MISCELLANEA GEOGRAPHICA – REGIONAL STUDIES ON DEVELOPMENT
Vol. 20 • No. 2 • 2016 • pp. 39-45 • ISSN: 2084-6118 • DOI: 10.1515/mgrsd-2016-0005

Agricultural land cover changes in metropolitan areas of Poland for the period 1990–2012

Abstract
Agricultural land covers more than half the area of metropolitan areas in Poland, and is therefore particularly prone to the influences of the processes associated with their development. The aim of the study was to analyse changes in agricultural land cover within the metropolitan areas of Poland for the years 1990–2012; and to capture their dynamics, types and directions. The percentage share of the total study area, for each of the forms of agricultural land cover and their changes were traced, with the spatial distribution of the changes also being determined. The results of the study show that in metropolitan areas, agricultural land cover is undergoing transformations that do not result in the loss of agricultural lands, or that involve a decrease in surface area due to their change into anthropogenic forms of land cover. The greatest transitions occurred between 2000 and 2006 and were observed in the outer zones of metropolitan areas.

Keywords
Land cover changes • agricultural land • metropolitan areas • Poland • GIS

Marta Nalej

Departament of Geoinformation,
Institute of Urban Geography and Tourism Studies,
Faculty of Geographical Sciences,
University of Lodz, Poland
e-mail: marta.nalej@geo.uni.lodz.pl

Received: 13 August 2015
Accepted:12 January 1016

Introduction

In studies concerning land cover[1] changes, the influence of cities and the urbanisation processes related to them are listed as some of the main causes for transformations occurring within their direct vicinity. (Lambin et al. 2001; Petrisor 2012; Bagan & Yamagata 2014). This is especially true in the case of cities that, as a result of development, have gained the status of a metropolis, and their influence has led to the creation of strong relationships between the surrounding areas and the core city. In these areas, called metropolitan areas, the influence of the core-metropolis causes significant transformations in the natural environment and spatial arrangement of the surrounding area (Parysek 2003; Jałowiecki 2005; Markowski & Marszał 2006; Gorzelak et al. 2009; Czyż 2009; Kozłowski & Marszał 2010; Liszewski 2010).

In the works devoted to the transformation of land cover in metropolitan areas, the researchers' attention has focused primarily on trying to grasp the size, dynamics and trends of these transformations through a variety of research tools (López et al. 2001; Weber & Puissant 2003; Yang & Lo 2003; Bagan & Yamagata 2014).

The results of analyses indicate the dominant role of the processes of expansion of built-up areas. These result in the loss of territory for other forms of land cover, which are transformed into urban areas. Agricultural and forested areas, comprising a large portion of the metropolitan area, are at the highest risk. It is also characteristic that the changes occur mainly within the zone surrounding the metropolises (Yuan et al. 2005; Zhou et al. 2008; Yılmaz 2010; Yin et al. 2011).

[1]Land cover is a multi-faceted concept that describes the physical condition of a fragment of the earth's surface in the context of the natural and anthropogenic elements occupying it. It does not refer to the socio-economic aspects, namely the functions performed by the area (Ciołkosz & Poławski 2005; Niedzielko & Lewiński 2012).

This article aims to analyse the agricultural land cover changes in metropolitan areas of Poland in the years 1990–2012. The study was based on data from four successive versions of the Corine Land Cover database and used Geographical Information System tools. The research process included determining the percentage of agricultural land and changes to it within the study area; the main directions and spatial distribution of changes in subsequent time periods both for metropolitan areas as a whole, and with regards to the division into core and outer areas.

The study area

The study covered eight metropolitan areas: Warsaw, Upper Silesia, Tri-City, Poznań, Wrocław, Cracow, Łódź and Szczecin, whose range was determined based on the National Spatial Development Concept 2030 (Ministry of Regional Development 2012; Markowski & Marszał 2006). They occupy a total of 19,361.75 km^2, representing 6.2% of the territory of Poland. The study considers the division of their structure into core and the outer areas (Figure 1).

The distribution of metropolitan areas within the country is uneven. The western and central parts of Poland are decidedly privileged in this regard. The east lacks significant city centres that qualify as developed metropolises. The metropolitan areas that were analysed are also not homogenous. Warsaw has a special place among them due to the leading role of the city as the capital of Poland and is identified as a continental-level, or even a global metropolis (Parysek 2003; Ilnicki 2003). It has the largest coverage of all monocentric metropolitan areas in Poland, with a total surface of 3,802.2 km^2, which equals 19.6% of the whole area under study. Other areas are national-level metropolises. Among them,

Vol. 20 • No. 2 • 2016 • pp. 39-45 • ISSN: 2084-6118 • DOI: 10.1515/mgrsd-2016-0005

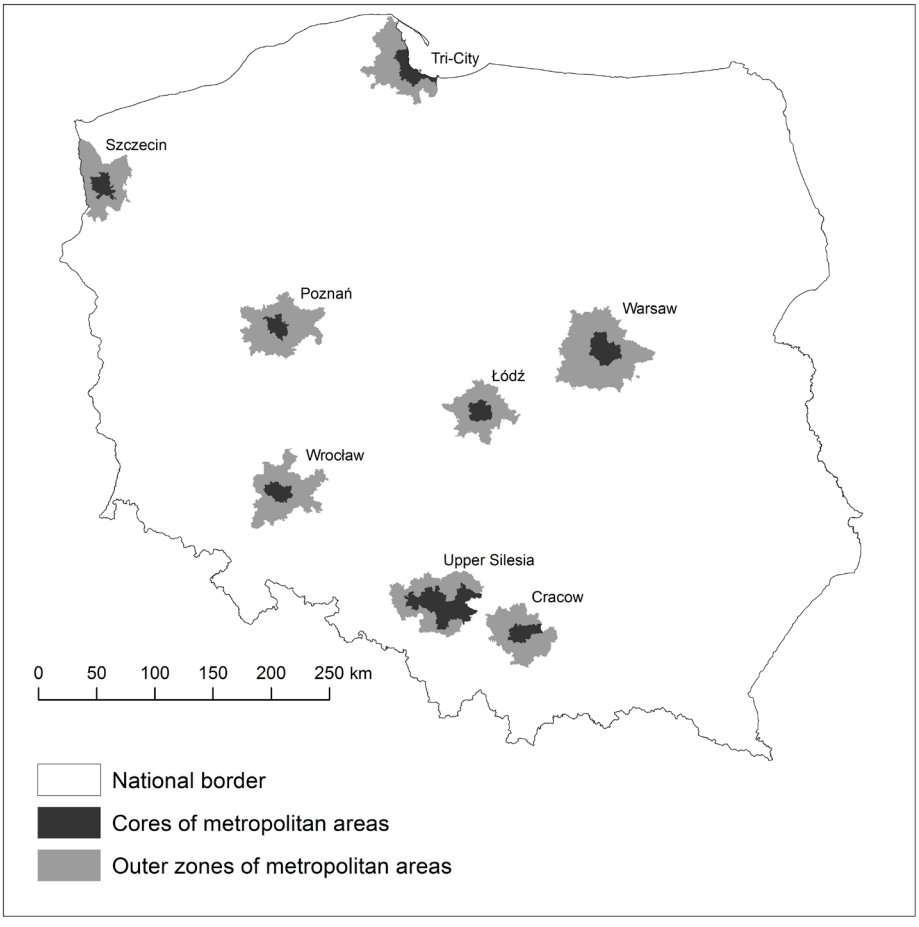

Figure 1. Metropolitan areas of Poland
Source: own study based on the state register data sets of boundaries and areas of units of territorial division for the country (Geodesic and Cartographic Documentation Center of Poland 2015)

Upper Silesia's polycentric area is especially interesting as it is second, after Warsaw, in surface area (2,934.4 km^2 or 15.1% of the overall study area). It has the largest core, being composed of 14 cities, which fills 41% of its surface area. Tri-City is also a polycentric metropolitan area with a core composed of 3 cities, occupying 20% of its territory. Other areas are mono-centric and account for 10–13% of the study area (Central Statistical Office of Poland 2015).

Corine Land Cover data

A land cover study requires significant amounts of data in the form of maps, aerial and satellite images, and vector files from various time periods. One of the sources of vector data concerning land cover is used for this study: CORINE (CO-oRdiantion on INformation on the Environment) Land Cover database (CLC) maintained by the European Environmental Agency, Chief Inspectorate of Environmental Protection in Poland and the Institute of Geodesy and Cartography. It is a vector database with polygon topology that stores European data concerning land cover. It was created in 1990, then updated in 2000, 2006 and 2012. The minimum discreet area is 25 ha, with a minimum width of 100 m, which corresponds to a map precision of 1:100,000. The data contained in the database are valuable primarily owing to the coherent criteria for their creation and the structure maintained for all four versions. The CLC legend is divided in to three levels of precision. The first level, the most general, comprises five main forms of land cover, described by a single-digit code from 1 to 5: artificial surfaces, agricultural areas, forests and semi-natural areas, wetlands, and water bodies. The second level includes 15 subgroups of land cover, labelled with a two-digit code, from 1.1 to 5.2. Finally, the third level, the most detailed, includes 44 basic land cover types, 31 of which can be found in Poland. They are marked with a three-digit code, from 1.1.1 to 5.2.3 , in which the first two digits indicate, respectively, affiliation to the main form and subgroup of land cover. Data reliability for Poland is estimated to be 85% to 92.7% (Chief Inspectorate of Environmental Protection in Poland 1995; European Environment Agency 1995; Bossard et al. 2000; Bielecka & Ciołkosz 2004; Lewiński 2007; Copernicus Land Monitoring Services 2014; Institute of Geodesy and Cartography 2015).

Research methods

Changes in land cover were analysed from the data for 1990–2012, divided into three periods:1990–2000, 2000–2006 and 2006–2012, distinguishing between the cores and outer zones of metropolitan areas. Implementation of the research task required the processing of a significant amount of vector data. For this purpose a tool allowing for the automatic processing of thematic layers for each of the four versions of the Corine Land Cover database was created. Using the ModelBuilder (ArcGIS 10.2) application, a workflow (model) was built based on the basic tools from the ArcToolbox application, which allowed for automatic:

Vol. 20 • No. 2 • 2016 • pp. 39-45 • ISSN: 2084-6118 • DOI: 10.1515/mgrsd-2016-0005

1. adjusting data from vector files to the limits of the study area, including its division into cores and the outer zones of metropolitan areas,
2. separation of agricultural land cover types,
3. comparison of data from subsequent years and highlighting areas of changes,
4. creation of a summary concerning the surface area of agricultural land cover forms and their changes.

On the basis of the results, the next stages of the analysis was carried out. Firstly, the percentage of the basic types of agricultural land cover: complex cultivation patterns, fruit trees and berry plantations, land principally occupied by agriculture with significant areas of natural vegetation, non-irrigated arable land, and pastures; were determined within the total study area, and their changes were traced. Next, trends in the changes of agricultural areas were studied by determining the percentage of surfaces of the main forms and basic types of land cover within the overall area of change, and the basic land cover types into which agricultural lands transform. A detailed analysis of transitions at the level of the basic land cover types was carried out for two groups: inter-group changes; namely, the change of agricultural areas into areas belonging, according to Corine Land Cover classification, to the other main form of land cover; as well as intra-group transformations, i.e. the transformation into other basic land cover types within the agricultural areas. The last step involved the determination of the spatial distribution of changes in agricultural lands. For this purpose, an analysis was conducted involving the demarcation of concentric buffer zones, each one kilometre wide, around the geometric centres (centroids) of the cores of metropolitan areas, and the determination of the percentage of changed areas within each zone. For the metropolitan areas under study, the range of cores includes buffer zones from 0 to 9 km. The remaining 35 buffer zones from 9 to 44 km covered the outer zones of metropolitan areas. This spatial approach was chosen due to the important role of core – metropolises in the formation of surrounding areas (Markowski & Marszal 2007).

Table 1. The percentage share of agricultural land cover in the area of Polish metropolitan areas, divided into cores and the outer zones in the years 1990-2012

Agricultural areas [%] Year	Metropolitan Areas	Outer Zones	Cores
1990	61,8	68,1	34,2
2000	61,4	67,9	33,3
2006	56,2	62,2	30,1
2012	51,1	56,9	25,9

Source: own study based on CORINEL and Cover database

The transitions of agricultural land in metropolitan areas

Agricultural areas cover more than half of the metropolitan areas. There is a clear difference between the outer zones, and the cores where the proportion of the surface area is two times smaller. In general, since the 1990s, there has been a continuous decrease in the proportion of these surface areas within the study area, as well as in all of the zones (Table 1).

The decline in their surface area was not the same for all the analysed periods. In the years 1990–2000 it did not exceed 1%. For subsequent periods the decrease in their proportion within the overall study area was higher than 5%, with the maximum value being reached in 2000–2006, in the outer zones. The agricultural area decreased by 10.7% for the whole period of the study, with the highest decrease being 11.2% in the outer zones. The changes to basic agricultural land cover types did not involve all of them equally (Table 2).

In the first analysed period of 1990–2000, a minor decrease in the proportion of all basic agricultural land cover types within the overall metropolitan areas was observed. In subsequent periods, non-irrigated arable lands and complex cultivation patterns were undergoing the most intense changes involving a decrease in their surface area. The largest fall in the proportion of arable land was for 2000–2006, by 3%, mainly in the outer zones. The percentage loss of surface area occupied by complex cultivation patterns for 2006–2012 reached a maximum value of 2.6%, equally in outer zones and the cores. Changes to the surface area of the other basic types of agricultural land cover usually did not exceed 1%.

An analysis of the trends in the changes of agricultural land cover for metropolitan areas has shown that almost half of them do not involve a transition between main land cover forms, but are transformations within agricultural areas at the level of basic land cover types. It is a permanent trend that can be observed across all the analysed periods, especially in the outer zones. At the same time, the difference between their proportions in the cores and outer zones kept decreasing (Table 3).

Also of significance is the percentage of change of agricultural areas into artificial surfaces, which decreased for the whole of the metropolitan areas, including their cores; while, taken separately, in the outer zones it increased. On the other hand, change of

Table 2. The percentage share of basic agricultural land cover types in the metropolitan areas of Poland, divided into cores and the outer zones in the years 1990-2012

Basic forms of agricultural land cover [%]	**Complex cultivation patterns**			**Fruit trees and berry plantations**			**Land principally occupied by agriculture, with significant areas of natural vegetation**			**Non-irrigated arable land**			**Pastures**		
Zone Year	MA	OZ	C	MA	OZ	C	MA	OZ	C	MA	OZ	C	MA	OZ	C
1990	7,6	7,6	7,3	0,4	0,5	0,1	4,9	5,4	3,0	41,8	47,2	18,3	7,1	7,4	5,5
2000	7,6	7,6	7,2	0,4	0,4	0,1	4,9	5,4	2,9	41,7	47,2	17,6	6,9	7,3	5,6
2006	5,9	6,2	4,8	0,5	0,6	0,1	4,3	4,8	2,3	38,6	43,6	17,1	6,9	7,1	5,8
2012	3,3	3,6	2,0	0,5	0,6	0,0	3,7	4,0	2,4	36,2	41,2	14,3	7,4	7,5	7,1

MA- Metropolitan Areas, OZ- Outer Zones, C- Cores
Source: own study based on CORINEL and Cover database

Vol. 20 • No. 2 • 2016 • pp. 39-45 • ISSN: 2084-6118 • DOI: 10.1515/mgrsd-2016-0005

Table 3. The percentage share of the main land cover forms in changes of agricultural land cover in the metropolitan areas of Poland, divided into cores and the outer zones in the years 1990-2012

Years	1990-2000			2000-2006			2006-2012		
Zone The share of the main land cover forms in the general area of changes [%]	MA	OZ	C	MA	OZ	C	MA	OZ	C
Agricultural areas	49,2	63,4	20,8	49,0	52,6	33,7	49,5	50,4	44,0
Artificial surfaces	41,9	27,3	71,1	38,2	34,1	55,9	36,0	34,2	46,7
Forest and semi natural areas	6,0	5,5	7,0	12,2	12,6	10,2	13,9	14,7	9,1
Water bodies	2,9	3,7	1,2	0,6	0,7	0,3	0,4	0,4	0,3
Wetlands	0,0	0,0	0,0	0,0	0,0	0,0	0,2	0,2	0,0

MA- Metropolitan Areas, OZ- Outer Zones, C- Cores
Source: own study based on CORINEL and Cover database

Table 4. The percentage share of the basic land cover types in transitions of agricultural land cover in the metropolitan areas of Poland in the years 1990-2012

transitions grups	transitions from / in to	Complex cultivation patterns			Fruit trees and berry plantations			Land principally occupied by agriculture…			Non-irrigated arable land			Pastures		
	Study periods	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
intra-group transformations	Complex cultivation patterns	0,0	0,0	0,0	2,7	0,1	0,1	0,2	1,7	1,4	3,2	9,1	7,2	0,6	0,7	0,2
	Fruit trees and berry plantations	0,3	0,7	0,1	0,0	0,0	0,0	0,0	0,1	0,0	0,3	1,5	0,6	0,0	0,2	0,0
	Land principally occupied by agriculture…	0,0	1,6	1,8	0,1	0,2	0,0	0,0	0,0	0,0	0,5	2,7	8,0	0,3	1,0	0,6
	Non-irrigated arable land	0,8	12,7	7,6	5,6	0,4	0,6	0,0	5,3	7,1	0,0	0,0	0,0	21,3	4,2	2,3
	Pastures	0,0	1,3	1,8	0,0	0,0	0,1	0,0	1,8	1,7	13,0	3,9	8,4	0,0	0,0	0,0
inter-group changes	Airports	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,4	0,1	0,1	0,0	0,1	0,0
	Broad-leaved forest	0,0	0,2	0,1	0,0	0,0	0,1	0,0	1,3	1,0	0,5	0,7	0,5	0,0	0,5	0,7
	Coniferous forest	0,0	0,1	0,2	0,0	0,0	0,0	0,1	0,5	0,5	0,6	1,0	0,8	0,3	0,2	0,2
	Construction sites	0,6	0,0	0,1	0,3	0,0	0,0	0,4	0,0	0,0	13,8	0,7	1,1	0,8	0,2	0,2
	Discontinuous urban fabric	4,1	21,9	19,9	0,3	0,1	0,0	1,0	1,2	1,0	7,1	7,2	7,9	1,5	0,8	0,7
	Dump sites	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,1	0,0	0,0
	Green urban areas	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,2	0,1	0,0	0,1	0,1	0,2	0,0	0,1
	Industrial or commercial units	1,3	0,5	0,5	0,0	0,0	0,0	1,5	0,1	0,1	3,9	1,4	1,5	1,8	0,1	0,3
	Inland marshes	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1
	Mineral extraction sites	0,3	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	2,1	0,4	0,4	0,3	0,0	0,0
	Mixed Forest	0,0	0,3	0,3	0,0	0,0	0,0	0,0	1,7	1,2	0,1	1,1	1,0	0,2	0,9	0,2
	Natural grasslands	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,1	0,0
	Road and rail networks and associated land	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,1	0,7	0,0	0,0	0,1
	Sparsely vegetated areas	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0
	Sport and leisure facilities	0,0	0,3	0,2	0,0	0,1	0,0	0,0	0,3	0,2	0,0	0,8	0,3	0,1	0,3	0,2
	Transitional woodland-shrub	0,0	0,1	0,4	0,0	0,0	0,0	0,1	1,5	2,1	0,9	1,3	3,2	3,4	0,4	1,4
	Water bodies	0,0	0,0	0,0	0,0	0,0	0,0	0,6	0,1	0,1	0,6	0,2	0,1	1,4	0,3	0,1
	Water courses	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,3	0,1	0,0

Study periods: 1- years 1990-2000, 2- years 2000-2006, 3- years 2006-2012
Source: own study based on CORINEL and Cover database

Vol. 20 • No. 2 • 2016 • pp. 39-45 • ISSN: 2084-6118 • DOI: 10.1515/mgrsd-2016-0005

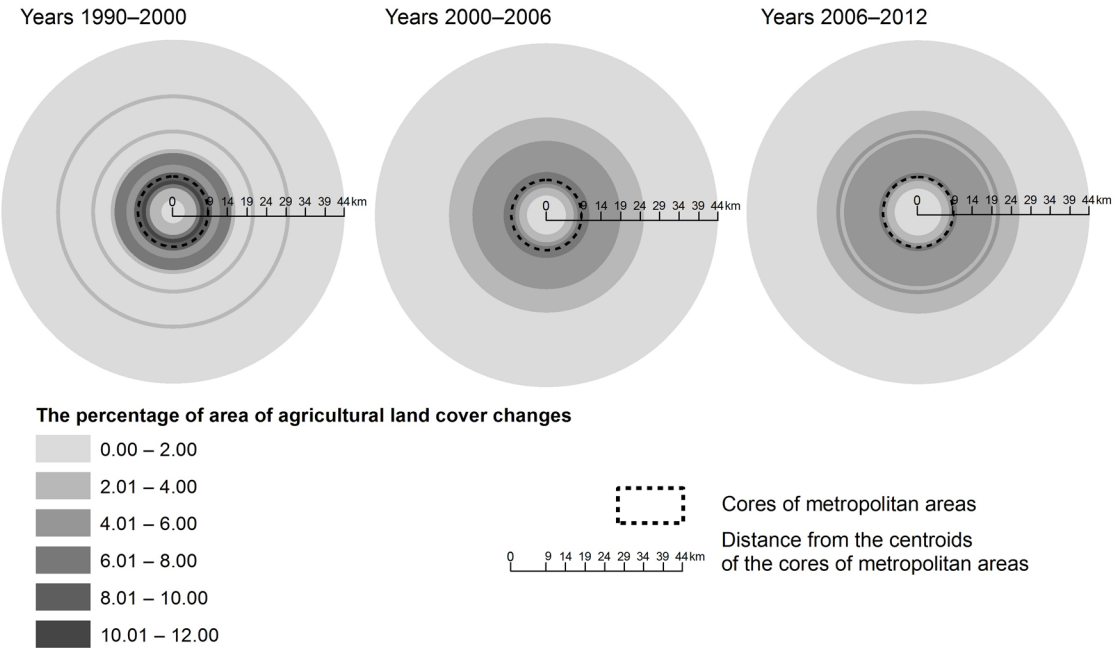

Figure 2. Scheme of spatial distribution for the percentage of agricultural land cover changes in the years 1990–2012, divided into core and outer zone for metropolitan areas of Poland
(Source: own study)

agricultural areas into forests and semi-natural areas kept increasing their share in overall surface area of change, except for the cores of the metropolitan areas for 2006–2012. Changes involving the transition of agricultural areas into water bodies were prominent only for 1990–2000, and mainly in the outer zones. In contrast, changes into wetlands were only observed for 2006–2012 in the outer zones of metropolitan areas.

The results of the land cover changes in the inter- and intra-groups show that the inter-group changes are dominated by the change from agricultural areas into discontinuous urban fabric. These mostly involve the areas occupied by complex cultivation patterns, but also by non-irrigated arable land. In each period analysed they were the most frequent changes, with maximum values being reached in 2000–2006 (Table 4).

The intra-group transformations of agricultural areas were transformations into non-irrigated arable lands. They concerned mainly pasture for the period 1990–2000 and complex cultivation patterns for 2000–2012. The transformations of non-irrigated arable lands to pasture reached their highest values in the first and third periods, and into complex cultivation patterns in 2000–2006, while transformations into land principally occupied by agriculture with significant areas of natural vegetation steadily increased their share in the overall area of transitions in subsequent years, reaching maximum values in the last period.

A dominant type of transition of agricultural land can be determined for each of the periods under study. For 1990–2000, these were transformations of pasture into non-irrigated arable lands, which comprised 21.3% of the whole area of change. Intra-group transformations were clearly dominant. In the years 2000–2006 the largest share in the area of transitions had changes of territories occupied by complex cultivation patterns in areas of discontinuous urban fabric (21.9%). The result is that in this period inter-group changes start to prevail and a visible growth of discontinuous urban fabric appears as the dominant land cover type into which agricultural areas are changed. A similar situation occurs in the last of the analysed periods, 2006–2012, in which 19.9% were changes of complex cultivation patterns into discontinuous urban fabric.

The spatial distribution of these transitions is an equally important issue that allows for the characterisation of the changes of agricultural areas. The analysis showed that for 1990–2000, changes in land cover in agricultural areas were focussed in the cores and their immediate environments (Figure 2).

Almost 68% of the changes were located in the cores and in the zones up to 5 km from the border of their ranges. The largest percentage of areas that have been changed (10.5%) was observed inside the cores, up to one kilometre from their border. In analyses of subsequent periods, there is a more and more visible dispersion of changes and their expansion into the outer zones. The differences in the proportion of changed areas in individual buffer zones decreased, while their share grows the further they are from the cores of metropolitan areas. There is also a visible decrease in the percentage of changes in the cores and their direct vicinity (up to 5 km from the cores), which in the periods 2000–2006 and 2006–2012 were 47% and 41%, respectively. (Table 5).

At the same time, the largest share of the area of change was observed within one kilometre, but outside the borders of the core. In each consecutive period, it was 1. 5% lower than the preceding one.

Conclusions

The results of the analysis showed that agricultural areas, which cover more than half of the metropolitan areas, are undergoing severe changes. More intense processes were observed in the outer zones of the metropolitan areas. The transitions can be divided into two types. The first mainly involves a decrease in the surface of agricultural areas due to changes, mainly into anthropogenic forms of land cover. The second includes transformations that do not result in the loss of agricultural areas but their conversion into a different basic type of agricultural land cover. In the periods analysed, the

Vol. 20 • No. 2 • 2016 • pp. 39-45 • ISSN: 2084-6118 • DOI: 10.1515/mgrsd-2016-0005

Table 5. The percentage of area of agricultural land cover changes in metropolitan areas of Poland, divided into cores and outer zones in the years 1990-2012

The percentage of changes area / Zone		Years		
		1990-2000	2000-2006	2006-2012
Cores		33,3	18,8	14,2
Outer Zones *	5 km	34,3	28,3	27,2
	10 km	14,9	21,8	22,5
	15 km	7,2	16,0	18,1
	20 km	4,1	8,4	9,5
	25 km	5,7	3,7	5,1
	30 km	0,4	2,5	2,9
	35 km	0,0	0,4	0,5

** divided into sub-zones at a distance from the borders of cores*
Source: own study based on CORINEL and Cover database

biggest changes occurred between 2000 and 2006, when 5.2% of the surface was lost and 10.1% of agricultural areas were transformed.

Metropolitan areas, including the metropolises, are highly internally integrated, big-city settlement systems. Their development is connected with the phenomenon of metropolisation of space that; in addition to transformation on a global level that cause concentrations of economic potential, innovation and economic management functions; also impacts relations between the centre – namely the metropolis – and the surrounding region. This leads to the transfer, beyond the metropolis, of urban lifestyle, changes to the environment, urban and suburban areas, which is especially visible in deurbanisation and suburbanisation, leading to the chaotic spread of urban areas known as *urban sprawl* (Markowski & Marszał 2006; Markowski & Marszał 2007; Kozłowski & Marszał 2010*)*.

Changes in agricultural land cover within metropolitan areas takes place under the influence of metropolisation processes and, at the same time, are their reflection in space. The transformations occurring within main agricultural land cover leads to a decrease of the area occupied by non-irrigated arable lands and their transformation into pastures or complex cultivation patterns. This reflects the changing relationship between the city – the core – and the surrounding region. As local agricultural production becomes less and less important for the supply of the centre, the transport network and the interconnections, co-operations and interrelations between metropolitan cities develop. This allows the fulfilment of the needs of a metropolis without engaging the surrounding areas, thus causing the demand for arable land to fall.

The loss of agricultural land mainly happens due to the expansion of anthropogenic areas into outer zones. The reduction of space occupied by them is usually caused by their change into discontinuous urban fabric. It is the dominant form of change, which accounted for 20% in 2000–2012. These processes are an expression of suburbanisation and the transfer of urban lifestyle beyond the centre that occurs in metropolitan areas and is related to the processes of metropolisation (Markowski & Marszal 2007; Klemens & Heffner 2013).

The impact of progressive processes of metropolisation is also apparent in the spatial distribution of changes to agricultural land cover. In each subsequent period, the changes were less concentrated and expanded into areas more and more remote from the cores of the metropolitan areas, which shows that the influence of the centres on the surrounding areas is growing.

A synthetic approach to the problem of changes to agricultural land cover allowed the capture of dynamics and types of transitions, as well as their relationship with the processes of metropolisation interacting with the space under study.

References

Bagan, H & Yamagata, Y 2014, 'Land-cover change analysis in 50 global cities by using a combination of Landsat data and analysis of grid cells', *Environmental Research Letters*, vol. 9, no. 6, pp. 1–14.

Bielecka, E & Ciołkosz, A 2004, 'Metodyczne i realizacyjne aspekty aktualizacji bazy CORINE Land Cover', *Prace Instytutu Geodezji i Kartografii*, vol. 50, pp. 73–95.

Bossard, M, Feranec, J & Otahel, J 2000, *CORINE land cover technical guide: Addendum 2000*, European Environment Agency Copenhagen.

Geodesic and Cartographic Documentation Center of Poland 2015, *Zbiory danych państwowego rejestru granic i powierzchni jednostek podziałów terytorialnych kraju*. Available from: <http://www.codgik.gov.pl/index.php/darmowe-dane/prg.html>. [15 January 2015].

Central Statistical Office of Poland 2015, *Bank Danych Lokalnych*. Available from: <http://stat. gov. pl/bdl/app/strona. html?p_name=indeks>. [29 January 2015].

Chief Inspectorate of Environmental Protection in Poland 2008, *Krajowa baza danych pokrycia terenu CLC2006*, Available from: <http://clc.gios.gov.pl/index.php?IdCss=0&IdStr=1228813535>. [15 January 2015].

Ciołkosz, A & Poławski, Z 2005, 'Zmiany użytkowania ziemi w Polsce w II połowie XX w. na podstawie analizy danych kartograficznych', *Roczniki Geomatyki [Annals of Geomatics]*, vol. 3, pp. 17–26.

Copernicus Land Monitoring Services 2014, *Corine Land Cover*. Available from: <http://land. copernicus. eu/pan-european/corine-land-cover>. [29 January 2015].

Czyż, T 2009, 'Koncepcje aglomeracji miejskiej i obszaru metropolitalnego w Polsce', *Przegląd Geograficzny,* vol. 81**,** pp. 445–459.

European Environment Agency 1995, *CORINE Land Cover*, Available from: <http://www.eea.europa.eu/publications/COR0-landcover >. [29 January 2015].

Gorzelak, G, Jałowiecki, B & Smętkowski, M 2009, 'Obszary metropolitalne w Polsce: diagnoza i rekomendacje', *Studia Regionalne i Lokalne,* vol. 1 (35), pp. 52–73.

Ilnicki, D 2003, 'Miasta polskie jako potencjalne metropolie o znaczeniu kontynentalnym (próba identyfikacji)' in *Funkcje metropolitalne i ich rola w organizacji przestrzeni, XVI Konwersatorium Wiedzy o Mieście,* ed I Jażdżewska*,* Łódź, pp. 61–72.

Institute of Geodesy and Cartography 2015, *CORINE Land Cover*, Available from: <http://www.igik.edu.pl/pl/corine-projekt>. [21 December 2015].

Jałowiecki, B 2005, 'Polskie miasta w procesie metropolizacji', *Studia Regionalne i Lokalne***,** vol. 1 (19), pp. 5–14.

Klemens, B & Heffner, K 2013, 'Koncepcje zmian i nowe procesy przestrzenne na obszarach wiejskich w Polsce', *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu*, no. 296, pp. 90–101.

Vol. 20 • No. 2 • 2016 • pp. 39-45 • ISSN: 2084-6118 • DOI: 10.1515/mgrsd-2016-0005

Kozłowski, S & Marszał, T 2010, 'Obszary metropolitalne w Polsce kontekst spójności terytorialnej i współpracy między gminnej', *Bibliotek Wiadomośći Ststystycznych. Procesy metropolizacyjne w teorii naukowej i praktyce, Warszawa, Główny Urząd Statystyczny*, vol. 63, pp. 124–133.

Lambin, EF, Turner, BL, Geist, HJ, Agbola, SB, Angelsen, A, Bruce, JW, Coomes, OT, Dirzo, R, Fischer, G & Folke, C 2001, 'The causes of land-use and land-cover change: moving beyond the myths', *Global environmental change*, vol. 11, no. 4, pp. 261–269.

Lewiński, S 2007, *Obiektowa klasyfikacja zdjęć satelitarnych jako metoda pozyskiwania informacji o pokryciu i użytkowaniu ziemi*, Instytut Geodezji i Kartografii, Warszawa.

Liszewski, S 2010, 'Metropolia jako przedmiot badań naukowych i obszar dynamicznych przemian przestrzennych oraz społeczno-gospodarczych', *Biblioteka Wiadomośći Statystycznych. Procesy metropolizacyjne w teorii naukowej i praktyce,* vol. 63**,** pp. 27–41.

López, E, Bocco, G, Mendoza, M & Duhau, E 2001, 'Predicting land-cover and land-use change in the urban fringe: a case in Morelia city, Mexico', *Landscape and urban planning*, vol. 55, no. 4, pp. 271–285.

Markowski, T & Marszał, T 2006, *Metropolie, obszary metropolitalne, metropolizacja: problemy i pojęcia podstawowe*, Komitet Przestrzennego Zagospodarowania Kraju PAN.

Markowski, T & Marszal, T 2007, 'Metropolie i procesy metropolizacji w Polsce', *Biuletyn PAN. Komitet Przestrzennego Zagospodarowania Kraju*, no. 230, pp. 8–26.

Ministry of Regional Development 2012, *Koncepcja Przestrzennego Zagospodarowania Kraju 2030*, Ministry of Regional Development, Warszawa.

Niedzielko, J & Lewiński, S 2012, 'Detekcja zmian pokrycia terenu na zdjęciach satelitarnych Landsat–porównanie trzech metod', *Teledetekcja* Środowiska, vol. 47, pp. 87–98.

Parysek, J 2003, 'Metropolie: metropolitalne funkcje i struktury przestrzenne' in *Funkcje metropolitalne i ich rola w organizacji przestrzeni, XVI Konwersatorium Wiedzy o Mieście,* ed I Jażdżewska, Łódź, pp. 19–40.

Petrisor, A-I 2012, ‹Land cover and land use analysis of urban growth in Romania›, *HUMAN GEOGRAPHIES Journal of Studies and Research in Human Geography,* vol. 6, pp. 47–51.

Weber, C & Puissant, A 2003, 'Urbanization pressure and modeling of urban growth: example of the Tunis Metropolitan Area', *Remote sensing of environment*, vol. 86, pp. 341–352.

Yang, X & Lo, C 2003, 'Modelling urban growth and landscape changes in the Atlanta metropolitan area', *International Journal of Geographical Information Science*, vol. 17, no. 5, pp. 463–488.

Yılmaz, R 2010, 'Monitoring land use/land cover changes using CORINE land cover data: a case study of Silivri coastal zone in Metropolitan Istanbul', *Environmental monitoring and assessment*, vol. 165, no. 1–4, pp. 603–615.

Yin, J, Yin, Z, Zhong, H, Xu, S, Hu, X, Wang, J & Wu, J 2011, 'Monitoring urban expansion and land use/land cover changes of Shanghai metropolitan area during the transitional economy (1979–2009) in China', *Environmental monitoring and assessment*, vol. 177, no. 1–4, pp. 609–621.

Yuan, F, Sawaya, KE, Loeffelholz, BC & Bauer, ME 2005, 'Land cover classification and change analysis of the Twin Cities (Minnesota) Metropolitan Area by multitemporal Landsat remote sensing', *Remote sensing of Environment*, vol. 98, no. 2, pp. 317–328.

Zhou, W, Troy, A & Grove, M 2008, 'Object-based land cover classification and change analysis in the Baltimore metropolitan area using multitemporal high resolution remote sensing data', *Sensors*, vol. 8, no. 3, pp. 1613–1636.