

Urban Sprawl Impact on Farmland Conversion in Suburban Area of Wrocław, Poland

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Abstract. The developments in suburban areas are changing the peri-urban landscape, by transforming the agricultural land into discontinuous urban fabric. Tracking these changes requires different approaches. The aim of the research is to identify the spatial development of suburban zone with the use of the spatial information-based approach of estimating the location of suburban plots. The authors introduced parameters describing the building plots for single family housing in the suburban areas on the example of the surrounding municipalities of the city of Wrocław, Poland. Landscape metrics tools were used to delineate the suburban plots not identified by Corine Land Cover 2012. The results were verified with the use of the prices and values register for real estates. The results show that there is an increasing pressure on farmland conversion into suburban areas expressed by the number of transactions and the total areas of sold housing plots. The plots that have been purchased for the single-family housing between 2004 and 2016 constitute about 10 % of all existing plots. About 42 % of suburban properties are designed in the distance not exceeding 3 km from the existing settlements; they are, however, not connected by infrastructure with other build-up areas.

1. Introduction

Nowadays more than half of the world's population lives in urbanized areas [1] and the expected world's population growth will also be concentrated there [2]. Europeans are urbanized in 75 % [3] and a lot of them live in suburban areas created as a result of an urban sprawl. Urban sprawl is the expansive spread process of urban structures on rural areas [4], which is one of the most common spatial issues [5]. The suburban zone has not constant boundaries and therefore it is difficult to delimitate. The metropolitan land-use patterns undergo continuous transformation [6]. The uncontrolled urban sprawl has a negative impact on neighbouring rural areas [7, 8] and social relations [9]. Planning the countryside is done mainly by urbanites and future rural development is supposed to meet the urban needs [10].

Contemporary Polish suburbanization is characterized by large distances from the cities centres, dominance of single-family housing, gentrification and strong inflows of people from the central city [11]. People from core cities, who very often have high incomes, escape from urban traffic and daily life stress [9] and build their residences in the suburban, agricultural areas [12]. This urban sprawl model describes present developing suburban zone of Wrocław, Poland [11] - our research area. Spatial policies, determining which areas will be developed as residential areas, support urban sprawl. In 11 years (from 1998 to 2009), the population growth in this area was not constant. The number of



people living in that area was 748 000 in 1998, 741 000 in 2002, 755 000 in 2009 [11]. The spatial policy plans are, however, designed to accommodate 1 740 000 new residents.

There is a need to study the progress of urbanization and understand the trends of urban change and likely patterns [13-15]. The urban dynamic analyses are often conducted using land cover data [13, 16, 17]. CORINE land cover dataset provides land changes (also in the context of expanding suburban areas) between 1990 - 2000, 2000 - 2006 and 2006 - 2012. Since the urbanization is a very dynamic process, more detailed and temporarily data to verify the pace of suburban growth is recommended. Therefore, the urban dynamic analysis could be based on annual national cadaster data [18] which includes information about vacant parcels, buildings and their year of construction. Research based on such data can provide input for the future land use planning policies and planning strategies [18].

The aim of this study is to identify the spatial development of suburban zone of Wrocław with the use of the spatial information-based approach of estimating the location of suburban plots. Our analytical approach (figure 1), based on residential data, could give more accurate information about current and planned suburban changes regarding the building plots.

2. Data and methods

Suburban real estate displays different spatial patterns in various parts of the world. They may take a form of semi-detached houses with relatively small gardens, large plots with detached single family housing, terrace houses, apartment buildings, etc. In our case study area, the typical suburban housing is the detached single family housing with a garden and a front yard. The typical plot is between 600 m² up to 2000 m². In order to obtain permission to build a house from the local authorities, the area needs to be designated for the housing development. This means that there is either a master plan or a spatial study describing the land use functions. The developments in suburban areas are changing the peri-urban landscape, by transforming the agricultural land into discontinuous urban fabric. The transactions are recorded in the prices and values register for real estate, run by the provinces' geodetic departments. Because of the increase in the number and prices of transactions since 2004 [19], Wrocław surrounding municipalities experience constant influx of inhabitants. Our approach presented in this article derives from the changes in the register transactions and the land use transformations that come along with the land parcel purchase process. Spatial information data method was used to identify single family housing plots in the case study area and the prices and values register for real estate to assess the actual and predicted state of suburbanisation (figure 1).

2.1. Spatial information data method

The research included the design of area and shape index criteria to identify the building plots on suburban areas (table 1). The input data was a cadastral map provided by the municipalities' geodetic departments. The plots with area smaller than 600 m² and bigger than 2000 m² were not considered, because those plots are assumed not to have a housing purpose. The Shape Index was calculated according to the formula:

$$SI = p/(4\sqrt{a}) \quad (1)$$

where:

p - perimeter of the polygon;

a - area of the polygon

SI- Shape Index

Shape Index is used widely in the landscape ecology to assess the shape [20, 21]. The Shape Index represents the coherence of the shape - if the value of SI is closer to 1, the shape of the plot is closer to a square. Plots with SI=1.5 represent housing plots with a rectangular shape. Plots with SI above 1.5 describe roads and public squares or areas of other use. Our Shape Index criteria is applied

to elicit standard single family housing plots. It is not designed to identify plots that have different shape, for example long and narrow road parcels.

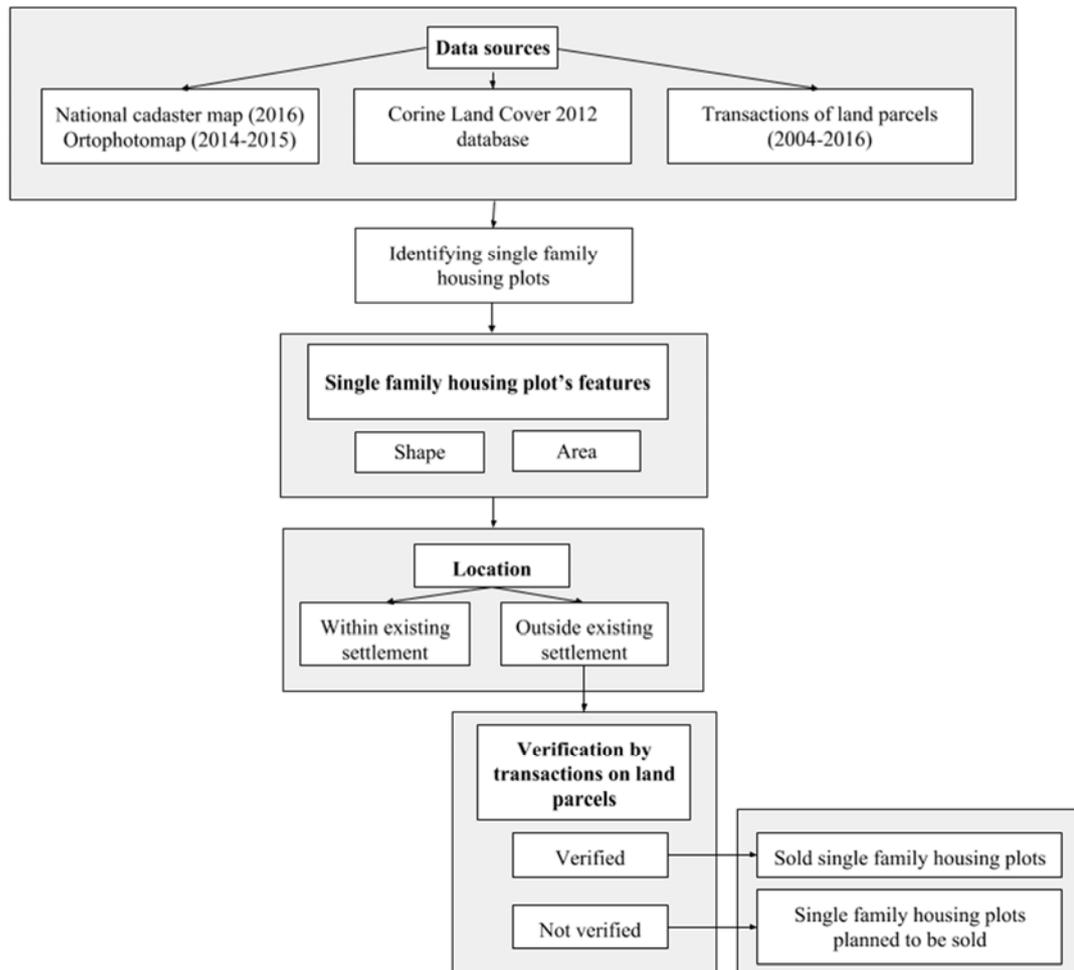


Figure 1. Conceptual framework of the study.

Table 1. Criteria used to identify single family housing plots in the suburban area.

Plot's feature	Value
Area	600 – 2000 m ²
Shape Index	0.9 - 1.5

The share of building plots within three distance zones was identified. The first zone included plots within urban areas, which means they overlap with the urban areas and so the distance is close to 0 km [18]. The second zone includes plots outside the build-up zone. These plots are located between 0 km and 3 km from urban areas. The plots located in the third zone are more than three kilometres away from the urban areas. The analysis was conducted using proximity tool (Near) of ArcGIS software. This analysis allowed to calculate the percentage of plots, area of plots and average area of plot in each distance zone.

2.2 Verification based on the prices and values register for real estate

The information about the prices and values of the real estate are gathered by different entities. In Poland, it is the geodetic departments of the provinces' municipal administration that keep records of the prices and values in the registers for real estate, due to the tax and administrative reasons. The register contains all the transitions of real estates within the province's area. In our study, the focus is on the land parcels that display the characteristics of the typical suburban developments. Authors have obtained the prices and values of the real estates for the surrounding municipalities including all transactions of land parcels after the year 2004 up to June 2016. The price of the 1 m² of a land parcel below 10 PLN indicates that the land is designated for agricultural practices. The land parcels whose price per square meter is above 400 PLN are non-market transactions, designated for industrial or multi-family purposes, or have some building constructions at various stages of the process. Therefore, to distinguish the typical suburban ones, several criteria have been applied: (1) the area of such parcels should be between 600-2000 m², (2) the price of 1 m² should vary between 10 and 400 PLN, (3) the purchase is a market transaction by two private parties, (4) the transaction concerns only the land parcel for housing and not the roads, industrial areas or enlargement of some other parcel, (5) there is no construction of a house at any stage on the land parcel. Authors could geolocate the transactions with the use of the land parcel shape file provided by the same geodetic departments (figure 2). Results were verified with the 2016 ortho photomap.

3. Results and discussions

The results of the analysis are divided according to two criteria: location within the discontinuous urban fabric (figure 3) and verification by transactions (table 3). The plots' distances to the nearest discontinuous urban fabric areas were estimated. The data on transactions taking place in our case study area between the year 2004 and 2016 was used. The research aims to identify existing (developed between years 2012 - 2016) single family housing plots according to the area and shape of the plot to analyze the dynamics of farmland conversion including properties already sold and those prepared to be sold. Plots not classified as discontinuous urban fabric (no. 112 according to CLC 2012) were divided into verified and not verified by transactions (table 2).

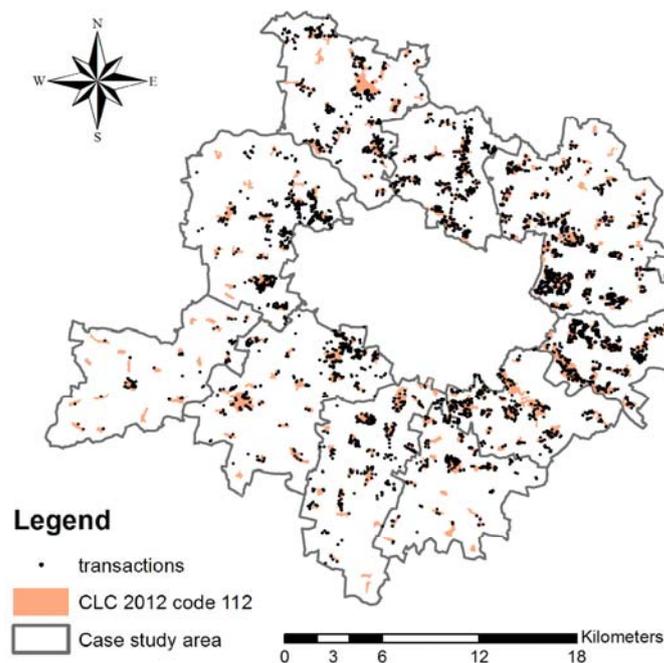


Figure 2. Transactions of vacant parcels in the case study area.

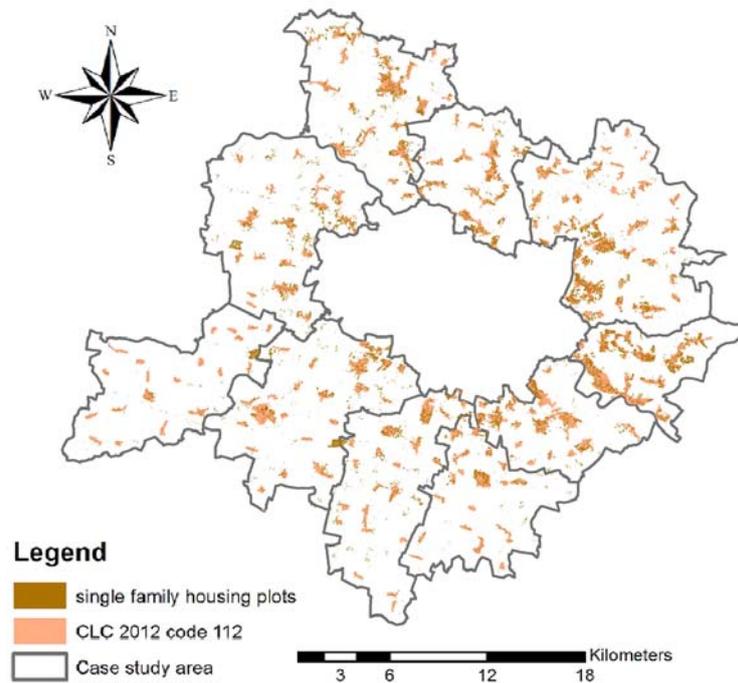


Figure 3. Location of single family housing plots and area classified as discontinuous urban fabric by Corine Land Cover 2012 database.

The study aims to identify changes in land cover that influence the landscape character. Corine Land Cover 2012 database identifies the existing discontinuous urban fabric areas. Discontinuous urban polygons cover the areas of the old settlements as well as new suburban developments built until 2012. The change in land cover from agricultural areas (CLC code 2.1.1.-2.4.4.) to other is very dynamic. Just in 22 years over 600 ha of agricultural land was turned into discontinuous urban fabric (CLC code 112) (figure 4).

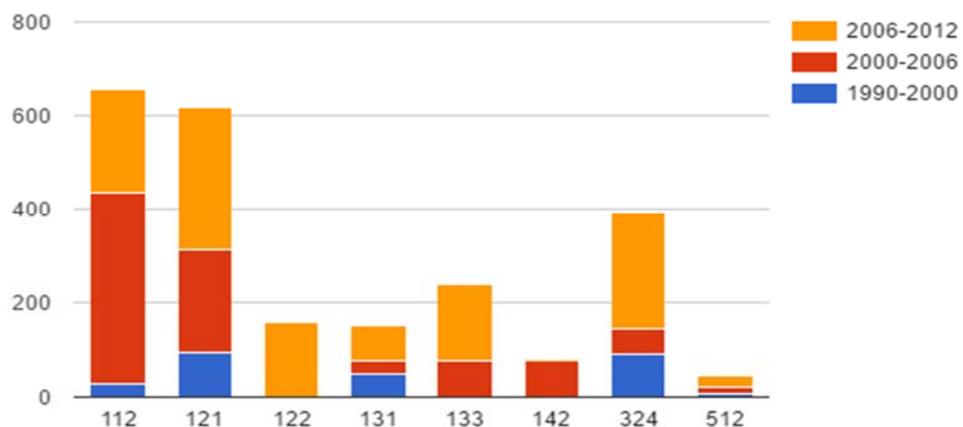


Figure 4. Conversion of farmland in years 1990 - 2000, 2000 - 2006 and 2006 - 2012 [ha] according to CLC change database (Legend: 112 - discontinuous urban fabric, 121 - industrial or commercial units, 122 - road and rail networks and associated land, 131 - mineral extraction sites, 133- constructions sites, 142 - sport and leisure facilities, 324 - transitional woodland shrub, 512 - water bodies). Source: own elaboration based on Corine Land Cover 2012 database

The most dynamic conversion took place in years 2000 - 2006 (400 ha). Second purpose for farmland conversion are industrial or commercial units (over 600 ha in years 1990 - 2012). Almost 400 ha of agricultural land was converted into transitional woodland shrub. Until 2012 over 200 ha was converted into construction sites that might be by now the area of discontinuous urban fabric, industrial or commercial units, road and rail networks and associated land or sport and leisure facilities.

Table 2. Results of proximity analysis. The number, percentage, area of plots and average area of a plot within each urban zone. Source: own elaboration

Distance [km]	number of plots	% of plots	area of plots [ha]	average area of a plot [ha]
0	33417	58.77%	3645.3206	0.1091
(0-3>	23423	41.19%	2620.6930	0.1119
>3	21	0.04%	2.64389	0.1259

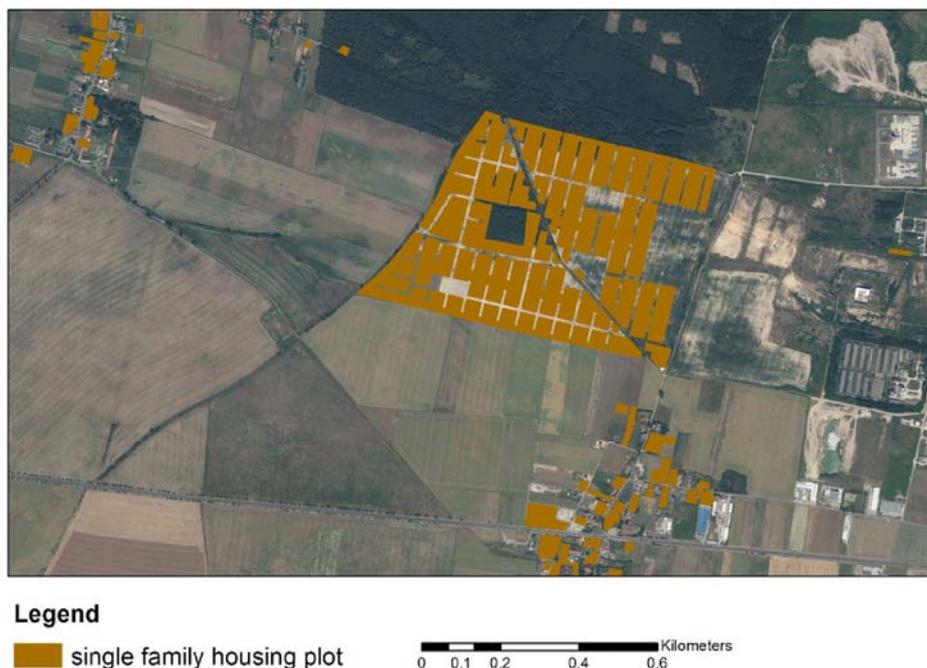


Figure 5. Single family housing plots located outside of discontinuous urban fabric in the area covered by forest and agricultural land with no connection to the existing settlement.

The average area of a plot increases together with the distance from the urbanized areas. On average, the plots located up to 3 km away from the existing urbanized fabric are larger by 28 square meters. Remote plots are even bigger by up to 168 square meters than plot located in a close proximity to existing settlements. That is very common feature of urban sprawl.

The authors identify plots classified as discontinuous urban fabric verified and not verified by transactions to track the actual farmland transformation into the housing area. Plots not classified as discontinuous urban fabric and verified by transactions were considered as sold single family housing plots. They represent 5 % of single family housing plots in the case study area. Plots not classified as discontinuous urban fabric and not verified by transactions are planned to be sold. These plots are prepared to be sold, but they are located in the areas covered by forest or agricultural land in 2016 (figure 6).



Figure 6. Plots located outside area covered by discontinuous urban fabric. Plots verified by transactions are the part of planned housing area

They represent 37 % of all housing area, which is 2313.82 ha. 42 % of all housing plots is located outside of the area classified as discontinuous urban fabric by CLC 2012 database. It is possible that the housing area in the suburban area of Wrocław will almost double its surface in the future. 59 % of housing plots identified in the case study area is classified as discontinuous urban fabric. 5 % of them are verified and 54 % are not verified by transactions. 5341 of 6451 transactions in the case study area (83 %) are located within plots identified as plots for single family housing purpose. The rest is not explained by the assumptions to our approach.

Table 3. Plots located within and outside existing settlement and their verification by transactions in the case study area

Plots	Area [ha]	No of plots	Area [%]	No of transactions	Transactions [%]
Plots not classified as discontinuous urban fabric (verified by transactions)	311.82	2749	5	2749	43
Plots not classified as discontinuous urban fabric (not verified by transactions = planned to be sold)	2313.82	20695	37	0	0
Plots classified as discontinuous urban fabric (CLC code 112) (verified by transactions)	284.40	2592	5	2592	40
Plots classified as discontinuous urban fabric (CLC code 112) (not verified by transactions)	3364.18	30825	54	0	0
Total	6274.23	56861	100	5341 of 6451	83

4. Conclusions

The results provide insights into the dynamics of the farmland conversion into suburban areas with the example of the municipalities surrounding the city of Wrocław. The increase in the total area of new housing estates is significant in the years from 1990 to 2012. It is predicted that plots with the parameters typical for a standard single family housing are planned to be sold and soon will become new housing areas. It can be concluded that there are 2695 housing plots are designated and waiting to be sold. If the business does not go as usual, the seller might receive negative housing permission or not find a merchant. If the business goes as usual and the plots will be sold, soon up to 40 thousand inhabitants will move to suburban area of Wrocław. The spatial policy supports this trend and new housing areas are being designed. Many (about 42 %) of new building plots are already located in 3 km distance from the urban areas.

The research involved the use of cadastral data, transactions data and criteria for typical single family housing plot in the case study area of suburban municipalities of Wrocław. Our results can be used as inputs for further analysis considering social and environmental aspects as well as to predict landscape changes by identifying their driving forces [22].

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