decisions and actions of local governments [Zysk, Źróbek-Różańska 2016], which results is costs, not only private but also public, which has to be covered.

Urbanization processes described above can have different dynamics. In order to detect and characterize them few analytical approaches can be applied. One of the options is to use a statistical data from a building permit register [Maleszka *et al.* 2016], however that approach does not allow to verify if building construction was completed, for instance due to unstable

economic situation on the market. Alternatively it is possible to use data collected from field survey [Kajdanek 2014]. This method is more accurate in terms of results, however, it is time-consuming and more expensive. Therefore, it cannot be applied as a general approach to monitor and analyse properties in a larger scale. The most universal approach and the most commonly used one is detecting land use changes based on remote data. It was applied worldwide in many countries like India [Kumar, Singh 2021], Vietnam [Le *et al.* 2016], Turkey [Tunc *et al.* 2021], Poland [Noszczyk *et al.* 2020]. Successful application of that approach requires proper land use classification [Karabin-Zych 2021; Matuk 2021] and statistical methods to analyse gathered data [Noszczyk 2019; Noszczyk *et al.* 2017).

Typical environment to analyse remote data of land use change are Geographical Information Systems (GIS). They are commonly used to analyse, monitor and support management in different geographical aspects both in non-urbanized [Jędruch *et al.* 2020; Sieczkowska *et al.* 2022] as well as urbanized areas [Foryś, Kazak 2019; Jędruch *et al.* 2020; Wang *et al.* 2017]. As stated by Bazan-Krzywoszańska *et al.* [2019], the use of GIS technology in spatial analysis and monitoring changes in spatial management provide the possibility to collect information that builds the base of knowledge on the area, which helps to make more aware decisions regarding a way of how land uses should be designed. Based on these decisions allocation of each real estate plots into proper land uses is assigned. Spatial analyses presented already its functionality not only in preparation of spatial planning documents (like policies or master plans) but also in regular city management covering for example energy [Bazan-Krzywoszańska *et al.* 2017], social [Kisiała, Rącka 2021] or economic aspects [Heldak 2017]. In this research the approach based on remote data analysed in GIS was used for the aim of this study in order to analyse a land use change pattern in a selected rural area which is under pressure of spatial development of a regional city.

STUDY MATERIALS AND METHODS

Land use change in suburban zone was assessed based on the remote data covering Urban Atlas dataset for 2006, 2012, and 2018 [EEA undated]. Data from Urban Atlas enabled to define dynamics in land use change. The European Urban Atlas provides high-resolution land use maps for over 300 Large Urban Zones and their surroundings (defined by the Urban Audit as having more than 100.000 inhabitants) for the 2006 reference year in EU member states and for about 800 Functional Urban Area (FUA) and their surroundings (defined by the Urban Audit as having more than 50.000 inhabitants) for the 2012 and 2018 reference year [EEA undated]. Additional data source was orthophoto map for 2021 which served as a reference in order to assess the precision of Urban Atlas data for the purpose of land use change identification at the level of single village. The study was performed on a case of Domasław village which is located in suburban zone of Wrocław, which is a fourth biggest Polish city (Fig. 1). For the purpose of the study spatial analyses of land use change with statistics of land use were used. Analyses were conducted in QGIS ver. 3.16.

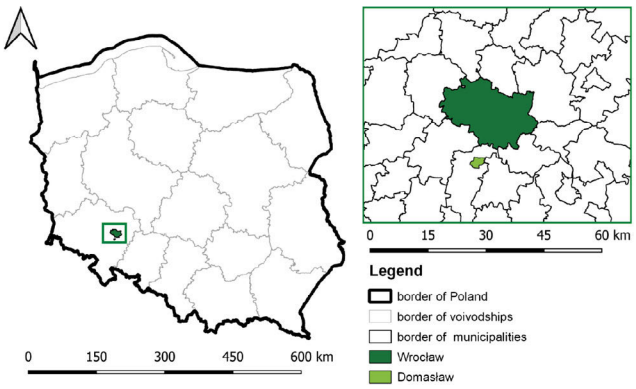

Fig. 1. Location of the study area; source: own study

RESULTS AND DISCUSSION

IDENTIFICATION OF LAND USES IN STUDY AREA

Based on collected data maps presenting land uses of Domasław village were prepared (Fig. 2). Study area was significantly changed in terms of its land use not only in terms of constructing new housing but also commercial objects. Moreover, in western part of the village new expressway was built up. Besides land uses which increased soil sealing, there were more changes in areas characterized by agricultural use of land. Between 2006 and 2012 in few locations arable land was converted into pastures.

The most significant change in land use was noticed between 2006 and 2012 (Fig. 3). The share of arable land, which is under the strongest pressure in urbanization processes, have reduced from 85 to 78%. In terms of strictly urban forms, expansion of discontinuous urban fabric (+1%), industrial and commercial buildings (+1%), fast transit roads (+1%) influenced the change in the most significant way. Additionally, conversion of arable land into pastures, which in terms of amount was the most noticeable (+7%) does not modify character of agricultural function of the village. Period between 2012 and 2018 was not that crucial in terms of expansion of built up forms, however, it presents one important aspect. In that period the area that was converted in forest.

Detailed values of area of land uses in Domasław in 2006, 2012 and 2018 are presented below (Tab. 1). As it can be seen, new development has form of discontinuous low, medium or very low density urban fabric. This is a typical form of new development in suburban areas. In case of Domasław new development is constructed as detached houses, semi-detached houses or terraced houses (Photo 1).

This type of new development explains observed changes in different categories of discontinuous urban fabric. Increase of built up area is observed in all levels of density which shows that different types of building can be developed. Processes of increasing density of existing built up area comparing to newly developed area is a potential field of future studies.

VERIFICATION OF LAND USES

In order to assess precision of Urban Atlas data for the purpose of land use change identification at the local level, classification of land uses was conducted based on user verification of ortophoto map. The same classification as the one used in Urban Atlas was

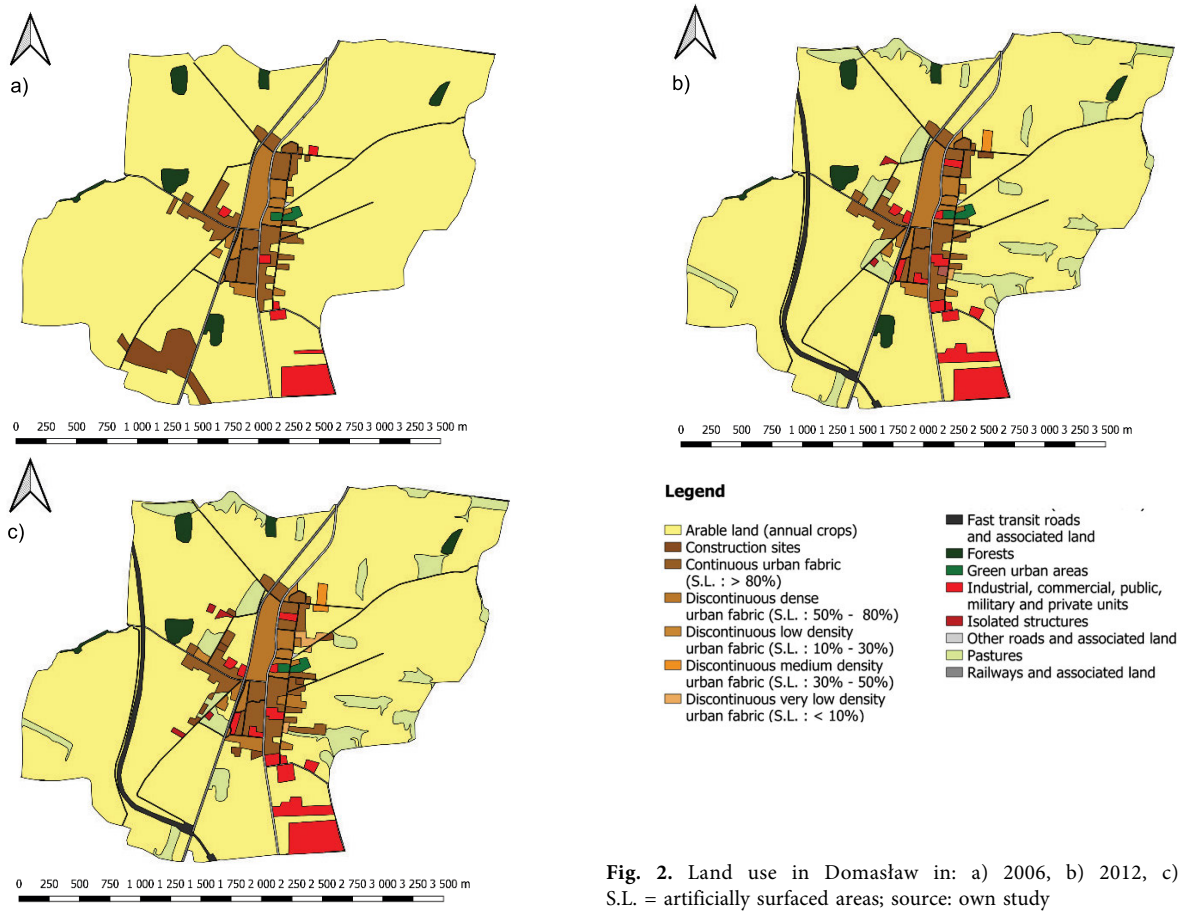

Fig. 2. Land use in Domasław in: a) 2006, b) 2012, c) 2018; S.L. = artificially surfaced areas; source: own study

applied. Land uses and their shares are presented graphically (Fig. 4). As it can be observed, there are some changes between Urban Atlas data for 2018 and ortophoto map for 2021. First of all the share of arable land is higher (by 4%). Moreover, data from 2021 confirmed that only 1% of areas are used as pastures. Total area of construction sites and discontinuous urban fabric is the same in both years. The share of industrial and commercial area is higher, which not necessary is a mistake, but it can be caused by new building that were completed.

Despite comparison of statistics between two different data sources, classification of land uses was verified by a user (Fig. 5). Results show that most of areas were properly classified. Some differences that appeared were connected not with the type of a class of land use but rather with the size of a patch. Therefore, Urban Atlas might present some errors which might be caused by the minimum mapping unit that is included in this kind of data. This aspect may result in low precision in case of many small patches, but it should not be as severe in case of bigger patches. Therefore, proper identification of a single house might be more problematic, while identification of neighbourhoods is correct.

DISCUSSION AND CONCLUSIONS

Defining urbanization processes is crucial in order to manage spatial planning system properly. Study shows that urbanization pressure between 2006 and 2012 was higher than between 2012 and 2018. The open question is how suburbanization processes

Table 1. Area of land uses in Domasław in 2006, 2012 and 2018

Land use classes	Area (ha) in the year		
	2006	2012	2018
Arable land (annual crops)	6 262 044	5 745 941	5 660 400
Construction sites	160 212	5 341	29 941
Continuous urban fabric (S.L. >80%)	338 170	291 503	321 676
Discontinuous dense urban fabric (S.L. 50–80%)	200 397	198 228	219 376
Discontinuous medium density urban fabric (S.L. 30–50%)	0	12 213	17 553
Discontinuous low density urban fabric (S.L. 10–30%)	0	8 635	12 707
Discontinuous very low density urban fabric (S.L. <10%)	0	3 694	20 077
Fast transit roads and associated land	0	96 960	96 961
Forests	124 868	124 868	95 824
Green urban areas	17 032	17 032	17 032
Industrial, commercial, public, military and private units	132 345	217 760	226 172
Isolated structures	0	7 347	14 642
Land without current use	0	5 512	0
Other roads and associated land	121 845	132 900	132 900
Pastures	0	489 364	492 037
Railways and associated land	48 323	47 938	47 938

Explanation: S.L. = artificially surfaced areas.
Source: own study.

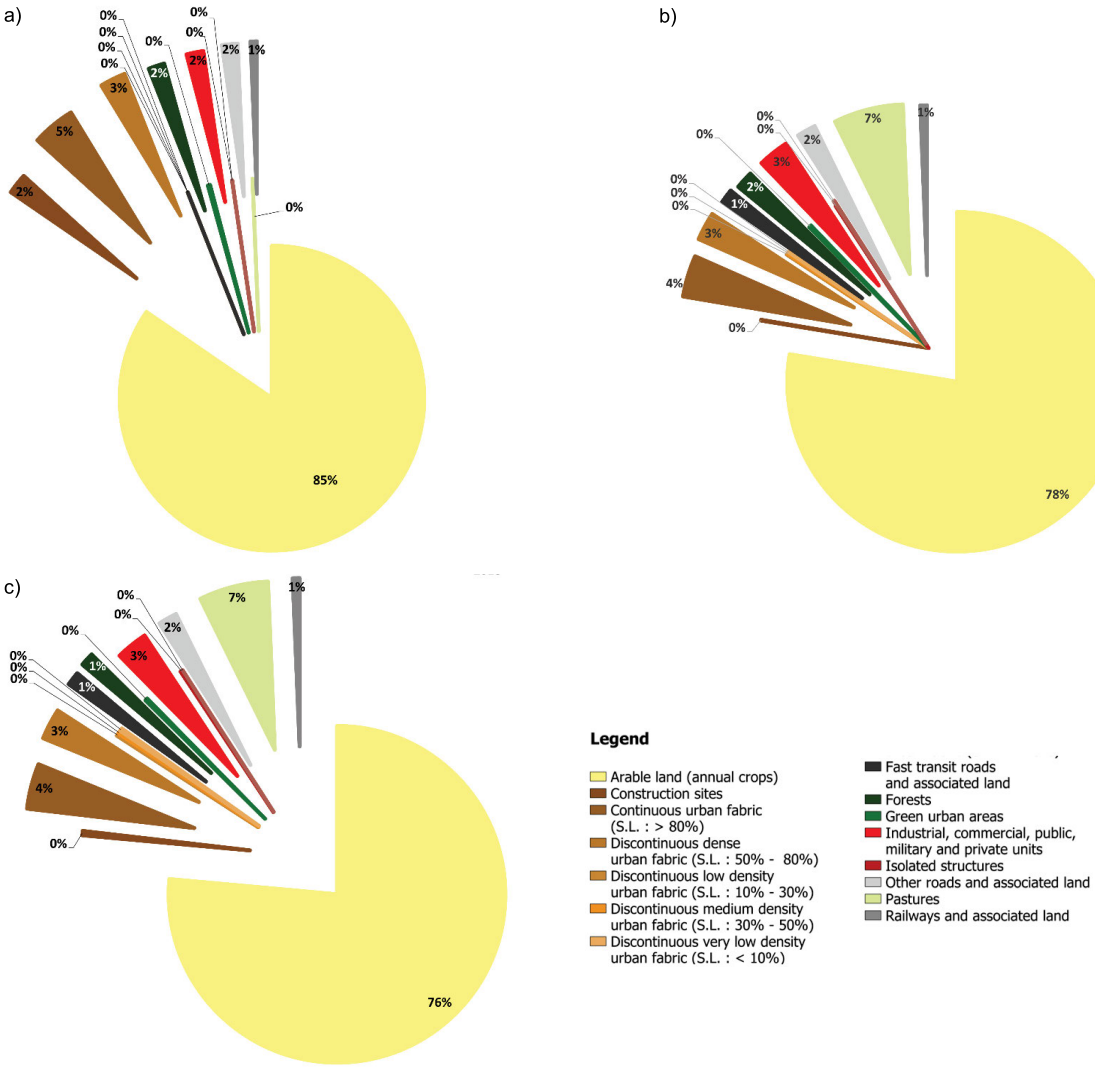

Fig. 3. Shares of land uses in Domasław in: a) 2006, b) 2012 and c) 2018; S.L. = artificially surfaced areas; source: own study

Photo 1. New development in Domasław (phot.: *M. Błasik*)

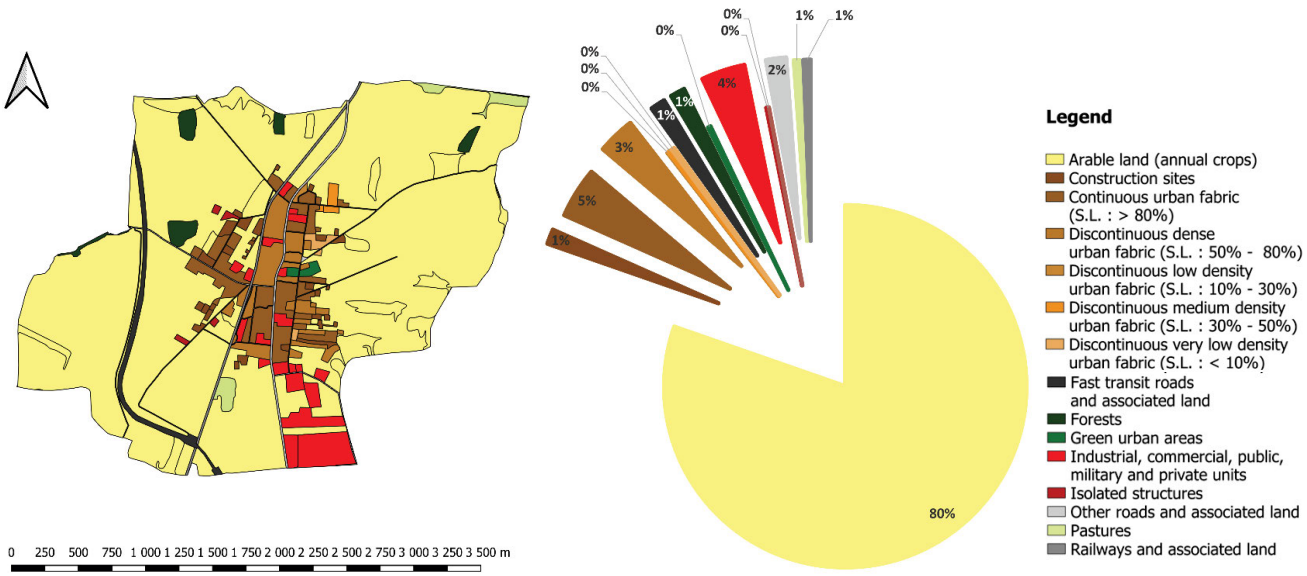

Fig. 4. Land uses and their shares in Domasław in 2021; S.L. = artificially surfaced areas; source: own study

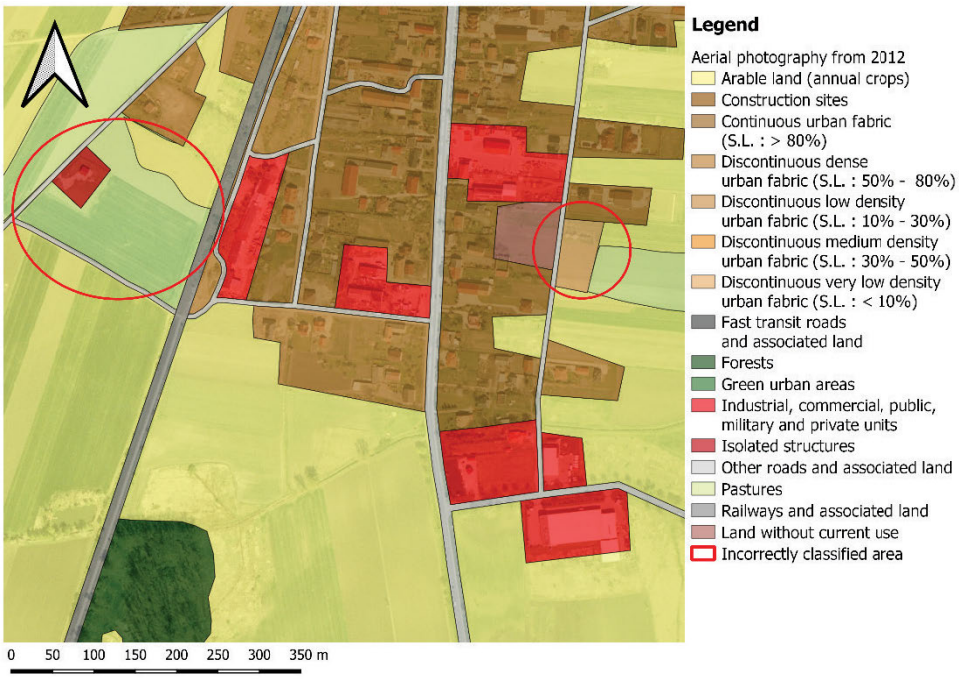

Fig. 5. Verification of land uses between Urban Atlas and ortophoto map; S.L. = artificially surfaced areas; source: own study

in have changed over time, since they were observed in 90s of 20th century. Village Domasław was selected intentionally, as besides new buildings, also new speedway was constructed. That increased the accessibility of the central city from analysed village, which can be defined by potential investors as a factor increasing their interest in locating new urban development. As the aim of the research was to analyse a land use change pattern, it can be defined that three main patterns were observed. Firstly, new built up area are constructed mainly on arable land. Based on the analysed case, not all agricultural land should be similarly considered as possible to convert into built up area, as pastures present an increase and new development was not settled there. Second pattern is connected with an impact of new speedway. New urban forms are more likely to be settled on the side of existing village which is closer to the speedway. It can be explained by higher level of accessibility of that part of area. Finally, urban sprawl in the analysed case does not result only in consuming new area, but also in increasing density in some parts of a village. That can be considered as directing slightly minimizing sprawled urban forms. However still it is important to mark that until now Polish suburbs seems to be perceived by part of population as more comfortable to live in, therefore, migration process is still visible. On the other hand there are new factors raising questions if suburbanization model is suitable for

people who live there [Kajdanek 2020]. Therefore, there is a need for further monitoring of land use dynamics in suburban zones in order to be aware of urban sprawl situation.

Identification on changes in land use structure is an element which should be reported by municipalities as that factor may inform public authorities that there might be future challenges which should be properly controlled. New development in that scale is usually associated with migration of new citizens. Depending on social background and lifestyle, there might be a potential of social conflicts between so-called "old-timers" and "newcomers" [Kajdanek 2014]. However, controlling that element it is possible to enhance their cooperation and social integration. Another aspect that should be taken into account is environmental situation of a village. Increasing amount of sealed surfaces influence water runoff. Newly located fences fragment landscape and block mobility of some species of fauna. New citizens increase water demand. Built-up areas reduce place for food production. All those and many other factors impact environmental carrying capacity which helps to answer if the community can handle more development or should it be limited to balance demand and supply of ecosystem services [Świąder 2018]. Finally new development in suburban zone is not only a cost for investors. That requires new infrastructure, like water, wastewater or electricity connection as well as roads, bus stops, or even kindergartens and schools. All these costs have to be covered, however, studies show that costs of new urbanization commonly has to be covered by "old-timers" [Hełdak, Płuciennik 2017]. Therefore, instead of economic boost for future development, "newcomers" can influence additional costs and reduce amount of available funds. All these elements proves that a land use change is an initial metric which enables to monitor urbanization processes, however, results on socio-environmental systems can be more severe, therefore, sustainable urban policy should not only limit to defining rules of development but also controlling its implementation [Błasik *et al.* 2022].

Monitoring of land use dynamics requires reliable data, therefore it is important to verify if data used for analysis presents analysed processes well, as different maps are being used for detecting changes in land use [Bieda 2013]. Although total changes in shares of land uses between the Urban Atlas (2018) and ortophoto map (2021) are quite significant it is important to see which categories present these differences. Main land use change flow is suggested between arable land and pastures. There are many studies for which such inadequacy between rural types of land uses would exclude Urban Atlas data as suitable data source. However, aims of some studies focus on more generalized topic like well-known for decades and still conducted studies on vegetation, impervious surface and soil (V-I-S) (Ridd 1995; Shih *et al.* 2020) or even limit to one category like identification of impervious surfaces [Liu *et al.* 2021; Sun *et al.* 2022). The goal of our study was to characterize urban sprawl patterns, therefore identification of differences of impervious surfaces was proper to define urbanization process. Considering that there was no difference between total share of construction sites and discontinuous urban fabric between Urban Atlas data and ortophoto map, it is possible to conclude that Urban Atlas data is suitable to detect general urbanization processes.

Successful implementation of land use change monitoring was defined by researchers as a task of local government administration in Poland [Noszczyk 2018]. Land use change evaluation presented in this research shows how this task could be realized in practice. Depending on a situation and goals of each municipality different factors might be alarming. While monitoring urban sprawl local authorities should be especially aware of increasing shares of construction sites and new urban fabric. It would be worth to compare it to amount of area predesigned for urban forms in order to know how municipality is getting close to its carrying capacity. Implementing such monitoring it is also important that the use of external data sources does not have to constitute an additional budget burden, as there is a possibility to use open source data which are more and more common due to Inspire Directive [Dawidowicz *et al.* 2020]. Proper defining of land use changes and their dynamics can be helpful also not only in monitoring ongoing changes but also to predict future expansion of urban development on open areas, which is another important field of further studies [Kazak *et al.* 2015].

REFERENCES

Bazan-Krzywoszańska A., Mrówczyńska M., Skiba M., Sztubecka M. 2017. Sustainable urban development on the example of the housing development of Zielona Góra (Poland), as a response to the climate policy of the European Union. In: 10th International Conference on Environmental Engineering, ICEE. Lithuania, 27–28.04.2017. Article ID enviro.2017.119. DOI 10.3846/enviro.2017.119.

Bazan-Krzywoszanska A., Mrówczynska M., Tront S. 2019. GIS technology, 3D models and mathematical models as a tool for assessing development capabilities of flood risk land to make arrangements of municipal planning documents. Journal of Ecological Engineering. Vol. 20(1) p. 25–33. DOI 10.12911/22998993/93866.

Bieda A. 2013. Using historical maps in researches over changeability of river network. In: International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM. T. 2 p. 517–524. DOI 10.5593/SGEM2013/BB2.V2/S09.067.

Błasik M., Wang T., Kazak J.K. 2022. Effectiveness of master plans: Case studies of biologically active areas in suburban zones. Geomatics and Environmental Engineering. Vol. 16 p. 27–40. DOI 10.7494/geom.2022.16.3.27.

EEA undated. Copernicus Land Monitoring Service – Urban Atlas [online]. Copenhagen. European Environment Agency. [Access data 10.08.2018]. Available at: https://www.eea.europa.eu/data-and-maps/data/copernicus-land-monitoring-service-urban-atlas

Dawidowicz A., Kulawiak M., Zysk E., Kocur-Bera K. 2020. System architecture of an INSPIRE-compliant green cadastre system for the EU Member State of Poland. Remote Sensing Applications: Society and Environment. Vol. 20, 100362. DOI 10.1016/j.rsase.2020.100362.

Foryś I., Kazak J. 2019. "Absorption" or "Carrying Capacity" of areas – assessment methods on the example of detached housing. Real Estate Management and Valuation. Vol. 27(2) p. 5–19. DOI 10.2478/remav-2019-0011.

Heldak M. 2017. Changes in transaction prices of real estate and agricultural land in Poland in years 2004–2015. 17th International Multidisciplinary Scientific GeoConference SGM. Vol. 17 (53) p. 95–102. DOI 10.5593/sgem2017/53/S21.010.

Hełdak M., Płuciennik M. 2017. Costs of urbanisation in Poland, based on the example of Wrocław. IOP Conference Series: Materials Science and Engineering. Vol. 245, 072003. DOI 10.1088/1757-899X/245/7/072003.

Jędruch M., Furmankiewicz M., Kaczmarek I. 2020. Spatial analysis of asymmetry in the development of tourism infrastructure in the borderlands: The case of the Bystrzyckie and Orlickie Mountains. ISPRS International Journal of Geo-Information. Vol. 9, 470. DOI 10.3390/ijgi9080470.

Kajdanek K. 2014. Newcomers vs. old-timers? Community, cooperation and conflict in the post-socialist suburbs of Wrocław, Poland. In: Mobilities and neighbourhood belonging in cities and suburbs. London. Palgrave Macmillan UK p. 182–199. DOI 10.1057/9781137003638_10.

Kajdanek K. 2020. "Have we done well?" Decision to return from suburbia to Polish cities in the context of the Covid-19 pandemic. City and Society. Vol. 32(3) p. 1–17. DOI 10.1111/ciso.12354.

Karabin-Zych M. 2021. The issue of updating the real estate cadastre in the field of land use in connection with the construction of a building. Geomatics and Environmental Engineering. Vol. 15 (2) p. 33–58. DOI 10.7494/GEOM.2021.15.2.33.

Kazak J., Wang T., Szewrański S. 2015. Analysis of land use transformation potential in spatial management. Real Estate Management and Valuation. Vol. 23(1) p. 5–14. DOI 10.1515/remav-2015-0001.

Kisiała W., Rącka I. 2021. Spatial and statistical analysis of urban poverty for sustainable city development. Sustainability. Vol. 13, 858. DOI 10.3390/su13020858

Kumar S., Singh R. 2021. Geospatial applications in Land Use/Land Cover Change detection for sustainable regional development: The case of Central Haryana, India. Geomatics and Environmental Engineering. Vol. 15(3) p. 81–93. DOI 10.7494/geom.2021.15.3.81.

Le G.T., Nguyen T.D., Tran V.Q. 2016. Research and application of remote sensing and GIS technologies in determining and forecasting land use changes by Markov chain in y Yen District-Nam Dinh Province. Real Estate Management and Valuation. Vol. 24(3) p. 27–39. DOI 10.1515/remav-2016-0019.

Liu K., Li X., Wang S. 2021. Characterizing the spatiotemporal response of runoff to impervious surface dynamics across three highly urbanized cities in southern China from 2000 to 2017. International Journal of Applied Earth Observation and Geoinformation. Vol. 100, 102331. DOI 10.1016/j.jag.2021.102331.

Maleszka H., Kazak J., Szewrański S. 2016. Małe miasto a obszary wiejskie w strefie suburbialnej – studium przypadku gminy Oborniki Śląskie [Small town and rural areas in suburban area – case study of Oborniki Śląskie municipality]. Studia Ekonomiczne. Zeszyty Naukowe Uniwersytetu Ekonomicznego w Katowicach. Vol. 279 p. 25–36.

Matuk O. 2021. A comparison of land use classifications in urbanized areas in selected European countries. Geomatics and Environmental Engineering. Vol. 15(2) p. 59–66. DOI 10.7494/GEOM.2021.15.2.59.

Noszczyk T. 2018. Land use change monitoring as a task of local government administration in Poland. Journal of Ecological Engineering. Vol. 19 p. 170–176. DOI 10.12911/22998993/79409

Noszczyk T. 2019. A review of approaches to land use changes modeling. Human and Ecological Risk Assessment. Vol. 19(1) p. 170–176. DOI 10.1080/10807039.2018.1468994.

Noszczyk T., Rutkowska A., Hernik J. 2017. Determining changes in land use structure in Małopolska using statistical methods. Polish Journal of Environmental Studies. Vol. 26(1) p. 211–220. DOI 10.15244/pjoes/64913.

Noszczyk T., Rutkowska A., Hernik J. 2020. Exploring the land use changes in Eastern Poland: statistics-based modeling. Human and Ecological Risk Assessment. Vol. 26(1) p. 255–282. DOI 10.1080/10807039.2018.1506254.

Ridd M.K. 1995. Exploring a V-I-S (vegetation-impervious surface-soil) model for urban ecosystem analysis through remote sensing: Comparative anatomy for citiest. International Journal of Remote Sensing. Vol. 16(12) p. 2165–2185. DOI 10.1080/01431169508954549

Shih H.C., Stow D.A., Tsai Y.M., Roberts D.A. 2020. Estimating the starting time and identifying the type of urbanization based on dense time series of landsat-derived Vegetation-Impervious-Soil (V-I-S) maps – A case study of North Taiwan from 1990 to 2015. International Journal of Applied Earth Observation and Geoinformation. Vol. 85, 101987. DOI 10.1016/j.jag.2019.101987

Sieczkowska D., Ćmielewski B., Wolski K., Dąbek P.B., Bastante J.M., Wilczyńska I. 2022. Inca water channel flow analysis based on 3D models from terrestrial and UAV laser scanning at the Chachabamba archaeological site (Machu Picchu National Archaeological Park, Peru). Journal of Archaeological Science. Vol. 137, 105515. DOI 10.1016/j.jas.2021.105515.

Solecka I., Sylla M., Świąder M. 2017. Urban sprawl impact on farmland conversion in suburban area of Wroclaw, Poland. In: IOP Conference Series: Materials Science and Engineering. Vol. 245, 072002. DOI 10.1088/1757-899X/245/7/072002.

Sun Z., Du W., Jiang H., Weng Q., Guo H., Han Y., Xing Q., Ma Y. 2022. Global 10-m impervious surface area mapping: A big earth data based extraction and updating approach. International Journal of Applied Earth Observation and Geoinformation. Vol. 109, 102800. DOI 10.1016/j.jag.2022.102800.

Świąder M. 2018. The implementation of the concept of environmental carrying capacity into spatial management of cities: A review. Management of Environmental Quality. Vol. 29(6) p. 1059–1074. DOI 10.1108/MEQ-03-2018-0049.

Tanaś J. 2014. The origin of property buyers in Poznań and its suburbs. Real Estate Management and Valuation. Vol. 22(2) p. 5–12. DOI 10.2478/remav-2014-0012.

Tunc E., Tsegai A.T., Çelik S. 2021. Analysis of spatial-temporal changes of agricultural land use during the last three decades in the Araban district of Turkey using remote sensing. Geomatics Environment Engineering. Vol. 15(1) p. 111–123. DOI 10.7494/geom.2021.15.1.111.

Wang T., Han Q., De Vries B. 2017. Sustainable industrial site redevelopment planning support: A case-based reasoning approach. International Journal of E-Planning Research. Vol. 6(2) p. 39–53. DOI 10.4018/IJEPR.2017040103.

Wolny A. 2016. Accessibility of real estate by transportation as a determinant of the development of suburban real estate markets – Case study. Real Estate Management And Valuation. Vol. 24(1) p. 5–18. DOI 10.1515/remav-2016-0001.

Wolny A., Źróbek-Różańska A., Źróbek R., Piotrowski M., Frey J. 2014. Development of areas and public purpose investments in suburban territories. Real Estate Management and Valuation. Vol. 22(2) p. 86–97. DOI 10.2478/remav-2014-0020.

Źróbek-Różańska A., Źróbek S., Źróbek R. 2014. Urban sprawl and the problems of changes of land use on the fringe areas of towns. In: 9th International Conference on Environmental Engineering. Vilnius, Lithuania, 22–23 May 2014. Art. No. enviro.2014.140 p. 1–6. DOI 10.3846/enviro.2014.140

Zysk E., Źrobek-Różańska A. 2016. The impact of a commune's planning tactics on the landscape of suburban areas. Real Estate Management and Valuation. Vol. 24(4) p. 59–69. DOI 10.1515/remav-2016-0030.