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In this edition of the *Geomatics, Landmanagement and Landscape* quarterly, the opening issue of the year 2017, we bring you eleven papers.

The first relates to the applications of cartographic and statistical methods in the analysis of the local real estate market. The town of Rabka-Zdrój was chosen as the object of the study, with its database of undeveloped land properties, subject to real estate trading between 2010–2015. The second article presents the possibilities for the application of artificial linear neural networks in real estate valuation. Both papers share the common Keywords of real estate market and property valuation. In the next article, authors discuss the problem of edge effect, and its impact on the accuracy of 2D and 3D modelling using laser scanning. They show sample renditions of the test object. The subject of the fourth article is the analysis of selected factors pertaining to the spatial structure of rural areas in the villages of central Poland. The study, conducted in the fourteen villages of the Białaczów municipality, encompassed the property structure, land use, and land fragmentation of individual agricultural holdings located therein. The calculated rate of fragmentation for each precinct led the authors to distinguish 4 types of villages. Fragmentation can be regarded as a criterion for determining the sequence of villages where work should be prioritized, aimed at the consolidation and exchange of land. The goal of the next study was to evaluate the insolation potential of land plots in the village of Łazy, in the municipality of Jerzmanowice-Przeginia, in terms of suitability for the construction of solar power plants. The authors have carried out the modelling of insolation and spatial analysis, using the ArcMap 10.3.1 and QGIS 2.8.1. Wien software. The end result of the study is presented in the form of maps, showing the most suitable land for investing in solar technologies. In the sixth article, Professor Magel from Germany raises the problem of the territorial justice for urban and rural regions, as well as the responsibility and role of the Bavarian Academy for Rural Areas in this regard. He presents the problem of the urbanization of countryside, in the context of the lack of discussion about the future comprehensive vision and strategy for rural areas. He states that Germany and Europe still believe in the principle of cohesion, and in the objectives of the Territorial Agenda 2020. The seventh paper presents proposals for a security model to protect cadastral information, which is recorded in the real estate databases in Poland. The model was developed for the implementation of tasks pertaining to multipurpose cadastre. In the next article, authors discuss the results of a research project carried out by the Terramap Sp. o.o. company, the result
of which is a measuring device used for 3D digitization, allowing for data acquisition and processing. A characteristic feature of the system is the automatic acquisition of information, both about the object geometry (spatial digitization) and colour information in the RGB colour space of the object (with high-resolution digital photos). In the ninth article, the author from China presents the historical process behind the Chinese land reform. He distinguishes three stages in the economic development of China. First is the land reform associated with the reform of state-owned enterprises. The second is related to the reform of the reconstruction system, and the third, to the reform of the spatial system for rural areas, in relation to the current process of urbanization. The author of the tenth paper in this issue writes about proposed modifications to the typology of the division of rural areas in Poland, based on the OECD standard and EUROSTAT typologies. The eleventh article presents the research procedure for determining the potential effectiveness of fire fighters in the city of Łódź, and in the areas surrounding the city within a 20-kilometer ring. In conclusion, the author states that the use of the Analyst ArcMap network tools and the 2SFCA method makes it possible to determine the timely availability of fire fighters in case of various threats.

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CARTOGRAPHIC AND STATISTICAL METHODS
IN THE ANALYSIS OF LOCAL REAL ESTATE MARKET
AS EXEMPLARYD BY RABKA-ZDRÓJ

Agnieszka Bitner, Urszula Litwin, Aneta Michalczewska

Summary
The article focuses on the use of cartographic and statistical methods in the analysis of local real
property market. The analysis covered the area of Rabka-Zdrój city. The database consists of
plots of undeveloped land traded between 2010 and 2015. The structure of transactions, spatial
distribution of unit prices and the impact on size of land on its price, depending on a category of
transactional real estate, have been examined.

Keywords
real property market • thematic map • spatial analysis • Rabka-Zdrój

1. Introduction
The article deals with the use of thematic maps and statistical methods in analysis of local real
property market. “Thematic maps present one or a few chosen elements of geographic
space, phenomena, processes, but also ideas, hypotheses and results of analyses and
syntheses” [Żyszkowska et al. 2012]. In case of real property market, thematic maps are
usually used to present spatial distribution of real property prices [Bitner and Bysina 2014,
Kolbe 2015, Maćkiewicz 2008, Tsutsumi 2011]. In this article transactional real prop-
erties and the structure of transactions have been presented. The analysis covers the area
of Rabka-Zdrój city. Database consists of plots of undeveloped land traded between 2010
and 2015. The data were acquired form the price and value register available at the
Geodesy, Land Registry and Cartography Department of the Starost’s Office of the Districts
of Nowy Targ. In order to create thematic maps, digital cadastral map, obtained from
this Office, was used. Thematic maps were created in ArcGIS software (ESRI Inc. 2016).

Rabka-Zdrój is situated in southern Poland in the Małopolskie voivodeship, district
Nowy Targ. The city is located 23 km north of Nowy Targ and 68 km south of Kraków.
Rabka-Zdrój jest located in the Rabka Valley, at an altitude of 500–600 m a.s.l. in the
Gorce and Island Beskid range, where Poniczanka, Skomielnianka and Słonka streams
join the river Raba. From the north and north-west Rabka-Zdrój borders on the Lubień
commune, from the east – on Mszana Dolna and Niedźwiedź communes, from the south on the Nowy Targ commune, and from the west – the Raba Wyżna commune. The city lies at the intersection of important communication routes, namely of Zakopianka, that is the road from Kraków to Zakopane, and national road no. 28 to Nowy Sącz and Bielsko-Biała.

The history of Rabka-Zdrój goes back to XIII century and is related to brine springs. The name of the city was first used by Jan Długosz, who referred to a document issued by the king Bolesław V the Chase in 1254. In it the lands of Rabka have been handed over for use to the Cistercian Order from Szczycyca. However in 1382 Louis I of Hungary took the property back from the Order. In 1446 Rabka was granted location privilege by Magdeburg rights, which was an important event in its history. In 1557 a parish was established and a few years later the first church in Rabka was built. It was destroyed for unknown reasons and in its place a new one was erected, St. Mary Magdalene’s Church, where today the Ethnographic Museum can be found. Since the second half of XVI century there was a growing interest in brine springs. In 1858 the first chemical analysis of brine was conducted. The results showed that local saltwater contains large amounts of iodine and bromine. In 1864 a spa, created by Julian Zubrzycki, was officially opened. The spa developed since then, reaching its greatest splendour in the interwar period. During the Second World War the spa resort was closed due to pollution of springs and lack of equipment, as it was taken to Germany. After the war Rabka became an important centre of tuberculosis treatment. On 21 September 1953 Rabka was granted municipal rights and in 1967 it was officially recognized as a health resort. In 1999 the name of the city was changed into Rabka-Zdrój to emphasise that the town has a spa character. The only brine graduation tower in Małopolska can be found here. The climate of Rabka-Zdrój is characterized by small amount of winds and precipitation, and strong insolation, which is not a typical mountain climate [Matuszczyk and Trybowska 2001].

The area of the city is 36.3 km², which is 2.4% of the Nowy Targ district. The city has 13 074 residents, 47.2% of which are men, and 52.8% are women. In recent years a slight increase in population, of 0.96%, has been noted. The population density is 360 person · km⁻². There are no big industrial plants in Rabka-Zdrój. Entrepreneurship is focused on service of tourists, accommodation and catering services, trading, construction and medical services. The companies active in Rabka are mainly small and one-man firms. Green areas constitute large part of Rabka, namely 1.32% of the city area, compared to 0.21% in the Małopolskie voivodeship. In the centre of the city there is a Park Zdrojowy of 32.5 ha. The Park came into being 112 years ago and in 2010–2011 it was comprehensively revitalized. It consists of two characteristic areas: representative-recreational and pedestrian-meditative, and it is one of the largest parks in Małopolska [Program Rewitalizacji… ].

2. Database

The analysis presented in the article concerns plots of undeveloped land sold between 2010 and 2015. In the researched period 233 of transactions were conducted. The terri-
The editorial scope of the local market is demarcated by administrative boundaries of Rabka-Zdrój city. Data were obtained from the Geodesy, Land Registry and Cartography Department of the Starost’s Office of the Districts of Nowy Targ in a PDF format. The data were used to create a database of real properties in Microsoft Excel. Transactions, the subject of which were roads and land designated for perpetual usufruct have been excluded. Finally, the analysis covers 199 transactions.

3. Data analysis

The analysis of real properties [Dudek et al. 2011, Guntermann and Thomas 2005, Colwell and Munneke 1997] started from examining trends of unit price of land plots during 6 studied years. Linear regression model was used for this purpose. The analysis showed that the market of undeveloped land is stable, the prices in the studied period were fixed at a constant level. The diversity of prices was greater in the second half of the studied period. The dynamics of the transaction showed that the highest number of transactions was carried out in 2015, the lowest in 2014. In the remaining years the number of transactions was fixed at about 30 annually. The total surface area of land sold was the largest in 2015, which was 0.35% of the whole land in the city. The land sold annually was on average 0.2% of the whole land in the city. Table 1 presents data on the dynamics of transactions.

Table 1. The number of transaction and structure of sold land in consecutive years from 2010 to 2015

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of transactions</th>
<th>Area of sold land [ha]</th>
<th>Share of transactional land in total land of the city [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>58</td>
<td>12.6</td>
<td>0.35</td>
</tr>
<tr>
<td>2014</td>
<td>17</td>
<td>2.7</td>
<td>0.07</td>
</tr>
<tr>
<td>2013</td>
<td>31</td>
<td>6.3</td>
<td>0.17</td>
</tr>
<tr>
<td>2012</td>
<td>28</td>
<td>5.9</td>
<td>0.16</td>
</tr>
<tr>
<td>2011</td>
<td>36</td>
<td>8.4</td>
<td>0.23</td>
</tr>
<tr>
<td>2010</td>
<td>29</td>
<td>5.8</td>
<td>0.16</td>
</tr>
<tr>
<td>Mean</td>
<td>33</td>
<td>7.0</td>
<td>0.19</td>
</tr>
</tbody>
</table>

Source: authors’ study

Figure 1 shows the spatial distribution of transactions carried out in Rabka-Zdrój. The area of the city is divided into three separate register zones: Rabka-Zdrój, Rabka-Zaryte and Rabka-Słone. One dot on the map corresponds to one transaction, while the colours of dots indicate the unit price level. The map shows 199 transactions of undeveloped land, carried out from 2010 to 2015. The analysis proves that the greatest number of transactions was conducted in the central part of the city. At the outskirts,
that is in forest areas, there were no transactions concluded. The highest number of transaction was finalized within Rabka-Zdrój, the smallest one within Rabka-Zaryte.

Three kinds of transactional properties can be singled out: multi-use agricultural land property, single-use agricultural land and properties intended for development other than farmstead. The structure of these transactions, according to their type, are shown in Table 2. The greatest increase of transactions has been noted in single-use agricultural, whereas multi-use agricultural land was least frequently traded, but the total area of these was the largest.
### Table 2. The structure of transactions according to a type of land property

<table>
<thead>
<tr>
<th>Type of real property</th>
<th>No. of transactions</th>
<th>Share in the market [%]</th>
<th>Area of sold land [ha]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural multi-use</td>
<td>44</td>
<td>22.11</td>
<td>17.5</td>
</tr>
<tr>
<td>Agricultural single-use</td>
<td>86</td>
<td>43.22</td>
<td>11.5</td>
</tr>
<tr>
<td>Intended for development other than farmstead</td>
<td>69</td>
<td>34.67</td>
<td>12.8</td>
</tr>
</tbody>
</table>

Source: authors’ study

### Fig. 2. Structure of transactions in undeveloped land properties

Thematic map (Figure 2) shows the number of transactions carried out in three zones of the city, depending on the kind of real property. The highest number of trans-
actions was conducted within Rabka-Zdrój, in the remaining zones: Rabka-Zaryte and Rabka-Słone the number of transactions was much lower. In Rabka-Zdrój the centre of the city is included, that is why the number of transactions in real properties intended for development other than farmstead was the highest. Within Rabka-Słone the most transactions were concluded in multi-use agricultural properties. In Rabka-Zaryte the agricultural single-use properties were sold the most.

The relation between unit price and the surface area of undeveloped land property was examined [Thorsnes and McMillen 1998]. This relation was defined for three types of properties. To this aim, the area of particular type of property was divided into equal class ranges and in each of them the prices were averaged out. Then for mean values a linear model \( y = a + bx \) of relation between the price and the surface area was adjusted by the least square method described in the work of Bitner [2008]. The obtained values of model coefficients determined for each type of real properties are presented in Table 3.

Table 3. The values of coefficients in linear model \( y = a + bx \)

<table>
<thead>
<tr>
<th>Type of real property</th>
<th>Direction coefficient ( b )</th>
<th>Standard error of direction coefficient ( b )</th>
<th>Constant term ( a )</th>
<th>Standard error of constant term ( a )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural multi-use properties</td>
<td>-0.0035</td>
<td>0.0006</td>
<td>44.23</td>
<td>4.51</td>
</tr>
<tr>
<td>Agricultural single-use properties</td>
<td>-0.0020</td>
<td>0.0021</td>
<td>37.92</td>
<td>6.40</td>
</tr>
<tr>
<td>Properties intended for development other than farmstead</td>
<td>-0.0125</td>
<td>0.0024</td>
<td>75.37</td>
<td>7.53</td>
</tr>
</tbody>
</table>

Source: authors’ study

Relation between unit price and the area in case of three types of undeveloped land properties is presented in Figures 3–5, together with regression lines adjusted by the least squares method.

As Table 3 and the charts shown in Figures 3–5 prove, the surface area of transactional property has the greatest impact on the price of real property intended for development other than farmstead. Together with the increase of the surface area by one are, the price of this kind of property dropped by 1.25 złoty, while the mean unit price in the studied area was 5578 złoty per are. The least influence of the surface area on the price has been noted in agricultural single-use properties and it amounted to 0.20 złoty per are, while the mean price was 3596 złoty per are. In agricultural multi-use properties the unit price falls by 0.35 złoty per are with the increase of surface area by one are, the mean price was 3141 złoty per are. The scope of the surface area of agricultural multi-use properties reached the areas between 60 m² to 14156 m². When making corrections, the attention should be paid to errors of the model’s determined direction coefficients. In agricultural single-use properties the direction coefficient error was 105%. Such high value of the error eliminates the obtained coefficient from practical
use and it resulted from wide diversity of prices in agricultural single-use properties of more than 30 ares.

![Graph](image1.png)

Source: authors’ study

**Fig. 3.** Relation between the price and area in agricultural multi-use real properties

![Graph](image2.png)

Source: authors’ study

**Fig. 4.** Relation between the price and surface area for agricultural single-use properties

The quota corrections made with regard to an area of property, obtained from the analysis, were compared with the quota correction determined in Prystupa [2001]. The author used a representative sample of a few dozen of representative empirical data gathered from undeveloped real properties and to these data adjusted a linear model by the least squares method. The linear model of the relation between the unit price (Y) and the surface area of (X), measured in m², within the range from 0 to 10000 m²,
has been described by the formula: \( Y = 233.1 - 0.012X \). The direction coefficient of straights is a quota correction due to area of the property, which is 1.2 zloty per are. The numbers and the results of the analysis presented in Table 3 can therefore be compared.

4. Conclusions

In the article the analysis of the undeveloped land property market has been presented. Statistical and cartographic methods were used. The study covered six years, from 2010 to 2015. The analysis covered the area of Rabka-Zdrój city. The base of selected data included 199 records. In the studied period the prices were stable. The spatial distribution of transactional real estate has been illustrated by a dot map (Figure 1). The highest number of transaction was completed in the central part of the city. The structure of transaction in three register surveying districts was presented by cartogram (Figure 2) and Table 2. It turned out that agricultural single-use properties were the subject of the highest number of transactions. The impact of plot’s area on the unit price was examined by statistical methods. The results show that surface area is an attribute that has the highest influence on the price of property intended for development other than farmstead.

References


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Summary

Transactional price is the result of some kind of free market game, and of independent decisions taken by the parties to the transaction. Prices depend on a number of factors, specific to the local real estate market. The impact of some factors is fixed, while others are dependent on the location of the property. Therefore, research into the determination of rules that would describe the relationship between the market price of the real estate, and its market characteristics, remain valid. The article presents the possibilities of applying linear artificial neural networks to real estate valuation. Using a database, the artificial linear neural network is developing a regression model, which produces the results that oscillate close to the market value of the property. The necessary condition is the creation of a database that is representative of the given real estate market.

Keywords

neural network • artificial neurons • training set • property valuation • database

1. Introduction

Artificial neural network operates on the principle of a scheme. In the scheme, by a suitable amount of interconnected elements called neurons, and with an appropriate amount of information (so-called signals), calculations are performed. The result is an approximate solution to the task demanded of the network.

Construction of artificial neural networks should be transparent, so that it can be traced easily and quickly, and if necessary, also easy to control. A sample scheme of an artificial neural network was presented in Figure 1. The artificial neural networks used in practice are flat networks with a regular structure, in which there are layers of neurons with a specific purpose. These neurons are usually joined together according to the “peer-to-peer” principle [Tadeusiewicz et al. 2007].

What is characteristic of the neurons, which are the components of the network, is that they have a number of inputs and only one output. Figure 2 shows a sample scheme
of a neuron. The input information $X_i \ (i = 1, 2, \ldots, n)$ and the output result $Y$ should take numerical values from the range of 0 to 1, or in some cases, $-1$ to $+1$. If we expect certain information or decision from the task demanded of and being solved by the network, we must first assume specific significance for potential output results as well as the input information in our possession. When the obtained values are outside the established range (e.g. between 0 and 1), we apply a scale to the results obtained. The task performed by the essential element (unit) of the artificial neural network, that is, the neuron, is based on processing and modifying the input information $X_i$ into the output results of $Y$, using its connections and the knowledge fed to it.

![Sample scheme of an artificial neural network](image)

Source: author’s study based on [Tadeusiewicz et al. 2007]

**Fig. 1.** Sample scheme of an artificial neural network

The knowledge of the neurons results from what the given neuron had been taught. For their learning, the neurons utilize the $W_i$ coefficients, or the so-called weights. The weights are assigned to each of the neuron’s inputs, and may have variable values. The information entering the given input is multiplied by the weight of that input. This modification enhances the information for further calculations, when the weight is greater than 1; or it represses the information, when the weight is less than 1. There exists also the so-called contradictory information. This applies to situations when the weight is of negative value (below zero). The inputs, in which there are negative weights, are commonly called inhibitory inputs, while the inputs with the positive weights are called stimulatory inputs. Inside the artificial neuron, aggregation occurs, which usually involves summing up the information modified by the weights. As a result, we obtain an auxiliary internal signal. The neuron frequently adds an additional ingredient to such an auxiliary internal signal, which is independent of the input information – the so-called threshold. In a situation, where the threshold is taken into account, it is subjected to the process of learning. Therefore it can be assumed that the threshold is an extra weight, associated with the input, to which an internal signal is connected, with a weight equal to 1. In order to obtain the output result, it is necessary to add up the internal signals, previously multiplied by the weights [Tadeusiewicz et al. 2007].
2. Method and area of study

In our studies, we have applied learning networks that were based on the collated database, which was created as a result of the analysis of the local real estate market. The data collected relate to transaction prices of real estate: business premises and residential properties [Siejka 2011].

The proposed learning process is a procedure of network learning “with the teacher.” Learning conducted using such a method entails, inter alia, the transfer of examples of proper operation to the network, so that the network imitates these examples later on, during its subsequent operation. The examples should contain specific input information and output result. The presented configurations of the input information and the required output result are analysed by the network in terms of the relationship between the input information and the result. In other words, during the network learning process “with the teacher” there are always two sets, coupled together. The first set contains the data for the task, while the other contains the solutions.

In practice, the “teacher” of the network is a computer program, equipped with a training set, containing properly selected and properly classified data with indications as to which are the input, and which are output data. Inessential data, useless for the purpose of solving the task, should be omitted [Tadeusiewicz et al. 2007].

Table 1 contains corrected transaction prices of 19 selected properties (business premises), with similar characteristics to the property, which is the subject of the value appraisal [Cymerman and Hopfer 2009]. In the presented data, we can distinguish the data we are going to use as input data – i.e. concerning the situation/location/zone, area, wear, standard and floor, and the output data on the corrected price. Therefore, one can assume that Table 1 contains information, based on which the network can be taught. In one of the data sets, features of the real estate market of business premises (offices and similar properties) have been selected, important for the local real estate market, in which the property under evaluation is located. In another data set, we shall find the output result, in the form of corrected prices for selected properties with similar characteristics.

Source: author’s study based on [Tadeusiewicz et al. 2007]

Fig. 2. Sample scheme of a neuron
Table 1. Learning set

<table>
<thead>
<tr>
<th>No.</th>
<th>Situation /location/zone</th>
<th>Area</th>
<th>Wear [%]</th>
<th>Standard W, P, N</th>
<th>Floor</th>
<th>Corrected price [zł/m²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>very good</td>
<td>very good</td>
<td>10</td>
<td>W</td>
<td>I</td>
<td>5 508.63 zł</td>
</tr>
<tr>
<td>2</td>
<td>good</td>
<td>very good</td>
<td>20</td>
<td>P</td>
<td>III</td>
<td>4 983.31 zł</td>
</tr>
<tr>
<td>3</td>
<td>good</td>
<td>very good</td>
<td>10</td>
<td>N</td>
<td>ground</td>
<td>5 300.92 zł</td>
</tr>
<tr>
<td>4</td>
<td>very good</td>
<td>very good</td>
<td>30</td>
<td>W</td>
<td>II</td>
<td>5 456.15 zł</td>
</tr>
<tr>
<td>5</td>
<td>poor</td>
<td>very good</td>
<td>10</td>
<td>W</td>
<td>I</td>
<td>5 174.14 zł</td>
</tr>
<tr>
<td>6</td>
<td>good</td>
<td>good</td>
<td>20</td>
<td>P</td>
<td>III</td>
<td>4 807.01 zł</td>
</tr>
<tr>
<td>7</td>
<td>good</td>
<td>very good</td>
<td>40</td>
<td>N</td>
<td>IV</td>
<td>4 983.90 zł</td>
</tr>
<tr>
<td>8</td>
<td>very good</td>
<td>very good</td>
<td>30</td>
<td>N</td>
<td>II</td>
<td>5 295.97 zł</td>
</tr>
<tr>
<td>9</td>
<td>poor</td>
<td>very good</td>
<td>10</td>
<td>W</td>
<td>I</td>
<td>5 163.69 zł</td>
</tr>
<tr>
<td>10</td>
<td>good</td>
<td>good</td>
<td>20</td>
<td>P</td>
<td>III</td>
<td>4 840.07 zł</td>
</tr>
<tr>
<td>11</td>
<td>good</td>
<td>very good</td>
<td>40</td>
<td>N</td>
<td>IV</td>
<td>5 014.58 zł</td>
</tr>
<tr>
<td>12</td>
<td>very good</td>
<td>very good</td>
<td>30</td>
<td>N</td>
<td>II</td>
<td>5 328.00 zł</td>
</tr>
<tr>
<td>13</td>
<td>poor</td>
<td>good</td>
<td>40</td>
<td>N</td>
<td>ground</td>
<td>4 447.52 zł</td>
</tr>
<tr>
<td>14</td>
<td>poor</td>
<td>good</td>
<td>40</td>
<td>N</td>
<td>I</td>
<td>4 530.24 zł</td>
</tr>
<tr>
<td>15</td>
<td>poor</td>
<td>good</td>
<td>40</td>
<td>N</td>
<td>I</td>
<td>4 509.56 zł</td>
</tr>
<tr>
<td>16</td>
<td>very good</td>
<td>very good</td>
<td>30</td>
<td>W</td>
<td>I</td>
<td>5 479.13 zł</td>
</tr>
<tr>
<td>17</td>
<td>poor</td>
<td>very good</td>
<td>10</td>
<td>W</td>
<td>II</td>
<td>5 181.64 zł</td>
</tr>
<tr>
<td>18</td>
<td>good</td>
<td>very good</td>
<td>10</td>
<td>N</td>
<td>IV</td>
<td>5 292.77 zł</td>
</tr>
<tr>
<td>19</td>
<td>good</td>
<td>very good</td>
<td>30</td>
<td>N</td>
<td>IV</td>
<td>5 000.00 zł</td>
</tr>
</tbody>
</table>

Source: author’s study

Most data presented in Table 1 is qualitative, that is descriptive or “nominal”. This means that the values of the data are names, which must be assigned the appropriate number. In order to properly apply the data, it is necessary to use the “one of N” technique, where N is the number of different possible values (names), which a given nominal variable can take. For example, one of the characteristics we want to reproduce in the input of the network is the situation in which \( N = 3 \), because the situation of the property in question might be: poor, good and very good. In order to tell the network the correct value when, for instance, the situation of the property is determined to be good, we give the signal 1, and in other cases, 0 [Tadeusiewicz et al. 2007].

During the process of network learning “with the teacher”, the key parameters are the weights, by which we multiply each input signal, and then add that up with other signals. In order to facilitate the start of the learning process, we can use the weights listed in Table 2.
The weights of individual market characteristics, presented in Table 2, have been calculated on the grounds of the database, created as a result of a detailed analysis of the local real estate market, of properties similar to the property which is subjected to appraisal and valuation [Siejka 2010].

Table 2. Weights of various market features

<table>
<thead>
<tr>
<th>No</th>
<th>Item</th>
<th>Pairs</th>
<th>Calculations</th>
<th>Weight of the feature [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>situation/location/zone</td>
<td>1–9</td>
<td>32.5073</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1–5</td>
<td>31.5223</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>average</td>
<td>32.0148</td>
<td>33</td>
</tr>
<tr>
<td>2</td>
<td>area</td>
<td>2–10</td>
<td>13.4991</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2–6</td>
<td>16.6142</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>average</td>
<td>15.0566</td>
<td>16</td>
</tr>
<tr>
<td>3</td>
<td>wear [%]</td>
<td>7–3</td>
<td>29.8760</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>7–18</td>
<td>29.1082</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>average</td>
<td>29.4921</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>standard W, P, N</td>
<td>4–8</td>
<td>15.0960</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4–12</td>
<td>12.0768</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>average</td>
<td>13.5864</td>
<td>14</td>
</tr>
<tr>
<td>5</td>
<td>floor</td>
<td>13–14</td>
<td>7.7953</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>13–15</td>
<td>5.8464</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>average</td>
<td>6.8208</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>sum</td>
<td>96.9708</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: author’s study

During the learning process, the values of the weights change. This is decided independently by each an autonomous neuron, that is to say, every single neuron, based on the appropriately selected rules, independently determines which weights should be changed and by how much. During the learning process, the “teacher” does not have to scrutinize all the details; instead, it is enough to provide the network with a training set, containing the pattern of a correct solution, so that the network can gain knowledge about the error that it has committed. This knowledge will be acquired as a result of the network having compared the solution it provided by itself against the solution stored in the training set as a reference. The appropriate structure of the learning algorithms allows the network to correct the value of the weights based on the error, until it learns to solve problems and tasks from the training set, and on the basis of this knowledge, to solve similar tasks put to it. The input signals \( X_i \) \((i = 1, 2, \ldots, n)\) and the output signal \( Y \) can take the values from an exemplary, delimited range.
When using the scaling function, we assume that $X \in [-1,1]$, for each $i$, and $Y \in [-1,1]$ while the relation of $Y = f(X_1, X_2, ..., X_n)$. Then, the output signal $Y$ can be determined using the following linear equation:

$$Y = \sum_{i=1}^{n} W_i X_i$$  

wherein coefficients $W_i$, known as synaptic weights, can vary during the learning process. This process is one of the essential traits of neural networks as adaptive information processing systems. Among other things, the element described with the linear equation (1) is capable of recognizing the input signals.

For our explanation, we use vector notation, that is, a set of input signals to the neuron creates a vector (2) stored as a column of $n$ components [Tadeusiewicz 1993].

$$Y = \begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_n \end{bmatrix}$$  

(2)

The above vector (2) can be interpreted as a point in the $n$-dimensional input space of $X$, which, when described in the form of a transposed matrix, is as follows:

$$X = [X_1, X_2, ..., X_n]^T$$  

(3)

The set of $n$ weight coefficients can be interpreted as a point in the $n$-dimensional space of $W$ weights, which, when described in the form of a transposed matrix, is as follows:

$$W = [W_1, W_2, ..., W_n]^T$$  

(4)

With the above assumptions, we express the equation of the neuron in the form of a scalar product of vectors: of the inputs and the weights.

$$Y = W \cdot X$$  

(5)

From the properties of the scalar product, it follows that the output signal $Y$ of the neuron is larger when the position of vector $X$ (input) corresponds to the position of vector $W$ (weights). The neuron thus perceives and distinguishes the input signals similar to its own vector of weights, because the components of the input signal $X$ include, for instance, the characteristics of certain objects. At the same time, the output signal $Y$ can be a measure of the similarity to the selected object [Tadeusiewicz 1993].

3. Results and discussion

The result of the network learning process “with the teacher”, as presented herein, is the market price of the property being appraised. The result is an approximate value, which
should be appropriately scaled. Therefore, for the proper interpretation of the result obtained, it is necessary to interpret the result obtained in the correct way, as artificial neural networks form two types of models: regression models and classification models.

The regression model of the network, shown in Figure 3, is tasked with providing a numerical value. This model can be helpful in assessing the market value of a real estate property (one used for an office or business premises). Then, the input information is provided, which may take the numerical format (e.g. the technical condition/wear given in percentage), as well as information in the nominal format (e.g. the situation/location/zone, designated as for instance “very good”). In turn, at the output we expect the result in the form of a value, which determines the approximate market value of the given property. Based on the information that the network has received for the purpose of learning, provided in the format of an appropriate database (selected as a result of the analysis of the local real estate market) including transaction prices for similar properties and characteristics assigned to them, that artificial neural network is able to perform a regression model that receives the results oscillating close to market value.

In the classification model, the network is designed to allocate the object in question into one of the classes. This model can be helpful in determining whether the profit from the given investment can be classified as, for instance “small”, “medium”, or perhaps “large”. Then, the input information is provided, which may take the numerical format, as well as the information in a nominal format. At the output, we expect a result in the nominal format. Based on the information that the network has received for the purpose of learning, provided in the format of an appropriate database, the artificial neural network is not able to perform a classification model that would produce the precise amount of profit from the given investment [Tadeusiewicz et al. 2007].

![Fig. 3. Regression network](image)

Source: author’s study based on [Tadeusiewicz et al. 2007]

4. Conclusions

The scheme of operation of the linear artificial neural networks, presented herein, shows that these networks can find their application in real estate appraisal and valua-
tion. Considering the fact that the operation of the linear artificial neural networks is possible to predict, and due to the fact that these networks have a simple mathematical description, they should be deployed for property valuation.

Current technologies make it possible to create systems, which facilitate the use of databases for the valuation of property. Please note that in order to prepare the appropriate databases, a detailed analysis of the local real estate market is required, which must be focused on similarities to the property being appraised.

When using the linear artificial neural networks, we must bear in mind that the results obtained by the network are approximate values. Therefore, we need to rescale them properly for the purpose of interpretation.

Further research will be conducted into the application of the linear artificial neural networks for measurement, using the specific examples of real estate properties.

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EDGE EFFECT AND ITS IMPACT UPON THE ACCURACY OF 2D AND 3D MODELLING USING LASER SCANNING

Przemysław Klapa, Bartosz Mitka

Summary

The edge effect is a measurement error resulting from the reflection of the laser beam on the adjacent walls, or by its breaking on the edges. Coordinates of points in such cases are determined by averaging the measurements in several areas, resulting in their incorrect positioning in space. Corner points are determined with the same accuracy as the other (flat) elements of the scanned object. This effect is frequently mentioned in publications, which typically state the reasons and mechanisms of the error thus occurred. However, there is a lack of specific examples, showing the impact of the edge effect on the quality and accuracy of geodetic and cartographic reports. In this paper, the authors present sample case studies of the 2D and 3D representation of the test object. The selected corner elements, as well as the vector elements fitted into a cloud of points, show the discrepancy between the breaking points in the drawing (model), and the curved surface of the point cloud. On the basis of the known geometry of the building, distances were determined between the corner points and their representatives on the cloud. In this way, we were able to determine the accuracy of corner points’ presentation by means of the cloud of points, and therefore, we were able to determine the size of the edge effect in specific cases.

Keywords

Laser scanning • measurement errors • edge effect • cartographic representation

1. Introduction

A number of publications provide information about the measurement errors occurring during laser scanning. The most common of these include: errors related to the impact of the environment on the quality of the measurement; errors derived from a malfunctioning of the instrument; or those resulting from improperly performed observations, for instance, methodological errors.

One of the most common errors that occur during the measurement is the edge effect. We find the explanations of what it is and when it occurs in many published studies. However, there is insufficient literature dealing with the results caused by this type of error, when using the point cloud for geodetic and cartographic studies.
We can distinguish two main types of work involving the vectorization of the point cloud, and performing various kinds of studies on that basis. 2D representations are the first type. These can include, for example: projections, sections of buildings, drawings of elevations or various elements. The second type is the modelling, that is the work that results in developing a 3D model of the given object. In the latter case, the edges are of even larger importance, and their number (compared to the 2D representations) is far greater. Error, in this case no longer refers to the two coordinates (X, Y), but also to the third (Z). This issue is all the more important that especially in the case of historic buildings, or those with rich architectural details, we shall often encounter both sharp edges and curves, and their correct identification will be reflected in the quality of the final result (representation or report). In the article the authors explain, what is the edge effect, where it comes from, and what consequences it entails.

2. Edge effect – its occurrence and its impact on the cloud of points quality

Scanners use mounted rotating mirrors, which reflect the laser beam and perform distance measurements in a certain segment of the surrounding sphere. By conducting the measurement of the angles of the sent beam, the measuring instrument determines the spatial coordinates (X, Y, Z) of points, which reflect the surface of the object being scanned. The cloud of points thus created contains information about: the terrain, the buildings and technical facilities within the range of the scanner’s operation.

The TLS technology (where TLS stands for Terrestrial Laser Scanning) makes it possible to measure the position of the spatial points with an accuracy of several millimetres. The quality of the obtained cloud of points is directly linked to the impact of the various stages of its creation and processing. It also depends on four major factors: the operation of the mechanism of the instrument; the weather conditions; the properties of the surface of the object being scanned; as well as the scanning geometry [Soudarissanane et al. 2011]. The possibilities afforded by the TLS technology are almost limitless. Note, however, that the laser scanning, just like any other geodetic measurement is subject to error, which must be properly defined and classified. The size of the modelled error generated during the measurement is influenced by many factors, both physical and empirical. These can include, among others, the rangefinder error (offset), collimation and inclinations errors, vertical and horizontal index errors, and other cyclical and random errors [Lichti and Licht 2006]. Many studies are conducted aiming at the determination of the calibration parameters of individual scanners, and developing methods of auto-calibration of devices in order to configure measurement parameters in such a way that the measurement can be carried out with the highest accuracy possible [Lichti 2007]. This will allow us to avoid confusion during the measurement studies, as well as provide the appropriate level of accuracy and quality of the generated reports/models.

One of the fundamental characteristics of the scanner is the width of the beam used in the laser instrument, along with its divergence. The latter has a significant impact on the resolution of the point cloud, and on the accuracy of mapping of the measured object.
Laser pointer - formed during the operation of the scanner – when hitting an object, takes a certain value. Since the laser beam is not a point but an ellipse, when it is hampered by the break of the surface, it gets divided into two or more parts (Figure 1). Different grades of breaking from the surface of the object cause various distortions to the exact determination of the location of the laser’s incidence [Cosarca et al. 2008]. When we direct the laser beam to the edge of the break of the object, the result is that only a part of the range of the laser point hits its edge. The remaining part is reflected from the adjacent walls, and it can even go unregistered by the instrument [Boehler et al. 2004].

Fig. 1. Possible situations of the laser beam hitting the edge: the laser point hits simultaneously two or three adjacent walls, in various proportions of surface

The energy of the laser point, reflected from the object, and returning from it, gets recorded. Either based on the time of its return, or based on the information about the phase shift, spatial coordinates are designated, which are incorrectly calculated. This happens, because the information is derived not only from the corner of the element, but also from its surroundings. The averaged result leads to the situation, where the point in the cloud is not in the right place, and thus creates the edge effect. This effect rounds the corners. Information is obtained about locations around the edge, whereby averaged results are given to the points. Then, the latter are entered into the point cloud as an alleged representative of the edge. In the case of TLS technologies, depending on the position of the measuring stand with respect to the object being scanned, the size of such error may vary from a few millimeters to a few centimeters in extreme cases [Boehler et al. 2004].

The size of the edge effect is affected by many factors: beginning with the shape, texture and color of the object being scanned, to the scanning distance, to the type and quality of the scanner. Many examples and experiences drawn from the analysis and
subsequent conclusions can be found in publications by, among others: [Boehler et al. 2004, and Voegtle et al. 2008]. The accuracy and the quality of the obtained point cloud are also affected by the amount of noise that arises during the measurement. Noise is a distributed laser beam, causing interference to the recording of points. Noise can be an additional problem, which in combination with the edge effect causes difficulties in determining the precise position of the corner points of the scanned object. These are usually caused by: bad conditions of the scanning, the surface, texture, or color of the object being scanned that is wrong for the given type of laser. The resulting noise, combined with the edge effect, contributes to difficulties in determining the precise position of the corner points of the scanned object [Soudarissanane et al. 2007].

In the case of the large number of points defining the spatial position of the object in its surroundings, it is almost impossible to precisely register the corner points and edges. These data must be subjected to a modelling process based on a cloud of points, in order to obtain their spatial geometry as well as accurately marked edges and breaking points. It is possible to measure one object from different measurement stations, and subsequently combine the results thereof. It is impossible to obtain exactly the same measurement points. They are only used to supplement the information about the surface of the object. Deviations from the positions of points on the cloud, and the actual dimensions of the object, presented in the form of models, can be identified and measured. In order to do this, we need to know the geometrical parameters of the scanned object. For conducting such experiments, in terms of the best properties, it would be ideal to use an object with a flat surface and well-defined shapes. Therefore, almost any object could be considered provided that it lies within the range of the scanner [Boehler et al. 2004].

3. Research methodology

For the present study, we have used Z + F Imager 5010 and Leica P40 scanners. The first of the scanners was used to scan a fragment of a housing estate within the city, located in the north-eastern part of Kraków. The cloud of points in this area includes within its scope a number of spatial elements, which are located directly in our environment. The second device was used to scan the area of the Comparatorium unit at the University of Agriculture in Krakow, featuring spatial elements with known geometrical parameters. They constitute examples of studies on the elements, which have been carefully measured, and the size of breaking points, as well as exact locations of edges and corners are known. The juxtaposition of these two extremely different types of objects will illustrate what level of edge effect has an impact on the quality and accuracy of geodetic and cartographic modelling.

4. Impact of the edge effect on 2D modelling

Flat (two-dimensional) modelling constitutes the most commonly performed representation in geodesy. This group includes not only maps, performed for various purposes,
but also plans, cross-sections, and elevation drawings of buildings. These drawings are developed using the data points obtained through the work of Total Stations, GPSs, and – increasingly often – also the laser scanning technology. When drawing subsequent items, we use spatial point data, whose positional accuracy is determined using precision analysis. The points, whose location accuracy is too low, are removed from the study, because they do not provide an appropriate accuracy level in terms of the representation of reality.

During the deskwork on collating and reporting the measurements from terrestrial laser scanning, we are able to determine the accuracy of the position for individual points in the cloud. The edge effect introduces some degree of difficulty in mapping individual buildings. In addition to the errors that it carries, it also causes difficulties in obtaining a clear indication of the breaking points and edges of the measured objects.

The figure below (Figure 2) shows a fragment of the plan of the Comparatorium unit at the Agricultural University. The object was scanned using Leica P40 scanner. The facility includes such elements as: measurement pillars; a large rectangular platform, which is a concrete platform used to perform geodetic and measurement studies; and other items that are part of the Comparatorium unit equipment. The aforementioned concrete platform and a measuring pillar were subjected to the analysis. The report on the measurement results, using the cloud of points, was presented in the form of the 2D presentation, which shows the scanned object and its reflection in the form of a portion of the point cloud, with the superimposed geometric model of the object.

![Source: authors’ study](image)

**Fig. 2.** Accuracy of determination of the platform’s edges (fragment of the plan, accuracy analysis of the edges’ fit, view of the studied object)

In Figure 2, attention should be paid to the edges of the concrete platform. In these places there is a noticeable inconsistency of the developed report, compared to the cloud of points. Our knowledge of the elements’ breaking points in these places (that is to say, our knowledge of the geometry of the object) allows us to determine the error that edge effect introduces to the point cloud. The measurement between the tip of
the breaking point (the actual location of the corner points), and the curve of points from the scanning, allows us to determine the accuracy of mapping the position of the measuring points.

An error of several millimetres is a relatively small error, given the well-known geometry of the measured object. This allows for an almost perfect fit with the actual edge.

Another example illustrating this effect is developing the plans of buildings, scanned with the Z+F 5010 scanner. Figure 3 shows a fragment of a representation developed for a number of edges and corners of buildings, as well as the measurement of the difference between the actual position of points (lines of the drawing), and the position of their counterparts in the point cloud.

The white dashed line, indicated in Figure 3, represents the outline of the point cloud, which has been compared with the continuous red line, showing the outlines of the object. The differences between the theoretical position of the object's corner and its counterpart on the cloud of points allowed us to determine the accuracy of mapping the edges. Errors are observed at the level of several millimetres.

Fig. 3. The impact of the edge effect on the accuracy of determining the corner points (fragment of the plan, accuracy analysis of the edges' fit, view of the studied object)

5. Impact of the edge effect on 3D modelling

3D modelling of different types of buildings has become very popular, as a fast and accurate tool to perform a full inventory of objects. Much work has been put into developing automated 3D modelling processes that could use digital maps and the cloud of points obtained from the measurement in order to automatically create objects. With a detailed and dense cloud of points, it is possible to precisely create the actual mapping of spatial objects [Pu and Vosselman 2006, Pu 2008]. Increasingly often, possibilities of auto-fit of the corresponding geometric elements (e.g. the planes) in the cloud of points are being applied. For the latter purpose, algorithms are developed that recognize specific objects in point clouds. In their breaking points and discontinuities, outlines are drafted, representing the edges of the object [Tang et al. 2010]. Unambiguous inter-
interpretation of the edge is difficult due to the occurrence of the edge error – therefore
the intersection of planes helps to determine them unequivocally. The geospatial data,
obtained using laser scanners, serve not only for the creation of 2D and 3D models of
individual objects, but also their larger sets and combinations. Examples of such studies
are presented, among others, in the work of [Arayici 2007].

The edge effect, as shown in 2D representations, here too, has its impact, and that
impact is felt to a greater extent. It does not affect only two edges, but the three, which
contain between them a rounded sphere of points – instead of the designated points
of the edges. In this case especially, we need to pay attention to whether the object has
naturally rounded edges or not. If yes, then the cloud of points, and the developed
model should reflect such rounded edges. If the edge effect occurs, it must be identi-
fied and eliminated from the study. In order to be fully satisfied as to the shape of the
corners and the edges, we need to know the object, or conduct a supplementary scan to
fill in the measurement data, for instance, of the images that contain dubious elements,
or ones that are likely to cause problems at the stage of the further deskwork.

An example of a 3D model of an object of known geometry is the measuring pillar
located in the Comparatorium unit at the University of Agriculture in Kraków. This is
a concrete pillar in the shape of a cylinder with a height of 1.421 [m], and a diameter
of 0.458 [m] with an indent extending through the entire width of the column; indent
dimensions being the following: width – 0.135 [m], height – 0.165 [m].

The marked, actual edges (in the presented model) were compared with the edges
represented by the cloud of points. Figure 4 shows the cloud of points representing
the measuring pillar; the theoretical model of the object; and their comparison, which
made it possible to determine the value of the error arising from the edge effect.

Source: authors’ study

Fig. 4. Determining the value of the edge effect between the 3D model and the cloud of points,
being the image of the measurement pillar
Measuring the pillar is only possible by comparing the measurement between the upper base and the surface of the floor on which the object is embedded. Accurate and precise measurement of the cloud of points representing the edge of the column is made difficult by the rounding of the edges, visible in the cloud of points. Multiple measurements of the individual elements of the pillar, carried out on the basis of the cloud of points, allowed us to determine the dimensions and their respective accuracies. The measurements of the height and the width of the pillar remain in the range of: ± 0.002m with respect to the adopted reference value. The indentation of the pillar is determined with the accuracy of ± 0.004 [m] for the height, and the accuracy of ± 0.002 [m] for the width. The least accurate measurement concerns the indication on the edge of the object, and the determination of the distance between the actual point and the area represented by the cloud of points. The corner of the object, presented in the drawing (Figure 4), has been subjected to comparison. Measurement of the accuracy (result of the edge effect on the developed model) was measured as the distance from the centre of the sphere of the cloud of points (for visualisation purposes, presented as a dashed white line) to the edge represented by the model (the actual edge - marked in green). The error amounting to an average of 8 mm was possible to determine through the modelling of the solid object of known geometrical parameters.

6. Conclusions

Edge effect obstructs the proper determination of the breaking points and corner points of the objects. In the aforementioned publications, you will find information on the impact of various factors on the size of the measurement error. In 2D representations, we can see a varying degree of impact of the edge effect on the accuracy of the drawings as they are developed. In most of these, the error remains in the range of several millimetres. The errors that arise are lesser when we know the exact geometry of the drawn solids, because we have the necessary knowledge about their edges. By drawing the lines denoting the object's plane elements, and combining them together, we are able to properly set the edges. This is not the case, if instead of having sharp edges, the corners are rounded. In the latter case, the knowledge of geometry is necessary in order to avoid an error during the study.

3D modelling, which is a three-dimensional drawing, allows for accurate representation of the scanned object via a three-dimensional solid. The impact of the edge effect influences the quality of the developed representations and reports. Errors of several millimetres typically result from the disappearance of the corner points, which is most particularly felt in the peak points.

To a large extent, in order to avoid errors caused by the edge effect, in the measurements we conduct we should use high quality laser scanners, which register high-resolution cloud of points. The greater the density of the points that map the measured object is, the clearer the selected edges. The material, the texture and the environment all have an impact on the quality of the measurement. Also the amount of noise gener-
ated is of great importance to the precision issues, particularly in the emerging edge
effect, which is formed at each measurement with laser scanners.

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THE ANALYSIS OF CHOSEN FACTORS OF SPATIAL STRUCTURE OF RURAL AREAS IN VILLAGES OF CENTRAL POLAND

Żanna Król, Justyna Wójcik-Leń

Summary

The article presents a spatial analysis of rural areas in 14 villages in the Białaczów commune. The study has focused on land tenure and use as well as land fragmentation in private farms. On the basis of a synthetic fragmentation index of registered parcels a detailed research of private land fragmentation in villages of the Białaczów commune was carried out. The index calculated for each area allowed to distinguishing four types of villages. The types differ according to parcels' fragmentation, a factor that may be one of the criteria in establishing which villages require land consolidation and land exchange works in the first place.

Keywords

spatial structure of rural areas • land fragmentation • land consolidation

1. Introduction

Spatial state of today's village is the result of centuries-old human activity strictly connected with socio-economic relations and natural conditions of each era. To ensure his livelihood, man has been changing his natural landscape, while disregarding negative consequences of his activity. Each change, especially the one related to transformation of a village's spatial structure, is dependent on various factors resulting mainly from natural and structural as well as economic conditions, and from the level of urbanization and investment. The spatial factors include: shape and area of parcels, land ownership and use, land fragmentation and dispersion structure of private farms. Natural site-specific conditions are also important, such as the lie of the land and climatic conditions.

Rural areas in Poland have different spatial parameters depending on the region. For this reason detailed analyses are necessary to determine adequate factors indicating where comprehensive land consolidation and land exchange works are particularly urgent. Such studies essential since rural areas in Poland require deep structural changes, related to both agricultural production as well as size of farms, fields layout, demo-
graphic, spatial and institutional structure [Sobolewska-Mikulska 2009, Sobolewska-Mikulska and Wójcik 2012, Wójcik 2012]. Villages in south-eastern Poland are known for their high parcels’ fragmentation [Leń 2010, Noga and Leń 2010, Leń and Mika 2016a, Siejka et al. 2015]. The research showed that it is where land in private farms is highly dispersed too (external land patchwork). In villages of the Brzozów district every fourth plot owned by private individuals is located in the external land patchwork [Leń 2009, 2012]. In a village located in the Ropczyce-Sędziszów district every fifth plot is owned by an external non-resident owner [Leń et al 2015b]. The study conducted in the Lesko district showed that in Olszanica 32% of plots are owned by external non-resident owners, which is 36% of the total area of the village [Leń et al. 2015a]. The study carried out in the Strzyżów district proved that in the Konieczkowa village 15.8% of all parcels are located in the external land patchwork, which is 17.7% of the total area of the village. On the other hand in the Lutcz village 19.9 of parcels belongs to external non-residents, which is 18.8% of the total area of the village [Leń et al. 2016].

Like in south-eastern Poland, land belonging to private farms in eastern Poland is also highly fragmented. In the Brzeziny village, Puchaczów district, small parcels of 0.11 to 0.2 ha dominate [Król 2014]. As the study showed, the land of private farms is located in the external land patchwork. In the Cyćów commune, Łęczna district, the plots within external land patchwork make 46.1% of all parcels belonging to private land owners in the village. The surface area of land belonging to those who live outside the analysed commune is 5370.6 ha, which is 43.6% of the total area of the studied commune. The total number of external non-residents possessing land in the Cyćów commune is 2671 persons. More than 40% of private farms’ plots is owned by external non-residents [Noga and Król 2016]. Whereas in Cyćów alone, 211 owners (external non-residents) possess 317 register plots of total area 264.89 ha, that is 28.6% of the total area of the village. It turned out that 351 inhabitants in the Cyćów village possess 675 register plots of 874.42 ha [Król and Leń 2016]. Both the dispersion and unfavourable elongation of too small plots impede field works, which increases the costs of farming, related to plots layout, negatively influencing the measurable benefits derived from agricultural production [Król 2014].

The studies conducted in villages of central Poland indicated that, like in eastern and south-eastern Poland, the land of private farms is located in the external land patchwork. In the Sławno commune within the external patchwork of land there are 40.9% of the total area of land in private farms, which make 43.1% of all plots in the private sector [Leń and Mika 2016b,c, 2017]. In the village of Brzustowiec, Drzewica commune, 26.9% of all parcels of private farms belong to external non-residents, which is 23.8% of all the area of private lands [Leń and Mika 2016d].

The goal of the article is to conduct a study of chosen spatial factors, such as the analysis of ownership, use and land fragmentation, with regard to land in private farms. The results will be used to determine the urgency of land consolidation works in the analysed area of central Poland, as it is an opportunity to properly organize the farms, while maintaining the natural environment. Land consolidation works ensure the proper conditions of sustainable and multifunctional development of rural areas by
limiting harmful influence of intensive agriculture on natural environment and also improves living and working standards of rural population [Wójcik and Leń 2015].

2. Characteristics of the research area

The commune Białaczów is located in the Opoczno district, in the south-eastern part of the Łódzkie voivodeship. The register surface area of the commune is 11483.6 ha, which is 11.0% of the total area of the district and 0.63% of the voivodeship. Spatial location of the studied commune is presented in Figure 1.

![Spatial location of the Białaczów commune](image)

**Source:** authors' study

**Fig. 1.** Spatial location of the Białaczów commune

Białaczów is a rural commune, consisting of 14 subdivisions (sołectwo): Białaczów, Kuraszków, Miedzna Drewniana, Ossa, Parczów, Parczówek, Petrykozy, Radwan, Skronina, Sobień, Sędów, Wąglany, Zakrzów, Żelazowice. The commune has diverse natural and landscape values, because it is located in a transitional sphere between the uplands and lowlands. The region is suitable for development of tourism and recreation.

3. Detailed study

In villages of the Białaczów commune natural persons have the highest share in the ownership structure, the study shows. The surface area of private farms is 7690.1542, which is 67.0% of the whole area of the studied commune. Their percentage share across villages is diverse and ranges from 17.52% in Ossa to 94.3% in Żelazowice. The share of land in private farms that exceeds 90% was noted in Sędów (94.1%), Radwan
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<th>No.</th>
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<th>Total area of land [ha]</th>
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<th>Land of companies wholly owned by the State Treasury, by state enterprises or other state legal entities.</th>
<th>Land of communes and intercommunal unions, excluding land given to perpetual usufruct</th>
<th>Land of communes and intercommunal unions given to perpetual usufruct</th>
<th>Land of natural persons</th>
<th>Land of cooperatives</th>
<th>Land of churches and religious associations</th>
<th>Land of land communities</th>
<th>Land of districts, excluding land given to perpetual usufruct</th>
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</table>

Source: authors' study based on data from Land and Building Register (EGiB)
The State Treasury land represents 28.7% (3299.7 ha), and it is mainly land belonging to Agricultural Property Agency of Treasury and The State Forests National Forest Holding. This hierarchy is maintained in every village, with the exception of Ossa, where the share of natural persons’ land is only 17.5% (159.2%), whereas the State Treasury possess as much as 80.97% (735.8600 ha). In Białaczów and Miedzna Drewniana the share of these two register groups is relatively balanced. In every village of the studied commune the remaining register groups cover small areas.

The spatial ownership structure in the villages of Białaczów commune is illustrated in Figure 2.

![Legend](image)

Source: authors’ study made in QGIS software

**Fig. 2.** Spatial image of land ownership structure

The study of the ownership structure shows (Table 2) that the Białaczów commune is a typically agricultural area, with domination of cultivated land (54.16%), the largest part of which is arable land (40.23%), and the smallest share belongs to the land under ditches (0.19%). Another significant group are forest land and land planted with trees and shrubs, making 31.39%, out of which 41.11% is forest land, whereas land planted with trees and shrubs covers the remaining 0.28%. The overall share of developed and urbanized land is 3.07%, the largest part of which were roads (2.44%), and the smallest – industrial areas (0.01%). Land under water covers 1.35% of all the area, out which 0.31% are surface flowing waters, and 1.03% surface stagnant waters. The lowest percentage share in the structure of land use belongs to ecological land (0.02%) and various land (0.01%). The ways of using lands depend on climatic conditions, location
and lie of the land, and these are relatively favourable in the analysed commune. More than two thirds of private farms, occupying altogether 7689.7 ha, exercise only agricultural activity. In the commune recreational and rural tourism activity is also practised, a consequence of high afforestation rate and the use of water reservoirs for recreational purposes. Roads also play an important role in the structure of land use. Their route influences not only the location of buildings but also access to fields from farmsteads. The spatial image of land use in villages of the Białaczów commune is presented in Figure 3.

![Figure 3. Structure of land use in studied villages](source)

The analysis of land fragmentation was carried out with regard to land belonging to private farms (Table 3). The study covered 14573 register plots, or 79.3% of total number of plots in the studied commune. From the data presented in Table 3 it can be concluded that most plots, 34.6% of their total number, are the ones with an area from 0.11 to 0.30 ha. The percentage share in this range is very diverse and fluctuates from 21.7% in Kuraszków village, up to 45.8% in Parczówek village. The studies show that the share of plots in specific surface range in each village is very diverse.
Table 2. Structure of land use in the Białaczów commune

<table>
<thead>
<tr>
<th>No.</th>
<th>Village</th>
<th>Total area of land [ha]</th>
<th>Agricultural land</th>
<th>Forest land, land planted with trees and shrubs</th>
<th>Developed and urbanized land</th>
<th>Land under water</th>
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<tbody>
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<td></td>
<td></td>
<td></td>
<td>Arable land</td>
<td>Permanent pastures</td>
<td>Developed agricultural land</td>
<td>Land under ditches</td>
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<td>0.9</td>
<td>0.3</td>
<td>29.4</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>11483.6</td>
<td>4620.0</td>
<td>99.9</td>
<td>690.5</td>
<td>465.8</td>
</tr>
<tr>
<td></td>
<td>Percentage share of land use h</td>
<td>40.23</td>
<td>0.87</td>
<td>6.01</td>
<td>4.06</td>
<td>2.24</td>
</tr>
</tbody>
</table>

Source: authors’ study based on data from Land and Building Register (EGiB)
### Table 3. The number of plots in particular area range

<table>
<thead>
<tr>
<th>No.</th>
<th>Village</th>
<th>No. of plots in private farms</th>
<th>Surface ranges of plots [ha]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>to 0.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No. %</td>
</tr>
<tr>
<td>1</td>
<td>Białaczów</td>
<td>1712</td>
<td>555</td>
</tr>
<tr>
<td>2</td>
<td>Kuraszków</td>
<td>437</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>Miedzna Drewniana</td>
<td>1428</td>
<td>552</td>
</tr>
<tr>
<td>4</td>
<td>Parczów</td>
<td>816</td>
<td>57</td>
</tr>
<tr>
<td>5</td>
<td>Parczówek</td>
<td>1804</td>
<td>547</td>
</tr>
<tr>
<td>6</td>
<td>Petrykozy</td>
<td>600</td>
<td>69</td>
</tr>
<tr>
<td>7</td>
<td>Radwan</td>
<td>647</td>
<td>157</td>
</tr>
<tr>
<td>8</td>
<td>Skronina</td>
<td>1370</td>
<td>88</td>
</tr>
<tr>
<td>9</td>
<td>Sobień</td>
<td>1144</td>
<td>187</td>
</tr>
<tr>
<td>10</td>
<td>Sędów</td>
<td>746</td>
<td>47</td>
</tr>
<tr>
<td>11</td>
<td>Wąglany</td>
<td>1256</td>
<td>441</td>
</tr>
<tr>
<td>12</td>
<td>Zakrzów</td>
<td>588</td>
<td>52</td>
</tr>
<tr>
<td>13</td>
<td>Żelazowice</td>
<td>1472</td>
<td>291</td>
</tr>
<tr>
<td>14</td>
<td>Ossa</td>
<td>553</td>
<td>205</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>14573</strong></td>
<td><strong>3261</strong></td>
</tr>
</tbody>
</table>

Source: authors’ study based on Land and Building Register (EGiB)

The area of plot is decisive of labour input. In the EU countries the surface area of plots ranges from 0.8 to 10.0 ha. The scope of this diversity depends mainly on the surface area of a farm and its specialization, degree of mechanization of field works, lie of the land and field invariants. With the increase of a plot’s area the work becomes less time-consuming and deduction in plot's value is smaller [Noga 2005]. Detailed characteristics of plots’ area in the villages of the Białaczów commune is presented in Table 4.

### Table 4. The area of private farms

<table>
<thead>
<tr>
<th>No.</th>
<th>Village name</th>
<th>Area of plots in private farms</th>
<th>Area range of plots [ha]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>to 0.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No. %</td>
</tr>
<tr>
<td>1</td>
<td>Białaczów</td>
<td>1150.0</td>
<td>28.3</td>
</tr>
<tr>
<td>2</td>
<td>Kuraszków</td>
<td>462.9</td>
<td>1.1</td>
</tr>
<tr>
<td>3</td>
<td>Miedzna Drewniana</td>
<td>485.1</td>
<td>27.9</td>
</tr>
<tr>
<td>4</td>
<td>Parczów</td>
<td>536.7</td>
<td>3.9</td>
</tr>
<tr>
<td>5</td>
<td>Parczówek</td>
<td>517.4</td>
<td>28.5</td>
</tr>
</tbody>
</table>
The study showed that the highest percentage (43.3%) are plots larger than 1.0 ha. Their area is 3136.0 ha. The percentage varies greatly according to a village and it ranges from 15.9% in Parczówek, up to 72.8% in Kuraszków. Plots up to 0.10 ha constitute only 2.5% of the total land area of private farms. In five villages the analysed area range is smaller than 1% of the overall area. The spatial image of land fragmentation in private farms, with respect to area of plots, is illustrated in Figure 4.

![Fig. 4. Land fragmentation in private farms](image-url)
To acquire more specific and detailed results a synthetic index of land fragmentation in all villages of the Białaczów commune has been calculated according to a formula presented in Noga and Leń [2010]. On the basis of the calculated synthetic measure 4 types of villages were singled out. First with a value to 3.50; second in the range 3.51–4.00; third from 4.01 to 4.50, and fourth – above 4.51. The ranges assigned to each village, together with the value of land fragmentation index, is presented in Table 5.

Table 5. Land fragmentation index in the Białaczów commune

<table>
<thead>
<tr>
<th>Village</th>
<th>Fragmentation index</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parczówek</td>
<td>3.16</td>
<td>I</td>
</tr>
<tr>
<td>Wąglany</td>
<td>3.31</td>
<td>I</td>
</tr>
<tr>
<td>Ossa</td>
<td>3.34</td>
<td>I</td>
</tr>
<tr>
<td>Miedzna Drewniana</td>
<td>3.50</td>
<td>I</td>
</tr>
<tr>
<td>Skronina</td>
<td>3.63</td>
<td>II</td>
</tr>
<tr>
<td>Sędów</td>
<td>3.68</td>
<td>II</td>
</tr>
<tr>
<td>Żelazowice</td>
<td>3.71</td>
<td>II</td>
</tr>
<tr>
<td>Radwan</td>
<td>4.06</td>
<td>III</td>
</tr>
<tr>
<td>Zakrzów</td>
<td>4.09</td>
<td>III</td>
</tr>
<tr>
<td>Parczów</td>
<td>4.10</td>
<td>III</td>
</tr>
<tr>
<td>Petrykozy</td>
<td>4.15</td>
<td>III</td>
</tr>
<tr>
<td>Sobień</td>
<td>4.20</td>
<td>III</td>
</tr>
<tr>
<td>Białaczów</td>
<td>4.24</td>
<td>III</td>
</tr>
<tr>
<td>Kuraszków</td>
<td>4.54</td>
<td>IV</td>
</tr>
</tbody>
</table>

Source: authors’ study

The above classification is aimed at singling out villages with similar spatial structure and determining the variation degree in the commune and consequently establishing the demand for comprehensive works of land consolidation and exchange. The set of features typical of particular villages and their percentage share allowed to make general characteristics of the studied area.

Table 6 and Figure 5 show that the first type of villages consist of 4 villages of total area 1542.85 ha and has the second highest share in total number of plots in the commune. The mean area of plots in this area range is the smallest with 0.31 ha. The second type consists of villages located close to borders of the commune, and takes more than 20% both of the total area and number of plots in the studied area. The most numerous group are villages belonging to the third area range. It consists of 6 villages...
taking up almost 50% of the total area of the commune and nearly 40% of total number of its plots. These villages are mainly Białaczów and neighbouring ones: Zakrzów, Parczów and Petrykozy. The highest value of fragmentation index, belonging to the last type, was noted in Kuraszków, the village up to the north-east, with the lowest number of plots in private land.

Table 6. Characteristics of selected types of villages

<table>
<thead>
<tr>
<th>Village type</th>
<th>Villages of one type</th>
<th>Area of villages of one type</th>
<th>Plots of one type</th>
<th>Mean area of plots [ha]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No. [ha]</td>
<td>%</td>
</tr>
<tr>
<td>I</td>
<td>4</td>
<td>28.57</td>
<td>1542.85</td>
<td>21.29</td>
</tr>
<tr>
<td>II</td>
<td>3</td>
<td>21.43</td>
<td>1671.81</td>
<td>23.07</td>
</tr>
<tr>
<td>III</td>
<td>6</td>
<td>42.86</td>
<td>3569.82</td>
<td>49.26</td>
</tr>
<tr>
<td>IV</td>
<td>1</td>
<td>7.14</td>
<td>462.94</td>
<td>6.39</td>
</tr>
<tr>
<td>Razem</td>
<td>14</td>
<td>100.00</td>
<td>7247.42</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Source: authors’ study

Fig. 5. Spatial variation of land fragmentation index in villages of the Białaczów commune

Source: authors’ study
4. Conclusions

The conducted studies showed that not only southern or south-eastern Poland require spatial restructuring of rural areas. The analysis indicated that land of central Poland is characterized by very high percentage of land belonging to private farms. In 50% of studied villages private land constitutes 80% of their total area. In four cases the percentage reached over 90%. In the structure of land use the studied area is highly diverse. Arable land constitutes more than 40% of the total area of the commune, while forest land covers 41.1%. The study on land fragmentation in private farms showed that land fragmentation is considerably smaller in comparison with land of private farms located in the south and south-eastern Poland. The analysis revealed very high diversity in particular villages of the studied area. Therefore it was necessary to calculate the synthetic land fragmentation index, that was used to classify villages into types, and this allowed to notice relationships and similarities occurring in the studied area and to assess the state of plots' fragmentation in the private sector. The obtained value of the synthetic index of fragmentation will be one of many factors taken into consideration in determining the urgency of land consolidation works in villages in the Białaczów commune. It is noteworthy that plots in private farms of the Białaczów commune have a very flawed geometry, because of their excessive elongation.

References


GIS-BASED ASSESSMENT OF THE FEASIBILITY OF SOLAR ENERGY APPLICATIONS, IN THE CASE OF ŁAZY VILLAGE

Tomasz Stachura, Mateusz Krzyś

Summary
The aim of the study was to evaluate the potential of solar plots in Łazy village, located in the municipality of Jerzmanowice-Przeginia, in terms of suitability for the construction of solar power plants of 4 different sizes: large, medium, small and micro. As a part of the study, the modelling of solar radiation and spatial analyses were performed, using the ArcMap 10.3.1 and QGIS 2.8.1. Wien software. The entire test area was divided into 4 classes, according to the isolation potential. The end result consists of maps showing the land with best prospects for solar investments. We have also presented the evaluation of the possibility for obtaining solar energy via photovoltaic panels located on the roofs. Within the village of Łazy, we have identified 63% of the parcels, of which at least 80% enjoy good or very good solar conditions, that is to say, during the year, the solar radiation for these places exceeds 960 kWh · m⁻².

Keywords
modelling of solar energy • GIS • photovoltaics (PV)

1. Introduction and aims of the study
Traditional methods of obtaining electricity will soon be exhausted, because the supply of minerals is limited. Furthermore, the production of energy from such raw materials is becoming increasingly expensive, and remains disadvantageous to humans, as large quantities of dust and harmful gases escape to the atmosphere during its production. Thus the growing demand for the proliferation of alternative methods of obtaining energy. Among the latter, the most common is solar energy. It is ubiquitous, inexhaustible and free. The surface of Poland is reached by approx. 1000 kWh · m⁻² · year⁻¹. Compared to the rest of Europe, this is an average result, however it is completely sufficient for the acquisition of solar energy to be profitable [Kołodziej and Matyka 2012].

In addition, energy received from solar radiation is environmentally friendly, and its production does not emit any harmful gases. CO₂ reductions have already been imposed on the EU Member States, and by 2020, the emissions are to be reduced by about 30% [Dyrektywa… 2009]. The development of alternative sources of energy is therefore an extremely important aspect for us, as currently in Poland, the most energy
is produced from coal. During the combustion of the latter, large quantities of carbon dioxide and particulate matters are emitted. This has had a heavy impact on the city of Krakow and the surrounding villages, where air pollution norms are frequently exceeded [www.radiokrakow.pl 2016]. Therefore, we should aim at the fullest possible use of alternative energy sources.

Using the solar energy, we can produce both electricity and heat. Electrical energy is obtained by means of photovoltaic panels [Chaar et al. 2011], while the heat energy is obtained from solar collectors [Rylatt et al. 2001]. The energy use of these devices, however, depends largely on the insolation, and therefore it is very important to choose a suitable location for the construction of solar energy installations [Sabó et al. 2016].

In order to determine the best places, reached by the most solar energy, we carry out the modelling of solar radiation, which can be performed for each and any area on Earth, provided that we have the right model and data set [Wong 2016, Brewer 2015].

The aim of the present study was to:

- prepare maps showing the variability of solar radiation in time, within the studied area,
- check the suitability of the plots within the village of Łazy with the view to the construction of solar power plants in 4 different sizes: large, medium, small, and micro,
- assess the possibility of obtaining solar energy through photovoltaic panels, which can be located on the roofs in the village of Łazy.

2. Methodology

The basic primer used for the analyses was a digital terrain model (DTM) with a resolution of 30 m, that is, one pixel in the field has dimensions of 30 m × 30 m. The DTM has been downloaded from the http://earthexplorer.usgs.gov (accessed 12.2015).

Then, using the ArcMap 10.3.1 software and its available tool of “Area Solar Radiation”, we have drawn maps of annual and monthly totals of solar radiation.

The modelling of solar radiation was performed using the algorithm adapted for the GIS by P. Rich [1994]. In its operation, the algorithm takes into account the exposure of the area, the relative heights, the gradients, the veiling (shadowing) of the horizon, the diffuse reflection factor and the degree of transparency, among other factors. The result is calculated based on a digital terrain model for each pixel separately (Figure 1) [Wojkowski 2007].

Map of the veiling of the horizon (Viewshad) was established by determining, for each point, the vertical angle in 32 geographical directions; and on that basis, by creating the lines of the veiling (shadowing) of the horizon (Figures 2, 3).

By applying astronomical formulas, a map is created showing the position of the Sun (SunMap) consisting of sectors representing the position of the Sun every half hour for the day (east-west axis in the figure), and in monthly intervals for the year (north-south axis in the figure). The map is drafted in the same system as the map of the veiling (shadowing) of the horizon, and therefore the two can be superimposed on
one another, thus presenting the actual journey of the Sun across the horizon during the day, and throughout the year, at a given point. We thus obtain information about direct radiation. The colours used are only intended to illustrate the multiplicity and diversity of sectors (Figure 4).

Source: [Stachura 2009]

**Fig. 1.** Algorithm for the calculation of solar radiation


**Fig. 2.** Horizontal angles
The map of the sky sectors (SkyMap) is obtained by dividing the hemisphere of the sky above the horizon into 16 azimuth sectors and 8 zenith districts (Figure 5). It provides us with information about the diffused radiation. Quantitative parameters of the sectors can be freely changed in the software. In the present analysis, 8 azimuth divisions and 8 zenith divisions were introduced.

Other parameters may also be subject to change. The following are the parameters used in the ArcMap for the purpose of analysing the sum of total solar radiation in 2014. These include: latitude, resolution, the period of analysis, hourly interval, Z axis multiplier, the number of geographical directions, in which the angle of the veiling of the horizon will be measured, the number of zenith and azimuth sectors, as well as diffuse reflection factor and transparency factor (Table 1).
Table 1. Parameter used for calculating solar radiation totals

<table>
<thead>
<tr>
<th>Data entered into the ArcMap software</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolution</td>
<td>200</td>
</tr>
<tr>
<td>The period of analysis</td>
<td>Whole year, in monthly intervals</td>
</tr>
<tr>
<td>Data</td>
<td>Year 2014</td>
</tr>
<tr>
<td>Topographical parameters</td>
<td></td>
</tr>
<tr>
<td>Z axis multiplier</td>
<td>1</td>
</tr>
<tr>
<td>The number of geographical directions</td>
<td>32</td>
</tr>
<tr>
<td>Radiation parameters</td>
<td></td>
</tr>
<tr>
<td>The number of zenith sectors</td>
<td>8</td>
</tr>
<tr>
<td>The number of azimuth sectors</td>
<td>8</td>
</tr>
<tr>
<td>Diffuse reflection factor</td>
<td>0.3</td>
</tr>
<tr>
<td>Transparency factor</td>
<td>0.3</td>
</tr>
</tbody>
</table>

2.1. Classes of insolation potential

In order to assess the suitability of different areas for the construction of solar power plants most effectively, it was decided that the studied village should be subjected to a detailed valuation. The subdivision of the area into the so-called classes of insolation potential was introduced, based on the elaboration by Stachura [2009]. The method assumes that the energy obtained from photovoltaic panels would be used by the device
found in every home, and working on a continuous basis – in this case, a refrigerator. The average power consumption of the latter was rated at 3.3 kW. Then, the sum of daily solar radiation was divided by the daily power demand, which produced the value of the ratio, showing the coverage of the demand for electricity. In this manner, six grades were set, from A to F (Table 2).

Table 2. Classes of insolation potential according to Stachura [2009]

<table>
<thead>
<tr>
<th>Classes of insolation potential</th>
<th>Description of the insolation potential class</th>
<th>Value of the ratio of coverage of the demand for electrical energy</th>
<th>The amount of solar energy [kW · m⁻²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Very good</td>
<td>≥ 1.0</td>
<td>&gt; 1200</td>
</tr>
<tr>
<td>B</td>
<td>Above good</td>
<td>0.9–1.0</td>
<td>1080–1200</td>
</tr>
<tr>
<td>C</td>
<td>Good</td>
<td>0.8–0.9</td>
<td>960–1080</td>
</tr>
<tr>
<td>D</td>
<td>Sufficient</td>
<td>0.7–0.8</td>
<td>840–960</td>
</tr>
<tr>
<td>E</td>
<td>Satisfactory</td>
<td>0.6–0.7</td>
<td>720–840</td>
</tr>
<tr>
<td>F</td>
<td>Non-satisfactory</td>
<td>&lt; 0.6</td>
<td>&lt; 720</td>
</tr>
</tbody>
</table>

Variations have been introduced to the above method, by reducing the number of classes and changing their names, while retaining the border values (Table 3).

Table 3. Classes of insolation potential applied in the studied area

<table>
<thead>
<tr>
<th>Classes of insolation potential</th>
<th>The amount of solar energy [kWh · m⁻²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very good (A)</td>
<td>&gt; 1080</td>
</tr>
<tr>
<td>Good (B)</td>
<td>960–1080</td>
</tr>
<tr>
<td>Average (C)</td>
<td>840–960</td>
</tr>
<tr>
<td>Poor (D)</td>
<td>&lt; 840</td>
</tr>
</tbody>
</table>

2.2. Selection of plots for the construction of a solar power plant

The analysis of suitable locations for the construction of photovoltaic installations was based on the vectorized plots, located within the village of Łazy. Then the plots were divided into 4 surface (area size) classes, depending on what type of facilities could be potentially fitted there (Table 4). The installations were divided according to the law on renewable energy sources [Ustawa… 2015]. The division is as follows:

- large solar power plants, generating capacity of more than 1MW,
- medium-sized solar power plants, generating power from 200 kW to 1MW,
small solar power plants, with a power of 40 kW to 200 kW,
- micro power plants, with a capacity of up to 40 kW,
- In addition, for the purpose of the present study, micro-installations on roofs with the capacity up to 10 kW have been distinguished.

Table 4. Subdivision of solar installations and their areas

<table>
<thead>
<tr>
<th>Subdivision of solar installations</th>
<th>Nominal power of the plant [kW]</th>
<th>Required area size [m²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td>&gt; 1000</td>
<td>&gt; 20000</td>
</tr>
<tr>
<td>Medium</td>
<td>200–1000</td>
<td>4000–20000</td>
</tr>
<tr>
<td>Small</td>
<td>40–200</td>
<td>1000–4000</td>
</tr>
<tr>
<td>Micro</td>
<td>&lt; 40</td>
<td>&lt; 1000</td>
</tr>
</tbody>
</table>

It has been determined that the classes of insolation potential marked as “very good” (A) and “good” (B) are suitable for solar energy investment projects, and therefore it was decided that plots located in such areas should be selected. To this end, the QGIS 2.8.1 Wien software was used, and by applying the geo-processing tool along with the “product” function, the intersection of admissible classes (i.e. “very good” and “good”) and the plots the village of Łazy was obtained.

3. Results
3.1. Solar radiation totals

On the basis of the solar radiation modelling, we have created a map showing spatial distribution of the annual solar radiation. In the village of Łazy, the annual amount of radiation ranges from 594 to 1153 kWh · m⁻² (Figure 6).

We noted that the highest solar radiation in the village of Łazy was recorded in July, remaining in the range of 126.7–171.9 kWh · m⁻², while the smallest radiation was received in December, and ranged from 2.7 to 12.7 kWh · m⁻² (Figure 7).

Within the Łazy village, the biggest surface is occupied by areas with “good” insolation potential class – namely, 441 ha; then, the “average” class occupies 111 ha; followed by “very good” class – occupying 33 ha; with the remaining class of “poor” only at 6 ha (Figure 8).

Overall, in the village of Łazy, there are 17 plots with area size greater than 2 hectares, which is suitable for the construction of large power plants. Also, there are 463 medium-sized plots, 579 small plots, and 152 micro plots (Figure 9, Table 5).
Source: author’s study (M. Krzyś)

Fig. 6. Annual solar radiation

Source: author’s study (M. Krzyś)

Fig. 7. Maximum and minimum monthly intervals of solar radiation
Fig. 8. Classes of insolation potential. “Very good” class when insolation exceeds 1080 kWh · m⁻², “good” class (960–1080 kWh · m⁻²), “average” class (840–960 kWh · m⁻²), “poor” class (less than 840 kWh · m⁻²)

Fig. 9. Subdivision of plots according to area size
Table 5. Subdivision of plots according to the size of the planned power plant.

<table>
<thead>
<tr>
<th></th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>---</td>
<td>--------</td>
</tr>
<tr>
<td>Large</td>
<td>17</td>
</tr>
<tr>
<td>Medium</td>
<td>463</td>
</tr>
<tr>
<td>Small</td>
<td>579</td>
</tr>
<tr>
<td>Micro</td>
<td>152</td>
</tr>
<tr>
<td>Total</td>
<td>1211</td>
</tr>
</tbody>
</table>

Having performed the analysis, the plots were designated, which are located in their entirety within the areas of classes A and B, and those where at least 80% of the surface of the plot overlaps with the aforementioned classes. The construction of power plants on those parcels is the most profitable. Table 6 summarizes the quantity and the surface area of plots belonging to particular classes. Also included is the information on the annual total radiation, reaching the area of these plots. The biggest amount of radiation, that is as much as 190.07 MWh · year⁻¹, reaches the area of medium-sized plots, due to the fact that they occupy the largest area. The least radiation reaches the area of micro plots, and is equal to 7.56 MWh · year⁻¹.

Table 6. Quantitative and area size Summary of plots, post-analysis.

<table>
<thead>
<tr>
<th></th>
<th>Number of plots</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Located in their entirety within the area of insolation potential classes A and B</td>
</tr>
<tr>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>---</td>
<td>--------</td>
</tr>
<tr>
<td>Large</td>
<td>17</td>
</tr>
<tr>
<td>Medium</td>
<td>463</td>
</tr>
<tr>
<td>Small</td>
<td>579</td>
</tr>
<tr>
<td>Total</td>
<td>1211</td>
</tr>
</tbody>
</table>

In addition, analysis was also performed of the roofs of the buildings, with the view of mounting photovoltaic panels thereon. 351 roofs in the village of Łazy have been vectorized. Then, similarly as this was done with the plots, the layer of roofs was compared to the layer of the insolation classes, thus obtaining the sets of roofs belonging in the classes described as “very good”, “good” and “unsuitable for investment.” Because, against the background of the whole village, the roofs shown on the map are poorly visible due to their small size, we decided to present only a fragment of the area, occupied by the largest number of these (Figure 10). Below we present a quantitative...
list (Table 7), and the percentage of roofs in each class of insolation potential (Figure 5). The vast majority, that is 88% of the roofs, lie within the area of “good” or “very good” conditions for the installation of photovoltaic panels. In 12% of roofs, micro installations would not be justified.

Table 7. Quantitative list of roofs in respective insolation potential classes

<table>
<thead>
<tr>
<th>Insolation potential class of roofs</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very good</td>
<td>19</td>
</tr>
<tr>
<td>Good</td>
<td>290</td>
</tr>
<tr>
<td>Insufficient</td>
<td>42</td>
</tr>
<tr>
<td>All</td>
<td>351</td>
</tr>
</tbody>
</table>

Source: author’s study (M. Krzyś)

Fig. 10. Analysis of roofs with the view to the installation of photovoltaic panels

4. Conclusions

The analyses we have carried out lead us to the conclusion that, in the village of Łazy, we can find a lot of favourable sites, suitable for the construction of solar power plants of different sizes, that is, large, medium and small or micro-installations. The results we obtained may be useful for future investors.
According to the analyses we have performed, the construction of large power plants would be reasonable (i.e. with at least 80% of the area located within class A and B of the insolation potential) in 3 plots; the average-sized power plants could be installed in 251 plots; while the small ones could be fitted in 342 plots, and micro power plants in 107 plots. Micro photovoltaic installations could be justified on as many as 309 roofs.

Installations using the energy produced from solar radiation in the period between April and September present a good alternative compared to fossil fuels. Using the example of the Lazy village, we have demonstrated that there exist many attractive and indeed optimum locations for that purpose.

Inventories of solar energy are inexhaustible, and after bearing the cost of the investment, we can profit from relatively cheap energy. It is necessary, however, to bear that initial investment cost of the construction, in order to be able to enjoy the cheap – and above all – “green” energy. If funds were to be found for the construction of such power plants, we could significantly improve the quality of air, and reduce the cost of energy production in the future.

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TERRITORIAL JUSTICE FOR URBAN AND RURAL REGIONS? ABOUT THE RESPONSIBILITY AND ROLE OF THE BAVARIAN ACADEMY FOR RURAL AREAS

Holger Magel

Summary

The article describes the one-sided global discussion on urbanization, conducted without developing sufficient future-oriented comprehensive visions and strategies for rural areas. The concepts discussion concerns mostly agriculture; while there is nearly nothing being said about establishing central places, or nurturing small and medium-sized enterprises (SME) in rural areas. Europe and Germany still believe in the principle of cohesion and the goals of the Territorial Agenda 2020 in endogenously developed rural areas, despite some controversial discussions about the need and outcome of specific and even enhanced strategies and measures in shrinking peripheral regions. It is not primarily a question of economy to support rural areas, but it is first and foremost a question of human rights, dignity and territorial justice. The constitutional demand of equivalent living conditions in Germany is a visible expression and result of territorial justice. Fortunately, this issue of justice is now a hot matter of political discussion in the Bavarian Parliament.

In the second part of the article, the indispensable roles and contributions of civil society and NGOs as independent partners and co-producers of the State are described – such as the Bavarian Academy.

Keywords

Equivalent living conditions • territorial justice • Enquete Commission • urban-rural cooperation • integrated rural development • active civil society • home-country strategy • independent academy for rural areas

1. As a preliminary point – why was only an urban summit organized?

During Oct. 17–20, 2016 in Quito, a South American city, a big world Summit on Housing and Sustainable Urban Development took place, under the name Habitat III. Many problems were discussed there, but mostly the opportunities for cities in the era of urbanization, and the idea of ‘smart city’ as a vital space for living and economy, and as a machine of growth and prosperity. The concept of the ‘right to the city’ was also formulated.
Similarly, the world of real estate looks on larger and growing cities. In the ‘Daily News’ of the Munich ‘Expo Real’ dated 4 October 2016, the President of Polish Echo Investment Nicklas Lindberg spoke of the ‘growing urbanization in Poland’ and the appearance of a (new) creative class and creative enterprises associated with this. The term ‘city’ in his opinion is synonymous with ‘creativity’.

And the rural areas? Were they ever mentioned? What about the right to rural life?! At Expo Real, there was almost zero discussion about it. Habitat III talked about urban-rural relations, but unfortunately only from urban perspective.

One would like to ask and call: Where is the UN World Summit on Rural Areas? There is nothing like this; we only find individual views and reports by the World Bank, the International Fund for Agricultural Development (IFAD) and the UN Food and Agriculture Organization (FAO) which are mainly about agricultural development, effects of climate change, buffer zones for flood protection etc. Globally, there is no common overall vision of urban and rural and of cities and villages. Unfortunately, neither do the Sustainable Development Goals (SDG) offer such a vision; not in a specific or convincing manner.

We are fortunate, as the EU has at least a holistic view on space, city and countryside. It can be inferred from the Territorial Agenda 2020\(^1\), or from the (not legally binding) Declaration of the Cork 2.0 Conference in September 2016\(^2\). It is a matter of pride that long before the EU, Germany and Bavaria adopted such a comprehensive look as the basis for all spatial policies and strategies undertaken for rural areas. Therefore, they have a lot of experience, which is helpful for all European neighbour countries, and even for e.g. China or Cambodia.

It is all about the Four Goals of European Territorial Planning:

1. Embedding and co-ordination of national spatial planning (Raumordnung) and spatial development (Raumentwicklung) within the European framework (e.g. TEN\(^3\)), based on the idea of a balanced and polycentric urban system.

2. Strong and vital cities.

3. Indigenous development, diverse and productive rural areas.

4. Rural-urban cooperation.

It is important to note that Europe, especially Bavaria, still believes in the ‘Central Place Theory’ by Walter Christaller, i.e. a functioning, hierarchically decentralized network of

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3 The Trans-European Networks (TEN) were created by the European Union by Articles 154-156 of the Treaty of Rome (1957), with the stated goals of the creation of an internal market and the reinforcement of economic and social cohesion https://en.wikipedia.org/wiki/Trans-European_Networks (accessed: 19.11.2016).
large, medium and small central cities in urban/agglomeration regions and rural areas. Talking about increasing urbanization all over the world, it refers to an increase in all categories of central localities, not only an increase of major or even mega cities, as it is suggested unfortunately many times at the global level, especially also in China.

2. Territorial justice – a real and substantial task for policy

It is worth noting that the German Constitution (Art. 72 paragraph 2), and especially the Federal Spatial Planning Act (Raumordnungsgesetz⁴) entail the goal of equivalent living conditions in all regions throughout the country. Nevertheless, urban and rural areas, which have developed in Germany separately from each other, are producing a growing gap between prosperous and weak parts of the country. Organization for Economic Co-operation and Development (OECD) provides regular statistical data in this respect. Also England and other European countries face the same problems. Rural areas with medium and small cities and municipalities, including the villages, especially in the case of mono or old industrialized structure and obsolete economy or unfavourable spatial location, continue to decline further. Demographic problems, such as aging population, declining birth rates and migration of young, well-educated people, and especially women, give the green light to a vicious circle (Figure 1).

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In the present situation, some economists and scientists advise the State against further investment and financial support for those areas, and in favour of the transition to the stand-by function, which is equivalent to a decrease in the minimum standards and expectations. They suggest to rely on strong regions and their large, medium and small cities, and to hope for the so-called spill over-effect on the surrounding rural communes and villages. However, recent studies – for example in Finland – shake the foundation of faith in this approach [Lehtonen et al. 2015].

Whether government supports only cities and / or rural areas: since long more and more opinions prevail, which indicate that the State cannot regulate everything any more (“father model of the State”); instead, local and regional activities and self-help principle must be assumed as the basis. This is expressed in a new spatial planning paradigm (*neues Raumordnungsparadigma*) marked by the growing “Active Civil Society”, which has become more self-confident, better informed, and better educated. The point is to agree on the appropriate infrastructure equipped with the negotiation processes between the State and the citizens. We call this a new joint responsibility community ("Bürgerkommune"), which sees the State as the “activator” and “enabler” through support (help) for self-help, and the citizens, NGOs and the business sector are considered as equal partners and co-producers, who take on more responsibility within their capabilities (Figure 2) [Glück and Magel 2000].

"Bürgerkommune” and Active Civil Society

**From**

Paradigm citizen as subject

Authoritative municipality

Citizen as a subject

Paradigm citizen as client

Entrepreneurial State

Service provider municipality

Citizen as a client

**To**

Paradigm citizen as partner and Co-producer

Activating and enabling state and Active Civil Society

Public authorities, institutions

Planners, experts

“Bürgerkommune”: joint responsibility of local politicians, local administration and civil society

Local government officials

Local government councils

Citizens and their NGO’s

Business sector

Source: author’s study. Copyright: Magel 2017

Fig. 2. The new paradigm of Active Civil Society
However, if the differences between the regions are too large, it is apparent that the poor regions will not cope. In that case, the State must take over the role of a guardian and a guarantor for social justice (the principle of the “Welfare State”) and try to rectify imbalances between the regions. This is not only for the sake of the economy and environmental protection, but it is an order of justice and the resulting injunction of general liability. Translating this into the development of cities and villages, in Germany we talk about the injunction of spatial or territorial justice (in Anglo-Saxon countries both terms “spatial” and “territorial” do exist). Although this concept was known already some 15-20 years ago, it has so far stayed in the shadow, and after the Johannesburg Summit in 2002, it was covered by the term “sustainable spatial development” (nachhaltige Raumentwicklung), at least in Germany.

However, we are experiencing a “resurrection” of a kind, especially in Bavaria, through changing the constitution, and through the creation of a parliamentary Committee of Inquiry into ‘Equivalent living conditions throughout Bavaria’ (Enquete-Kommission Gleichwertige Lebensbedingungen in ganz Bayern). As a member of this committee, I was asked to submit a paper on ethical and normative background for the work on equivalent living conditions in Bavaria [Magel 2015]. It cannot be the responsibility or an arbitrary decision by the government or certain economic lobbies, whether there exist equivalent living conditions or not. Justice and its impact on the spatial development is a universal and perpetual mandate, which is ultimately based on the universally applicable human rights and human dignity. It is enough to refer to the famous ‘Theory of Justice’ by John Rawls [1971] or to lectures about justice available on YouTube: by Professor Michael Sandel [2013] from Harvard and Professor Amartya Sen, a Nobel Prize laureate in economics [2013]. Based on these theories, together with another member of the committee Manfred Miosga, professor for regional development, we created a new model of spatial justice with four dimensions of justice (Figure 3). Firstly, equal opportunities, which are based on the fact that every newly born child will have a chance to have school education and much more. Secondly, the justice of distribution, which is about local infrastructure and equipment necessary to live and work (e.g. Internet access). Thirdly, procedural justice, i.e. mainly: equal rights for all, participation, and management issues. Last, but not the least, justice for generations or grandchildren. Here it is primarily an injunction of sustainable actions, e.g. in financial and environmental terms [Magel 2016].

This new model of territorial justice was accepted by all parliamentary factions in the Commission, as a basis for further discussion. It will now be used to determine specific criteria for each of the four areas of justice, by which the spatial justice for all regions will be determined, monitored and evaluated; or in other words, to ensure the equivalent conditions of living and working. These criteria must be developed taking into account the specificity of the region, together with the citizens and the civil society, which must most certainly include the NGOs. We call this disparity sensibility.

Why is this territorial justice so important to Bavaria? Looking at the map (Figure 4) it is evident that we have serious problems, especially at the borders of our region. Here we are talking about peripheral rural areas, which suffer from depopulation...
Fig. 3. Model of four dimensions of territorial justice. Based on theories of justice and empowerment (Rawls, Sen and Sandel)

Source: developed by H. Magel and M. Miosga at 2015. Copyright: Magel/Miosga 2015

Fig. 4. Peripheral or weaker rural areas (marked in green) within Bavaria. Left: the current system; right: the planned increase of the number of regions, which merit specific assistance of the State

Source: Draft of Bavarian Development Plan – Entwurf Landesentwicklungsprogramm of 2016
and the lack of jobs, and thus face the shrinking carrying capacity of the infrastructure for local supply, health and education, due to the decreasing population and the weakening local financial and causative strength, including the collapse of real estate prices. These areas need special care and attention of the State. It is against justice when some people suggest that they should be deliberately depopulated or emptied. Resilient strategies and adaptation projects, aimed at preventing the decline are necessary, but in my opinion, at the minimum, they must also include a “strategy of return” (“Rückfallstrategie”). We have to allow the eventual return to the “previous” situation, when the trend again reverses. But if we now let regions decline too much, that return will be difficult.

Even in the stronger regions, we also have structurally weaker districts and municipalities, which should get help.

3. Home-country strategy (Heimatstrategie) for Bavaria

Undoubtedly, the Bavarian Government is aware of this, but it communicates very little about how to react to the decline of such weak regions. In fact, ethical and normative dimensions of territorial justice are not discussed. Instead of theories and philosophies, more pragmatic ways are preferred, where the goal is equivalent living conditions – as it is written in the constitution. Naturally there are also criteria to measure living conditions, but these are not discussed along with the ideas and systemic approach of the Enquete Commission, rural municipality associations, or NGOs.

Government’s favourite solution is to give financial support. A lot of experts are surprised that the government wants to enlarge the weak rural areas in regions (see: Figure 4) by including those, which had never been seen as weak before. But this is the way of territorial politics and of “policy by money”, which is applauded by local politicians and mayors. This works as long as the State or the region is rich – like Bavaria is nowadays. It will be an exciting question whether the Bavarian Government will seriously study and implement the proposals of the parliamentary Commission of Inquiry on “Equivalent living conditions” in terms of measuring the situation everywhere after the end of the commission’s work.

It is worth mentioning that apart from these methodological and theoretical questions and differences, the Bavarian Government has started positive strategies and supportive programmes to avoid excessive weakening of the regions and municipalities. In its central policy approach, the so-called Home-country strategy (Heimatstrategie), which is complemented by many other specialized programmes of all line ministries, the government equips the rural regions, particularly those peripheral ones, with a catalogue of special projects. They include decentralization of government offices, even ministries, and set up branches away from large urban centres (like Munich), in district towns and rural communes; similarly so with university departments (institutes, research units). These decisions are guided by concepts and spatial programmes such as the integrated rural development (integrierte ländliche Entwicklung), followed by programmes like: village renewal or urban renovation; integrated town development
concepts (*integrierte Stadtentwicklungskonzepte*)’ LEADER; Regional management; and all other inter municipal and cross-cutting programmes. The goal is to reach a higher attractiveness of rural towns and villages in order to keep or attract people (especially young people) to the region. Naturally the business sector and enterprises must offer high qualification jobs in rural centres.

4. Long live the countryside – wishful thinking or the first turn of the trend?

The first successes are visible. A media report under the slogan “Long live the countryside” narrates that in some parts of rural Bavaria there is again a growing trend of living countryside, which it is often also psychologically conditioned, and corresponds to the new lifestyle. Federal Ministry of Agriculture speaks cautiously about the change in the trend. Der SPIEGEL already specifically mentioned the phenomenon of escaping the city. Also in Waldviertel in Lower Austria, or in western Poland positive, migration balance to rural areas has been observed again.

Why is this the case? Businesses consultants explain it in the following way: there is a tendency to shift from living in cities to living and working in rural areas. Global consulting firm Bain & Company have already spoken about the post urbanization era, when due to technological progress, the problem of the distance loses its importance (*declining cost of distance*), and thus the rural areas may be more attractive as a place of living and working (Figure 5) [Allen et al. 2016].

![Diagram showing the attractiveness of rural areas over time](source: [Allen et al. 2016])

Fig. 5. Rural areas are becoming more attractive – where people live now, and where they will live in five years’ time
So, again there is hope – and that reminds me of a book I wrote 25 years ago, together with the then President of the Bavarian Parliament Alois Glück. The book carried an intentionally motivational title ‘The countryside has a future: New perspectives for rural areas’ [Glück and Magel 1990]. The message is that we have to withstand the voices heard at meetings of UN or the World Bank, where some say with satisfaction, or try to convince us that the whole world will inevitably be urbanized, and thus creative and living in prosperity. This idea saddens me personally, when the concept of urbanization is understood only as a tendency to create mega-cities and agglomerations.

Here I recall the warning voiced by the former French Prime Minister Edgar Faure: “If rural areas stop breathing, cities will suffocate”. There is no need to look only at Beijing, Manila, Mexico City, Lagos or Cairo, in order to verify the truthfulness of these words; instead, it is enough to look at Munich, my city of residence, which for a long time now has been choking with problems related to transportation and housing, and it is on track to lose its attractiveness as an outstanding European city, and as a compact and green living space. More and more green areas of the city and its surroundings are being disappeared as a result of intensive “inner development” (Innenentwicklung).

‘The countryside has a future’ or ‘Long live the countryside’ – one way or another, once again, we need new, courageous and creative perspectives, which can be read partly in the new EU Regulation EAFRD [Regulation 2013], for example, the provisions aimed at supporting small and medium-sized enterprises (SME). Having said that, these measures are not yet bold enough, and they are too much focused on agriculture only.

If we want to keep people in the villages and the rural towns, we need – as I already mentioned – additional high-quality jobs; while agriculture can give work opportunities only to a part of rural population. On-going Digitization and Work 4.0 trends can enhance rural accessibility and mobility, and thus support job creation in the countryside.

Therefore for me, rural and urban renewal and development make sense only when they are accompanied by the support of regional economic development and workplace creation. At the same time, the integrated rural development and its counterpart support for urban development (integrated town development concept) must pass their biggest test. It would be best if they could merge in the form of a large or medium-scale urban-rural partnership, including e.g. new partnerships and collaborations between SME in urban and rural areas, with consequences for improving housing, infrastructure, mobility and harmony of work and family life for young parents. In this way, the Integrated Rural Development (Figure 6) and also the urban development concepts and projects in rural areas are best contributing to equivalent living and working conditions.
5. Who represents the interests of the countryside, outside the world of everyday politics?

Larger cities like Munich, and the region of Bavaria view the strong support for rural areas with some apprehension and envy. They complain about the too big (in their opinion) concern with rural areas, indicate their main problems, and stress the indispensable central function of the master supply centre for smaller cities and rural areas. This involves also political influence, rank and the game of power with the financial equalization for poorer municipalities.

Of course, rural areas have strong interest groups in the form of powerful municipal associations; but in their daily policy, many topics are treated superficially, even though they reflect accurately the nature and diversity of life in the countryside and its economic activity in antithesis to the city – namely, rurality, (agri)culture, regional architecture, land use, landscape, rhythm of life, proximity of nature, lifestyle, the slowness, slowing the pace of life etc.
In order to be able to identify, preserve and promote these aspects in the era of modernization, globalization and cultural egalitarianism, nearly 30 years ago in Bavaria we created our independent non-profit organization: Bavarian Academy for Rural Areas. It is a self-financing association, not a State institution like some German Academies for Rural Areas (Thuringia, Baden-Württemberg, North Rhine-Westphalia, Rhineland-Palatinate).

In Bavaria, Lower Saxony (Niedersachsen), Hessen and Schleswig Holstein academies see themselves as think tanks for politics and society. On the one hand, they support the inhabitants of rural areas and communes; on the other hand, through constructive criticism and suggestions, they help governments and parliaments. It is significant to mention that from the eight external experts of 21 members of the aforementioned Enquete Commission, five members come from our Bavarian Academy: professors, Directors-General of chambers of commerce and industry, heads of offices of Rural Development. Their contribution involves not only their personal competence and experience, but it also consists in expanding the potential of the academy as a whole, which had been developed over the last 3 decades on the basis of nearly 300 members, representing almost all professions and all social groups within Bavaria, whether they are independent freelance engineers and planners, government officials, business people, industry representatives, business leaders, bankers, mayors, governors, parliamentarians, or even the Secretaries of State and Ministers, university professors, theologians, or journalists etc.

It was, for example, our academy which warned the Bavarian government very early not to rely on the free market interests and forces to provide broadband network in rural areas; but instead to treat this new technology as an essential element of public services, on an equal footing with roads and water supply infrastructure. After several years, the situation has been managed by the new government exactly in the way that our academies had suggested.

It was the Bavarian Academy, which in 1994 organized the first conference in the country on inter-municipal cooperation (today we are talking about the aforementioned integrated rural development), and it was at a time when a stubbornly parochial thinking was still prevalent among the municipalities.

It is the Bavarian Academy, which warns all politicians in the government and parliament against destroying the open cultural landscapes for one-sided, short-term economic gains, by allowing the municipalities to create industrial areas on the “green meadow” much more than ever in order to generate tax revenue from businesses. Cultural landscapes, as mentioned by the European Convention on Landscapes, belong to the identity of the country, and give stability and orientation to people in times of globalization and high-speed modernization. We cannot allow them to be destroyed irreversibly, as it has already been happening, much too often.

Against its own background and constitution of a truly interdisciplinary body, our academy can more reliably than other institutions call upon the ministries and administrations of the State, in order to better and more closely cooperate for the good of urban and rural areas; because the future can be secured only by comprehensive, integrated solutions and more urban rural cooperation within or outside metropolitan regions.
Due to its high competence in the rural management and the municipal development, the academy can also convincingly argue that the current German support programme for rural development is still insufficiently focused despite official praises. Support for the SME sector in the new Federal Joint Task Law on Agriculture and Coastal Protection has been only possible thanks to the enormous pressure that our academies and sister academies put on the members of the German Parliament!

And yet let me stress: It is simply easier for an Academy to organize visionary conferences, and look not only at the practical issues or at the future of the agricultural sector, as it will be done e.g. by the Ministry of Agriculture.

Our Bavarian Academy, of course, with the cooperation of official institutions and ministries, created a lot of courageous views on the urban-rural partnerships, made comments to drafts of legal acts, and at hearings in Parliament on Bavarian State Development Program (Landesentwicklungsprogramm5). It submitted considerable solutions to educational policy and the location of schools in rural areas; health care; the situation of churches in rural areas; new jobs (including telework); renewable energy; agricultural development and regional marketing; biodiversity and cultural landscape; mobility in rural areas; the so-called inner development; new constructions; land protection; civic engagement; financial situation of the communes; reconciliation of work and family; and strategies for preventing the collapse of many villages. We especially focused on the fundamental issues, such as “changes in the heads” and we called for attention, long before the change of the Bavarian Constitution; we called for justice for all regions. The Rural Areas Working Group (Arbeitsgemeinschaft Ländlicher Raum), association of all German academies, raised the problem of aging in the rural community with enormous consequences, which is a tremendous challenge for new forms and standards of housing design, mobility and adaptation of rural infrastructure. Insufficient recognition and consideration of different phases of people’s lives – and thus of changing people’s needs and possibilities – is also a problem.

A new and significant problem, which we remember from last year’s European debate, is currently the integration of many immigrants and refugees in rural Bavaria. We could put an important emphasis on this issue, with the participation of the government, the parliament and federal institutions [Franke and Magel 2016].

Fortunately, we can enjoy the fact that, simply because of our independence, we can expect special attention from the media, i.e. radio or newspapers. There is hardly a month in which we would not be asked to give an opinion or take a stand on issues related to urban and rural areas.

6. The academies are the place of constructive confrontations and discussions

Why is this possible? By their very nature, our Academies for Rural Areas’ Development have such a broad composition, that they cannot be limited to, for instance, an indus-

5 Verordnung über das Landesentwicklungsprogramm Bayern (LEP) of 22 August 2013.
try or farmers lobbying. All members feel committed to strengthening the rural areas. Neither do we want to do business, nor do we strive for some private gain – and this, in all probability, makes us more credible.

It is important that our actions are not merely based on the fact that we are “basically against something” or that we “basically always demand something”; instead, our contribution is critical, but constructive, and thus we are a reliable and predictable partner. This also applies to the other academies, which act primarily from an urban point of view. We remain open, and we do not treat the larger cities and metropolitan areas as opponents, but as a necessary support for our country and our society. For reaffirming the role of cities, we also want to contribute to their more open attitude and partnership with rural areas. I see it as the key to the future of cities and rural areas, because only in the spirit of friendly cooperation, the city can be relieved and rural areas can be strengthened.

Our academy cannot argue “with the belly”. We need serious opinions, which are evidence-based (following the findings from scientific research). For this purpose, we have created our own Boards of Scientific Trustees, involving university professors, young scientists, lawyers, politicians, local planners and officials. The Board of Trustees often use the foundation of their own research or the practical results and experiences of planners or communes. If there is a difference of opinion within the academies, efforts are made to find common ground. After all, in our academy, you will find representation of the Presidents of the Bavarian Association of Rural Municipalities (Bayerischer Gemeindetag) and Association of Counties (Bayerischer Landkreistag), as well as the current Minister of Agriculture or the Secretary of State in the Ministry of Finance, Spatial Development and Home-country and a number of committee chairmen of the Bavarian Parliament. For all of these high officials, it is clear that the academy does not want to embody and represent the perspective of the official policy by the Ministry or communes only, but seeks to represent a more diversified and broader perspective of society. The Ministry and its representatives may only represent the official line of the government or the opinion of the coalition parties; therefore, they are often glad, if in some inconvenient circumstances, those more independent institutions such as academies express their opinion. That is the exact task for our academies. In addition, we also have an educational mission, which is realized in the form of a large number of conferences and hundreds of attractive publications, which are read by students and teachers at universities and by officials in the Ministries and municipalities.

7. Get on the nerves of time, people and things!

In the end, let me quote a basic definition – and at the same time, a confession of a kind – in relation to the responsibility and the role of the academy since its establishment, as well as from the beginning of my leadership.

‘The reputation of the academy depends to a decisive extent on how it sees itself and how it checks up a place of disputes, where there is a chance of opposite and contradictory opinions, and not only dealing with those which are compatible with the
specific agenda. In the various activities of the academy, conferences, scientific discussions, research projects, opinions, and support, it must always be important not to give up anything and always “get on the nerves”. Get on the nerves of time, the nerves of people and their home regions, the nerves of things and professional requirements! This is not in order to divide, but in order to unite’ [Magel 1998].

Keeping that in mind, we try to search, in the competent and pragmatic way, for solutions to the problems of rural areas in the context of overall development of towns and villages; we take impulses and inspire action for the future, far beyond the events of everyday life. We feel strengthened in our work by the global and European call for good governance and stronger civic involvement. We want to continue to act as a responsible and serious partner of the State, of the communities and municipalities, the economy and the society.

I wish the new Institute of Rural Development in Southern Poland complete success in their commitment to equivalent urban and rural development. You can count on trusting cooperation with our German Academies for Rural Areas.

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PROPOSED MODEL FOR DATA SECURITY PROTECTION OF CADASTRAL INFORMATION IN POLAND

Monika Mika

Summary

The paper presents a proposal for the data security model to protect the cadastral information recorded in the databases of real estate in Poland. The model was developed for the implementation of multi-purpose cadastral tasks. The problem has been considered from the point of view of the smooth functioning of the real estate market. Reliability of the real estate market is guaranteed by the full, accurate, easily available and current cadastral data. The latter is an important piece of information about the area or land, essential for the implementation of most of the real estate management processes. The publication indicates obligatory and optional sources of cadastral information. The basis for the model of cadastral data security system is the compatibility of the assumptions between the said model and the applicable law. The model contains four types of disclosure status for cadastral data (confidential information, public information, incomplete public information, non-confidential information requiring a license). The status was adjusted to specified groups of users of the multipurpose cadastre. The aforementioned groups are based on the entities, acting within the real estate market in Poland. The security model presented herewith assumes a full transition to computer storage media, including the descriptive information and spatial databases, contained in the multi-purpose cadastre, as well as full interoperability of the data collected therein.

Keywords

real estate cadastre • cadastral information • information protection • information security model • multi-purpose cadastre

1. Introduction

The aim of this publication is to present a proposal for a security model of cadastral information, to service the operation of multi-purpose cadastre in Poland. The issues of proper information security, data protection, and the aspect of efficient management of the cadastral database are often raised and discussed both among the users of the system, and in the circles of people and institutions who collectively make up the system. The subject was raised, among other authors, by [Mika 2010]. In the systems analysis of the subject in question, we need to take into account the specificity and
nature of the system itself, and the consequences resulting therefrom. Dawidowicz and Źróbek [2012] are among the authors who have discussed these aspects. It should be noted that the cadastral data have specific requirements as to the geodetic accuracy [Hanus et al. 2014]. There is a constant need for real-time updates of cadastral databases [Bieda et al. 2013] and for sharing the cadastral information in the context of multiple geodetic and legal processes, underpinning real estate management. The problem in terms of the harmonization of cadastral data has been analysed by Maślanka [2016], among other authors. In turn, research conducted by Przewięźlikowska and Buśko [2014] showed that there exists a lot of contradictory information, collected in the Land and Buildings Registry (EGiB) and Land and Mortgage Registry (KW) databases, which constitute the backbone of the cadastre of real estate in Poland. According to Źróbek [2000], in the real estate economy, information is interpreted as land data, collected in order to make certain decisions. For these decisions to be appropriate and effective, the information should be accurate, true, easily accessible, relevant, current, properly describing the area of interest, as well as original and presented in a form that is convenient for the user (recipient). Land information is an integral part of the functioning of each cadastral system. Cadastral information is part of the land information, recorded in cadastral databases, supported by local land information systems. Land and Buildings Registry, which serves as a cadastre of real estate in Poland [Ustawa… 1989], does not provide the users with complete cadastral data. The full cadastral information may be obtained only by using a combination of several different databases. For some years in Poland, work has been underway towards the construction of the Integrated Information System on Real Estate (ZSIN), which should partially solve this problem. Today, however, this system is not yet operational. Cadastral information can be of spatial (graphic) or descriptive character. The degree of informational detail depends on the needs of the cadastral system, and therefore it can include basic data about the property, or more complex information from the range of legal data, data on the location, technical data, planning data and statistical data. Cadastral information may relate to individual properties or groups of properties sharing similar attributes. According to Art. 155 of Real Estate Law [Ustawa… 1997], for the purpose of real estate management process, all data should be used that is contained in both mandatory and optional data sources. Obligatory (compulsory) sources of cadastral information should include the Land and Mortgage Registry (KW), the Land and Buildings Registry (EGiB), the Geodetic Register of Infrastructure Networks (GESUT), the Local Spatial Development Plan (LDP), the Database of Topographic Objects (BDOT), the Prices and Values Register (RCiWN), and in the future, instead of the latter, taxation tables and maps (in Poland, in the course of preparation at present). On the other hand, optional sources of cadastral information may include land information derived from, inter alia, trade or professional information systems, technical and project documentation, inventories held by the Tax Offices (US), databases collected by businesses and insurance companies as well as statistical studies of the Central Statistical Authority (GUS). The databases that record cadastral data contain information about the owners and their rights under the scope of personal data protection. According to the Law on
Personal Data Protection dated 29 August 1997, “Personal data shall mean any information relating to an individual that allows in any way to identify this person. Any operations on these data, i.e. storage, preparation, recording, or sharing may be carried out only with the consent of the person concerned.” At the same time, operating in the real estate market, there are a number of entities, most of which, it seems, should have access to cadastral information. This begs the question: what range of cadastral information (and in relation to which user groups) should be granted the status of full disclosure, and what scope of the information in question should retain the classified character?

2. Materials and methods

Multi-purpose cadastre, for the benefit of the present study, is the combination of data from the databases, which constitute obligatory sources of cadastral information. Figure 1 shows the original model of the multipurpose cadastre (REC) in Poland, with a structure resembling that of ZSIN, but differing in the scope of the data collected and the way of its management. The leading object of the REC is the real estate property, in its legal and actual sense. According to the Article 46 of the Civil Code [Ustawa… 1964], there are three types of real estate properties:

- Land properties – “parts of the Earth’s surface which constitute the subject of a separate ownership, i.e. a separate property (land)...”
- Real estate properties – “(...) buildings permanently connected to the land (...), if under special provisions they constitute the subject of ownership, i.e. a separate property, which is separate from the land.”
- Premises – “(...) parts of buildings, if, under the specific provisions, they constitute the subject of ownership, i.e. a separate property, which is separate from the land.”

The basis the data security model for the cadastral system thus defined, and presented later in the publication, is to bring the assumptions of the aforementioned model to compliance with all the applicable legal regulations currently in force in Poland, as listed in the references: [Dyrektywa... 2007], [Ustawa... 1989], [Ustawa... 2003], [Ustawa... 1982], [Ustawa... 2010], [Ustawa... 2010], [Ustawa... 2001], [Ustawa... 1997a], [Ustawa... 1997b], [Ustawa... 2005], [Ustawa... 2016], [Ustawa... 1964], [Rozporządzenie... 2001], [Rozporządzenie... 2015a], [Rozporządzenie... 2015b], [Rozporządzenie... 2014], [Rozporządzenie... 2012].

For the purpose of the data security model for cadastral information, the following types of disclosure status were assumed: confidential information (P), public information (J), incomplete public information (JN), and public information on the conditions specified in the license (JL). Confidential information (P) includes personal data or other information that requires protection for security reasons. On the other hand, the information referred to as non-confidential (J) assumes the public right of access to maps and records, upon the justification of legal interest (on principles similar to the currently existing KW). Incomplete public information (JN) concern extracts of
Fig. 1. The Real Estate Cadastre (REC) model, possible for implementation in Poland. Object of the primary system in the REC should be the 'real estate property'.

Source: developed based on [Mika et al. 2016]
information from the given data set (e.g. the positioning of N-property in the given taxation zone, without access to the information about the specific value of N). The degree of detail of these data should be adapted to the purpose or the legal interest, in which connection the given entity wants to obtain it, and it should be governed by separate regulations. Public information on the conditions specified in the license (JL) relates to data for the needs of professionals or experts who benefit from the servicing of processes occurring within the real estate market. These individuals, according to the assumptions of the model, are persons of public trust, who possess the appropriate professional qualifications and authority resulting thereof, who provide professional guarantee, and who do not abuse the aforementioned authority under the penalty of deprivation of the right to practice their profession, financial penalty or responsibility.

In the case of professional activity for the purpose of surveying, the issue is regulated by Article 48a of the Geodetic and Cartographic Law [1989], which provides that “Whoever uses the materials from the data resources without the required license or in breach of license conditions or provides them contrary to licenses to third parties, is subject to a fine in the amount of ten times the fee for the access to these materials.”

Access licenses and fees should be determined on a basis similar to the procedures set out in the field of geodesy [Ustawa… 1989, Rozporządzenie… 2014]. Article 40c of the Act [1989] says: “the powers of the entity relating to the possibility of using the released material from the data resources are defined by the license issued by the authority that is providing these materials.” Cadastral Information is predominantly derived from the geodetic data resources. Thus, in relation to the cadastral information, we should employ the rules currently applicable in the field of geodesy. Detailed permissions (specified in the license) for the use of materials issued in the digital (electronic) format should clearly define the scope and ability to perform operations on these data and materials. In particular, the scope of rights to their preservation, modification, or sharing should be defined. In turn, for the materials derived from the geodetic data resources, and provided in non-digital formats, we need to regulate the issues of duplication or conversion into the digital format. In any case, the authorized use of materials from the geodetic data resources should generate the obligation to quote the source of the material used. The license should be issued in the electronic (digital) format, and generated by the computerized system to allow the printout that does not require a signature or seal. The rates of fees for making resources available should be subject to annual indexation.

Table 1 proposes a classification of cadastral data, which all together provide full information on the cadastral N (real estate property). It should be noted that of the eight specified types of cadastral information, only two, namely – 3 and 8, do not come directly from the geodetic resources.

Information disclosure status was made conditional on the players in the real estate market in Poland, assuming that each potential owner of the property may be an individual investor in that market. He/she should have access to cadastral information, like the other players in the real estate market, after determining his/her legal interest for the purpose of obtaining information from the database. According to
Kucharska-Stasiak [2000], players in the real estate market include: investors, creditors, developers, brokers and technical market service providers (professionals). From the point of view of the present study, it is important to distinguish between two groups of investors: retail (or individual) investors (I-IND) and institutional investors (I-INST). The first group is composed of individuals (natural persons) who invest mostly in real estate for residential or utility purposes. The second group consists of investors with legal personality. A separate group of entities in the real estate market are the creditors (K). The next group comprises real estate development companies (D). It should be noted that this latter group is not uniform. The real estate market includes, on the one hand, the developers-investors (who acquire and build real estate properties), and on the other hand, the developers-speculators, who sell the property objects after their construction. Another group of entities operating in the real estate market are the real estate brokers (M). They deal with bringing together buyers and sellers, for which they receive commission or another form of remuneration. They perform the function of an element that stimulates the real estate market. The last group of players in the real estate market are the professionals, or specialists (S). These include, among others, the geodesy experts, surveyors, appraisers, investment advisors, realtors, architects, designers, lawyers responsible for the legal services market, insurance agents, and property managers.

Table 1. Classification of cadastral information in the data security protection model

<table>
<thead>
<tr>
<th>No.</th>
<th>Type of information</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Descriptive information on the actual condition of the N property</td>
</tr>
<tr>
<td>2</td>
<td>Spatial information (graphics) on the N property</td>
</tr>
<tr>
<td>3</td>
<td>Information on the legal status of the N property</td>
</tr>
<tr>
<td>4</td>
<td>Information on the value the N property</td>
</tr>
<tr>
<td>5</td>
<td>Information on the infrastructure within the land in question</td>
</tr>
<tr>
<td>6</td>
<td>Information on the terrain and land cover</td>
</tr>
<tr>
<td>7</td>
<td>Information on the situation of objects within the land in question</td>
</tr>
<tr>
<td>8</td>
<td>Information about land use functions and planning intentions</td>
</tr>
</tbody>
</table>

3. Results

The data security model proposed in this publication covers a wide range of cadastral information coming from multiple databases, included in the multi-purpose cadastre (REC). Figure 2 shows a context diagram of the REC in graphic notation of systems analysis according to [Robertson and Robertson 1999], indicating the liminal data flows of different types of cadastral information. Table 2 presents the security model for cadastral information, according to the adopted user groups.
Table 2. Data security model of cadastral information, according to the user groups adopted

<table>
<thead>
<tr>
<th>Type of information/data</th>
<th>Groups of users</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I-IND</td>
</tr>
<tr>
<td>1. Descriptive information on the actual condition of the N property</td>
<td>P</td>
</tr>
<tr>
<td>2. Spatial information (graphics) on the N property</td>
<td>JN</td>
</tr>
<tr>
<td>3. Information on the legal status of the N property</td>
<td>J</td>
</tr>
<tr>
<td>4. Information on the value the N property</td>
<td>JN</td>
</tr>
<tr>
<td>5. Information on the infrastructure within the land in question</td>
<td>P</td>
</tr>
<tr>
<td>6. Information on the terrain and land cover</td>
<td>JN</td>
</tr>
<tr>
<td>7. Information on the situation of objects within the land in question</td>
<td>JN</td>
</tr>
<tr>
<td>8. Information about land use functions and planning intentions</td>
<td>JN</td>
</tr>
</tbody>
</table>

1 – flow of descriptive information on the actual condition of the property,
2 – flow of spatial information (graphics) on the property,
3 – flow of information on the legal status of the property,
4 – flow of information on the value the property,
5 – flow of information on the infrastructure within the land in question,
6 – flow of information on the terrain and land cover,
7 – flow of information on the situation of objects within the land in question,
8 – flow of information about land use functions and planning intentions.

Source: author’s study

Fig. 2. Context diagram of the REC in the graphic notation of systems analysis, with the demarcation of liminal data flows
Another step in the analysis was to create the data dictionary for the liminal data flows in the graphic notation of systems analysis. The problem is presented in Table 3.

Table 3. Data dictionary for liminal data flows, as shown in Figure 2

<table>
<thead>
<tr>
<th>Name and number of data flow</th>
<th>Description of data flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Descriptive information on the actual condition of the N property</td>
<td>1 = [for natural persons: name and parents’ first and last names, address of permanent residence, nationality, PESEL social security number / in case of death, the information that the person is deceased / for the State Treasury – the name “State Treasury” / for local government units and their associations: the name of the entity or the association, the address of the official seat of the entity or the association / for public administration and organizational units: the name of the authority or the organizational unit, the seat of authority or organizational unit / for other legal persons: the name of the legal entity – full and abbreviated, the address of the seat of the entity, information whether the legal person is foreign] + numerical address (building / flat no.) + no. of cadastral plot + no. <em>ID</em> of the register unit (land / building / premises) + no. of registry group + name / ID of the precinct area + name / ID of the cadastral unit + area of the land plot + type of land property + contour area <em>IDs in Annex 1 to EGiB Regulation of 2016</em></td>
</tr>
<tr>
<td>2 – Spatial information (graphics) on the N property</td>
<td>2 = No. of the land plot + the coordinates of the boundary points of the plot + boundary lines of the plots + (outline of the building <em>if there is one on the land in question</em>) + (premises <em>if an integral part of the building</em>) + contours of the land / classification contours of the land <em>other information from the EGiB numerical map</em></td>
</tr>
<tr>
<td>3 – Information on the legal status of the N property</td>
<td>3 = KW number + first and last name (of the Owner / Perpetual User / entities recorded together <em>with a record of the share in ownership</em>) + inventory of property rights + encumberances and claims <em>if they are presented in section III of the KW</em> + mortgage <em>if it is shown in section IV of the KW</em></td>
</tr>
<tr>
<td>4 – Information on the value the N property</td>
<td>4 = the market value of the N property <em>based on the data from the RCiW until general taxation is introduced, and cadastral value replaces the market value</em></td>
</tr>
<tr>
<td>5 – Information on the infrastructure within the land in question</td>
<td>5 = cable type <em>values adopted according to the dictionary of GES_RodzPrzewodu</em> + the course of the cable <em>values according to the dictionary of GES_Przebieg</em> + function of the cable <em>values according to the dictionary of GES_Funkcja</em> with GESUT category of object classes of SU infrastructure utility networks, including the following classes of objects: SUPB petrol cable, SUPC heating energy cable, SUPE power cable, SUPG gas line, SUPK sewage pipeline, SUPN oil pipeline, SUPT telecommunications cable, SUPW water supply pipeline, SUPZ unidentified cable, SUPI other line, SUOP pipe or cable casing, SUBP underground structure, SUUS technical device connected to the network, SUPS point at a certain height, SUKP transmission corridor* + cable specifications</td>
</tr>
<tr>
<td>6 – Information on the terrain and land cover</td>
<td>6 = the type of point + top altitude (takes the values with the precision up to 0.10 m for a natural point of altitude, and with the precision of 0.01 m for an artificial point of altitude) + bottom altitude (takes the values with the precision of up to 0.01 m for an artificial point of altitude) *Class cat</td>
</tr>
</tbody>
</table>
6 – Information on the terrain and land cover

category of objects BDOT500 RT terrain represented by the class of objects RTPW point at a certain height* + Category of object classes BDOT500 PT land cover encompassing the following classes of objects: PTWP surface water, PTRY ditch, PTTL woodland, trees or shrubbery, PTTU area of permanent crops or lawn, PTCM cemetery + Category of object classes BDOT500 BU buildings and infrastructure encompassing the following classes of objects: BUBI engineering structures, BUBH hydrotechnical structures, BUBS sports buildings, BUBT tall technical structures, BUBZ earthen structures, BUUT transport infrastructure, BUOB other buildings + Category of object classes BDOT500 KT communications and transportation consisting of the following classes of objects: KTJZ road, KTPL square, KTCR path of pedestrian and bicycle traffic, KTUL street, KTKR curb, KTTR track, KTOK object associated with transportation + Category of object classes BDOT500 OB other objects encompassing the following classes of objects: OBOP natural object, OBOO landmark of orientation in the field, OBMO wetland, OBSZ rushes

7 – Information on the situation of objects within the land in question

7 = information about the spatial location of objects in the current national spatial reference system (flat rectangular coordinates of geometric middle points for point objects / breaking points for linear and surface objects) + characteristics of the objects using the attributes, according to the data model for BDOT500 *specification in Annex 2 to the Regulation of 2015*

8 – Information about land use functions and planning intentions

8 = function + land use designation *information from the MPZP range* / in case the latter is lacking, information from the SUiKRZ range / WZ data

Where: EGiB – Land and Buildings Registry, GESUT – Geodesic Registry of Infrastructure Network, BDOT500 – database of topographical objects, MPZP - local spatial development plans, SUiKRZ – studies of conditions and directions of spatial management of the municipality, WZ – decisions on land development conditions and building permits, RCiW – prices and values register, KW – Land and Mortgage Registers

Table 4 lists the terminology needed to create the data dictionary shown in Table 3.

Table 4. List of operators used when developing the data dictionary in the systems analysis methodology

<table>
<thead>
<tr>
<th>Operator’s symbol</th>
<th>Operator’s significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>=</td>
<td>Is composed of ....</td>
</tr>
<tr>
<td>+</td>
<td>and</td>
</tr>
<tr>
<td>[X/Y/Z]</td>
<td>Selection of element X or Y or Z</td>
</tr>
<tr>
<td>{......}</td>
<td>Repetitive elements</td>
</tr>
<tr>
<td>(......)</td>
<td>Optional</td>
</tr>
<tr>
<td><em>........</em></td>
<td>Comment</td>
</tr>
</tbody>
</table>

Source: developed based on [Robertson and Robertson 1999]
4. Conclusions

The present publication highlights the essential aspect of the modern real estate cadastre, which is to protect the cadastral information gathered therein. The data security model, as presented, assumes free flow (exchange) of information between different the systems forming parts of the databases, which are the components of the modelled multi-purpose cadastral system (REC). The system introduces the status of cadastral information disclosure, depending on the groups of potential users thereof – who simultaneously operate as subjects in the real estate market. The presented data security protection model assumes a full transition to computer storage media in the field of descriptive information and spatial data, of all the databases included in the REC, as well as full interoperability of the data collected therein. The model presented herewith seems to be feasible to implement in Polish conditions, provided some modifications to the regulations of law. A proposal for some changes in the law for the purposes of real estate cadastre has already been presented by [Mika 2016].

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Rozporządzenie Rady Ministrów z dnia 21 lutego 2012 r. w sprawie państwowego rejestru granic i jednostek podziałów terytorialnych kraju (Dz. U Nr 193, poz. 1287).

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Rozporządzenie Ministra Administracji i Cyfryzacji z dnia 2 listopada 2015 r. w sprawie bazy danych obiektów topograficznych oraz mapy zasadniczej (Dz. U. z 2015 r., poz. 2028).

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COLOUR MANAGEMENT IN THE PROCESS OF OBJECTS’ DIGITALIZATION USING THE REVOSCAN DEVICE

Bartosz Mitka, Marcin Prochaska, Paweł Szelest

Summary

This article presents the results of a research project carried out by the Terramap Sp. z o.o. company, which resulted in the development of a measuring device to digitize in 3D, allowing data acquisition and processing. A characteristic feature of the devised system is the automatic acquisition of information about both the geometry (spatial digitization) of the object and the colour information on the object within the RGB colour space (high-resolution digital photographs). The dedicated software, designed for the device makes it possible to plan and control the process of data acquisition, followed by data processing, and the development of the material ready for presentation. Implementation of the research results, by constructing the device and its software on the basis thereof, allowed us to significantly accelerate the digitization work, and thus reduce the unit cost of 3D digitalization.

In order to properly manage colour in the processing of data obtained using the device, we have applied a procedure to calibrate the colour of the material obtained. Studies and tests that we have conducted have shown the validity of the measures designed to control the colour of the resulting product. This publication presents the procedure used for colour management, applied in the process of creating a photorealistic 3D model, as well as the results of our research into automating the process.

Keywords

Digitization • 3D modelling • colour calibration

1. Introduction

The problem of colour management is an extremely important element in the process of digitization of museum collections. Experts appointed by the National Institute of Museology and Preservation of Collections (Narodowy Instytut Muzealnictwa i Ochrony Zbiorów), in the paper titled “Cyfrowe odwzorowanie muzealiów – parametry techniczne, modelowe rozwiązania” [Digital mapping of museum objects – techni-

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1 The research was performed thanks to financial support from the Operational Programme Innovative Economy 2007–2013, action 1.4 – Support of Targeted Project, contract UDA-POIG.01.04.00-12-124/11-00.
cal parameters, model solutions] [Bunsch et al. 2012], have pointed out that “Museums, caring for their collections of paintings, sculptures, objects of applied arts, and any items related to the wider material culture, must undertake a much more difficult challenge, already at the documentation stage. (...) They must not only provide the information about the stored resources, but also facilitate the reception of their aesthetic components.” The same authors draw attention to the fact that, because of the need to register the nuances of colour of a given museum object, and allow them to be perceived by the user of the documentation, the problem of colour management is one of the most challenging areas of digitization activities [Bunsch et al. 2012].

The mathematical basis for the issues of colour calibration in monitors, scanners, printers, and digital cameras, was presented in the work of Vrhel and Trussel [Vrhel and Trussel 1999]. The problem of the calibration of colour images processed in the course of digitization is also discussed in the work of Boiangiu and Ştefănescu [Boiangiu and Ştefănescu 2014], who pay particular attention to the fact that even the most professional imaging devices require calibration. One of the important issues of colour management process is the possibility of the automation thereof, at various stages of image processing [Joshi et al. 2005].

2. Basic problems of colour management

In his book “Colour in computer graphics” W. Pastuszak [2000] states that “Each colour can be fully and unambiguously defined by the three attributes: the shade of the colour (hue, or value), saturation and brightness.” Thus, the concept of colour as such is broader than the notion of the shade or hue of colour, although in everyday use, they function interchangeably. Therefore, according to the author, the shade of the colour is one of the attributes of colour. An important aspect of the problem is the fact emphasized by the same author, that everyone perceives colour differently. The issue of the definition of hue (shade of the colour) versus the definition of colour is also noted in the lectures on “The problem of hue and colour” by J. Tarasiuk [2012].

In turn, the colour space (gamut) determines the colour reproduction capabilities by specific devices such as digital cameras, monitors, printers, etc. It can also be defined independently of the device [Tarasiuk 2012]. The colour space is a mathematical – three-dimensional – model of the electromagnetic spectrum in the range between 380–780 microns. The digitization process uses two basic models of colour space: Adobe RGB and sRGB. The sRGB model was designed for online publication by Microsoft in 1996, and it is possible to map it on most of the monitors. The Adobe RGB model is more akin to the human eye, which is why it is recommended for use in professional applications [Bunsch et al. 2012]. However, note that only professional-grade monitors, dedicated to graphic applications, are able to reproduce the full range of the Adobe RGB model.

The Colour Management System (CMS for short) has been developed and is still being perfected by the International Colour Consortium. The latter is a suite of technical equipment, software, as well as rules and procedures aimed at ensuring the best possible colour reproduction [Tarasiuk 2012].
Colour calibration is performed by applying the appropriate colour model and colour space in the development process of the picture. For the purpose of the effective colour management in the digital imaging, the ICC colour profiles are used (short for “International Colour Consortium”). ICC is a colour management system that allows you to parameterize peripheral devices used for imaging (printers, scanners, displays, digital cameras), so that the printed colours of the image would be faithful to the original (ICC 2016). Profiles are produced as a result of the measurement of colour, shown by the specific devices. In order to create a profile, and thus to calibrate colour images, you can use the template of colours plus the software dedicated to creating colour profiles.

If you select the RAW recording format in the digital camera, the files that appear on the memory card or on your computer are not yet properly photographs. These are the raw data collected during the exposure of the light-sensitive camera sensor, and metadata about the camera settings at the moment when the picture was taken. After taking the picture, there is the possibility to “develop” it, i.e. modify the white balance, adjust the exposure, the colour saturation, and the contrast, and select colour intensity. For the professional processing of images, colour calibration of the photograph is necessary, as it guarantees that a faithful representation of the subject is obtained.

3. Description of the device

The aim of the completed project was to build an automatic measuring device (Figure 1) that would digitize small-sized objects, enabling the acquisition and processing of data about the colour and the geometry of these objects [Prochaska, Mitka 2016]. In the course of the project, studies have been carried out on the whole process of digitizing 3D objects of small size, from the stage of obtaining spatial data about the object, through the processing of that data, all the way to the publication of a virtual model of the object.
In the basic configuration, the device performs digitization of the objects in the form of a sequence of spherical, cylindrical or elliptical photographs, depending on the geometry of the object, which is the subject of the measurement. In addition to the location of the camera, resulting from the “approach plan” defined by the operator, it is also possible to manually specify the location of the camera for a single image within the range of the working area. The solution that further increases the capabilities of the device is the option to disconnect the measuring columns from the table, with a simultaneous rotation of the vertical measuring column by 90 degrees. This results in the ability to obtain images automatically (i.e. according to the “approach plan” defined by the operator) for surface objects of vertical or horizontal orientation, such as for instance reliefs.

An integral component of the constructed device is the HP Z420 graphics station, along with two 24-inch graphics-supporting monitors HP ZR2440w with a resolution of 1920x1200 pixels produced in the IPS technology. In order to reproduce the colours as faithfully as possible, the monitors were calibrated using the X-Rite i1 Pro spectrophotometer (X-Rite 2014), taking into account the surrounding lighting conditions in the operator’s workplace.

Colour management in the process of data acquisition and processing is facilitated by the module of image exposure, allowing control of other settings from the level of the device’s software, including, among other things, the white balance settings of the camera. Manual setting of the colour temperature parameters of the lighting used, at the stage of obtaining the source material of RAW images, allows the user to acquire data about the colour, which is as close as possible to the actual colour. At the same time, the calibration procedure performed during the measurement includes, inter alia, the registration of images containing the X-RITE colour template (Figure 2).

![Colour template used in the X-RITE device](image)

**Fig. 2.** Colour template used in the X-RITE device
4. Colour calibration procedure applied in the RevoScan device

The validity of using a dedicated colour profile for each individual object has been demonstrated by the test, which consists in developing the same image using different profiles. In the figure below (see: Figure 3) we have shown the effect of developing images saved in RAW format, coming from Nikon D800 (ISO 100, f/16, 1s, 35 mm), using the AdobeRGB colour gamut recording for the following ICC colour profiles: Adobe Standard (Figure 3a), CameraStandard (Figure 3b) and a dedicated profile obtained using the X-Rite template (Figure 3c). Photos were developed using the CameraRaw 9.1 application, which is an addition to Adobe Photoshop CS6 software.

![Fig. 3. a) Left: image developed using the Adobe Standard profile; b) Middle: image developed using the Camera Standard profile; c) Right: image developed using the profile based on the template](image)

The relatively small visual differences between the images seen on the printed version result from the proper white balance settings and low ability for colour mapping by printing devices in the RGB colour space. For colour calibrated graphic display monitor, differences in various colour tones are much more noticeable.

The RevoScan device uses the following procedure for colour calibration and colour control of the generated 3D models:

1. When the object is placed on the table of the device, photographic lamps are set (either continuous or flashing light) in order to obtain the most uniform illumination of the object possible, using a shadow-less tent.

2. In the module, which controls the operation of the camera, parameters of the image exposure are set, i.e. the focusing distance, aperture size, the time of exposure, light sensitivity of the camera matrix, and the white balance. For the white balance
parameter, colour temperature is set depending on the colour temperature of the lamps that will be used.

3. A set of calibration images is then taken, containing the template of colours as well as the geometric template for the calibration and verification of the resulting geometry of the object.

4. The image, along with its colour template, is saved to Digital Negative (DNG) format. DNG is an open, lossless format for digital negatives, containing unprocessed data from a digital matrix (RAW), developed by the Adobe Systems. Adobe provides a free converter to DNG from RAW formats of many different manufacturers cameras (Figure 4). Having a photograph in DNG format, you can use the software supplied along with the colour template for creating a colour profile. Open format is also perfectly suitable as a universal way for archiving raw images.

Using the ColorChecker Passport software, you create and save the colour profile for the digitized object. The software is supplied together with the colour. Its use is very intuitive – it is sufficient to drag-and-drop the photo along with the colour template in
the DNG format onto the working area of the application. The ColorChecker Passport application automatically detects the colour template in the photo, and when you click the “Create Profile”, it creates the colour profile (Figure 5).

![ColorChecker Passport application](image)

Source: authors’ study based on ColorChecker Passport application

**Fig. 5.** ColorChecker Passport application with a colour template detected automatically

The next step is to develop all the source images. This is accomplished in a single process, using Adobe Photoshop CS6 with the Camera Raw 9.1. plug-in. All source files in RAW format (for Nikon cameras, they have the NEF extension), after they have been developed, are saved to JPG format and are the basis for generating a photorealistic 3D model. Due to the number of images obtained in the processing of data, manual calibration corrections are not performed on the individual source images.

The last stage of the verification of colour of the digitized 3D model of the object is to compare its photorealistic 3D model to the original, with appropriately selected parameters of the rendering engine display. Practical experiences resulting from the dozens of 3D models executed so far show that when lighting and white balance are set properly, and when colour calibration has been performed on the basis of individually generated colour profiles, the 3D models obtained correspond to the colours of the original in a satisfactory manner (Figure 6 a–c).
5. Studies on the possibility of automating the process of acquiring colour-calibrated photos

The procedure presented above for calibrating colour photographic material harvested for the 3D modelling of objects is largely based on manual operations, requiring the intervention of the device’s operator. Striving for the maximum automation of all activities related to the digitization process of three-dimensional objects, as a part of this research project, we have also conducted the study and testing of the feasibility of automated colour calibration.

The following is a procedure for automating the process, developed within the framework of the present study. The whole process needs to be structured, i.e. RAW files developed to TIFF or JPEG, along with the colour profiles, should be placed in the proper directory structure.

The process of obtaining colour-calibrated images can be divided into several stages:

1. Obtaining the colour profile:

   After setting the scene, and performing the white balance adjustment, the picture of an object is taken. Colour template is placed within the frame. The image is then downloaded from the camera to your computer drive, written and stored in a suitable location in the directory structure. The format of the picture depends on the manufacturer’s camera. Let us assume that the image is given a name calibration_photo_1.NEF.

2. Converting the image named calibration_photo_1.NEF to the DNG format, using the DNG Converter software. As a result, we obtain the file named calibration_photo_1.DNG:
From the menu of commands (CMD)> “Tools\dngconverter\Adobe DNG Converter.exe”, “-c -d “ + fullDestPath + “ + fullPathToPhoto, we have created the class named DngConvStarter (singleton) which automatically (that is, without the need for the operator’s involvement) launches the converter program. Below we present the method, which launches the Adobe DNG Converter.exe software in response to the command:

```csharp
async public static Task AsyncExecute(string fullPathToPhoto, string fullDestPath)
{
    RunModule("Tools\dngconverter\Adobe DNG Converter.exe", "-c -d " + fullDestPath + " + fullPathToPhoto);
}
```

3. Creating the colour profile.

The converted image named `calibration_photo_1.DNG` is dragged and dropped onto the working area of the ColorChecker Passport application. Similarly as above, the class of PassportStarter has an in-built method for launching the ColorChecker Passport program. The process of creating the colour profile is performed in a separate thread; therefore it is working in the background and is not blocking the operation of other applications:

```csharp
async public static Task AsyncExecute(string fullPathToPhotoToColorCalibration)
{
    string args = string.Format("/Select, {0}" , fullPathToPhotoToColorCalibration);
    ProcessStartInfo pfi = new ProcessStartInfo("Explorer.exe", args);
    System.Diagnostics.Process.Start(pfi);
    RunModule("Tools\passport\passport.exe", "");
    DirectoryInfo d = new DirectoryInfo(@"ICC\");  
    FileInfo[] files = d.GetFiles("*.dcp");
    if (files.Length > 0)
    {
        RunModule("Tools\dcp2icc\dcp2icc.exe", "ICC\" + files.Last().Name + "
5000");
        if (File.Exists("ICC\" + files.Last().Name))
            File.Delete("ICC\" + files.Last().Name);
    }
}
```

The AsyncExecute method first brings up a window with the converted picture (DNG), and then runs a program to create a colour profile, and finally writes the profile in the ICC format.

4. Processing of RAW images.

The last step is to process (“develop”) RAW images, using the created colour profile. After careful reviewing and analysis of tools available for developing photos, we have decided that the DCRAW software performs best. At the time that the photo is being taken, demanding the calibration of colour, the application automatically develops (processes) the image based on the previously created ICC profile. The process does not require the presence of the operator.
The key features of the DCRAW application include:

- It is free software (open source);
- Is written in C programming language;
- It is portable (using only the standard C libraries);
- It is expanded;
- It has the ability to develop images using the ICC profile to TIFF or JPEG;
- Because we possess the source code, we can modify the software and adapt it to our needs;
- It fulfills the most important criterion – it allows the user to automate its operations.

The DcrawStarter class (singleton) is responsible for running the version of the DCRAW application, compiled under the Windows operating system, in a separate thread. Below is an asynchronous method of launching an automatic process of developing photos:

```csharp
async public static Task AsyncExecute(string fullPathToPhoto, string destPath, string fullPathToColorProfile, string format)
{
    if (format.Equals("tiff, jpeg") || format.Equals("jpeg, tiff"))
    {
        RunModule("Tools\dcraw\dcraw.exe", "-v -p " + fullPathToColorProfile + " + fullPathToPhoto);
        RunModule("Tools\dcraw\dcraw.exe", "-v -T -p " + fullPathToColorProfile + " + fullPathToPhoto);
        RunModule("Tools\cjpeg\cjpeg.exe", "-v -outfile " + fullPathToPhoto.Replace("nef ", "jpeg") + " + fullPathToPhoto.Replace("nef ", "ppm")");
        if (File.Exists(fullPathToPhoto.Replace("nef ", "ppm")))
            File.Delete(fullPathToPhoto.Replace("nef ", "ppm"));
    }
    else if (format.Equals("jpeg"))
    {
        RunModule("Tools\dcraw\dcraw.exe", "-v -p " + fullPathToColorProfile + " + fullPathToPhoto);
        RunModule("Tools\cjpeg\cjpeg.exe", "-v -outfile " + fullPathToPhoto.Replace("nef ", "jpeg") + " + fullPathToPhoto.Replace("nef ", "ppm")");
        if (File.Exists(fullPathToPhoto.Replace("nef ", "ppm")))
            File.Delete(fullPathToPhoto.Replace("nef ", "ppm"));
    }
    else
    {
        RunModule("Tools\dcraw\dcraw.exe", "-v -T -p " + fullPathToColorProfile + " + fullPathToPhoto);
    }
}
The method writes the processed photos in either the TIFF or JPEG format, to an appropriate folder, and gives them an assigned file name.

6. Conclusions

The colour profile (ICC) and the applied colour space (gamut) cause significant visual differences when processing (developing) digital photos. The results generated using standard colour profiles are not satisfactory – the image still do not fully correspond to the original. Performing the colour calibration of an image, by taking the photo of the colour template with the same lighting conditions and the same camera settings (ISO, aperture, exposure time, focal length) significantly improves the reproduction of object colours, and its digital representation in the form of pictures, and then the 3D model generated from the calibrated images. In order to create the correct colour profile, you can use the applications that came with the colour template. Colour calibration of images is essential in digitization of museum objects. The process of obtaining colour-calibrated photos can be automated through the use of appropriate software and custom-made scripts to support it.

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LAND MANAGEMENT ISSUES IN CHINA'S RURAL AREAS

Weidong Qu

Summary

This article reviews China's land system reform along the timeline of economic development and in three stages: land system reform in line with the reform of State-owned enterprises; the housing system reform; and the current urbanisation process. It focuses on the process and characteristics of urbanisation in China and the characteristics of the land system reform constrained by urbanisation. Combining the current and future characteristics of China's economic development, this article offers some advice on the balance between urbanisation and rural land management issues.

Keywords

China's Land System Reform • Urbanisation • Urban and Rural Development • Rural Land Management

Since China implemented its reform and opening-up policies in 1978, it has experienced dramatic economic development. In 2010, China's GDP surpassed that of Japan, and it has since ranked second in the world. In 2010, China's GDP was $6.066 trillion1, while Japan's was $5.498 trillion. By 2015, China's GDP had reached $11.181 trillion, while Japan's decreased to $4.124 trillion. China also formed the trizone with the other BRICS – Russia, India, Brazil and South Africa – and has expanded its economic development (Figure 1).

China currently has the largest foreign exchange reserve in the world (more than $3 trillion). By hosting the 2008 Beijing Olympics, the 2010 Shanghai World Expo, the 2014 Beijing APEC Conference and the 2016 Hangzhou G20, China has attracted worldwide attention, and has developed into one of the largest economies in the world. Over the last 30 years, China's land reform and revolution have made great contributions to the country's economic development. This article reviews the first stage of China's land reform and revolution, and goes on to analyse the characteristics of China's current land reform policies. Finally, it combines questions of urbanisation and new country construction, in order to analyse future Chinese countryside land management issues against the backdrop of balancing urban and rural problems.

1 100 US$ = 686.32 CNY according to the Bank of China on February 15, 2017.
1.

The first phase of the land system reform

The first phase of China’s reform of the land system began with the enterprise system reform. China’s reform and opening-up policy have mainly focused on the reform of State-owned enterprises (SOEs) and the development of modern company reform policy. Before the reform and opening-up policy, China had a centrally-planned economy. All companies were owned by the State, all wages and salaries were fixed, and there was no salary incentive system. It was therefore necessary to change this system, in order to make the development of modern companies possible. China has since held managers and chairmen responsible for their actions, and rewarded employees according to their contributions, which has improved worker attitudes and increased work efficiency. Another important policy is the reform that privatised SOEs or changed them into joint-stock companies. In the SOE restructuring process, land that had been permanently given to SOEs during the planned economy period had to be valued. With SOEs restructured into joint-stock companies, such land has been regarded as a real asset, having a defined value, because now it could be sold or rented to others. Separating land use rights and land ownership is the most important process for SOE and land policy reform.

China’s constitution provides for public ownership, and a 1988 amendment allows land use rights to be transferred. Article 10 stipulates:
Land in urban areas shall be owned by the State, and land in rural areas and urban suburbs shall be collectively owned by the State, except by the law and shall be owned by collectives. The State may, in the interest of the public interest, impose levying or requisitioning and compensating the land in accordance with the law, and no organisation or individual may encroach, buy or sell or otherwise illegally transfer the land, and the land use rights may be transferred in accordance with the law.

The terms of land use rights vary: residential land can be used for up to 70 years, commercial land for up to 40 years, industrial land for up to 50 years, and mixed-use land for up to 50 years.

The first phase began with the 1982 reform and opening-up and lasted until 2000, when China began to implement housing system reform. This phase can be divided into three specific development processes [Weidong 1997].


In the first phase of the land system reform, with the creation of China’s highest land management agency, the State Land Administration Bureau, a system was established through which land could be traded, leased for limited use and transferred. The government improved the relevant laws and regulations, implemented land registration, cadastral management and other land property protection measures, and established the real estate appraisal (valuation) system. Gradually establishing a benchmark land price for the system, the state began to collect geographic-based land information. This stage of land use system reform was the foundation for China’s land system establishment stage.

2. The second phase of the land system reform

The second land system reform phase was mainly synchronous with the 14-year period from the housing reform to the establishment of the Chinese real estate market (2000–2014). China began to explore the idea of the housing system reform in mid-1990s. It had implemented a welfare housing distribution system during the planned economy, in which housing was mainly allocated to employees by the enterprises and institutions that built them. Housing construction was the responsibility of the State, which assigned projects to enterprises and institutions free of charge. With China’s reform and
opening-up policy aimed at building a socialist market economy, this welfare distribution housing system had to be reformed. China sought to establish a market-based, social-security-supplemented housing market. Under the leadership of Premier Zhu Rongji, the comprehensive housing market allocation reform plan was launched in 1998. However, the reform was delayed until 2000 because of unfinished housing welfare policies.

The management system of land for housing development also required reform. After the first phase of the reform, a land use compensation system was established. This system was mainly used for enterprise land and residential construction land, and it was not widely implemented for paid use. With the implementation of housing system reform, the use of land for the construction of housing changed from free, indefinite use and fixed configurations to paid use. At the beginning of the reform, the land for housing construction was sold in a variety of ways, including through both paid and free transfers. The specific forms of paid transfer are agreements, tenders and auctions. Free transfer has been used throughout history, although its use has decreased since the reform of the housing system. The supply of land by agreement can breed bribery and other forms of corruption, resulting in unfair competition for land users. Thus, on 3 April 2002, the Ministry of Land and Resources passed Decree No. 11: the Provisions on Bidding, Auction and Listing of State-owned Land Use Rights, which stipulated the second phase of the land use system reform in China. At first, the effects of the aforementioned policy were not significant, as even the well-located and developed land was not easy to transfer. Many developers had sufficient reserves of land to develop. Enterprises typically waited to find out the effect of the agreement and the auction mode, while Chinese enterprises sought to determine how strict the policy would be. On 5 June 2003, the Ministry of Land and Resources passed Decree No. 21: the Agreement to Sell State-Owned Land Use Rights, and ruled that after 31 August 2003 the competitive development and construction of land would no longer be sold through agreement mode. This provision was called the ‘831 deadline’. After the atypical pneumonia epidemic in 2003, many people realised the importance of living environments, and developers began to increase the construction and supply of housing. Developers’ increased competition was shown in the differences in the land auction results and land transfer prices, and land auction premiums rose steadily. According to a study of Beijing’s land transfer market, auctioned land prices were 39.7% higher than non-auctioned prices [Weidong 1997].

In China, the revenue from land sales is shared by the central and local governments: the central government takes 30%, while the local government takes the rest. As the housing prices rise, so do the prices of land, which in turn spurs new increases in the housing prices. Thus, the local government obtains revenue from the rental of land. According to the land transfer provisions, local governments are free to invest this income according to their own needs. China considers that the local government’s most important task is to increase local revenue, and land finance must be in line with this goal. Local governments can put extra-budgetary land transfer income into the construction of many types of urban infrastructure, so cities can change quickly. Local government officials have frequently used this mechanism to seek promotions. Since
the implementation of the ‘trick shot’ policy in 2002, land revenue has comprised a particularly important portion of local revenue – for many years, more than 50%. Although land revenue has played a significant part in supplementing fiscal revenue and in promoting infrastructure construction, land finance itself is unstable and unsustainable. As Figure 2 shows, the 2003 land revenue accounted for more than 50% of local government revenue in 2014. This proportion fluctuated dramatically, from 40% in 2005 and 2008 to nearly 70% in 2010. Since 2015, as the real estate market has declined, so has this ratio, and land trading has become difficult. The main reason for land revenue instability is that the land transfer and the real estate market cycle are highly related to factors that affect the real estate market.

The pursuit of land finance by the local governments has resulted in the rapid rise of real estate prices as well as in real estate overdevelopment and construction. Real estate prices in Beijing rose twelvefold from 2002 to 2016. Many of China’s cities have been excessively developed, resulting in a large backlog of commercial housing, and thus the inventory of the latter has become an important task for the government (Figure 2).

Source: author’s study

Fig. 2. Share of the local government land revenue in the general budget revenue between 1991 and 2014

The second stage of the land reform established a complete market-oriented allocation mechanism of land resources – a bidding and auction system – through the coordination of the housing system reform and real estate market construction. The effects
of the reform on land wealth are obvious, as the local government now has access to land finances, urban infrastructure has been extensively developed, people’s quality of life has been significantly improved and China’s urban construction has made remarkable achievements. However, the excessive pursuit of land finance has led to the excessive development of real estate, environmental deterioration and social inequality.

3. The third phase of the land system reform

3.1. The current status of arable land protection in China

Since 2015, China’s overall economy has been slowing down, and the real estate market has become polarised. In first-tier cities such as Beijing, Shanghai, Guangzhou and Shenzhen, housing prices rose, but in a large number of third- and fourth-tier cities, real estate inventory became serious. Reducing inventory became a top priority for local governments, and housing prices fell. The central government put forward a number of new measures to promote the economy, such as ‘the Belt and Road’ initiative, structural adjustments and supply-side reform. In addition to these national strategies, this article argues that the core of China’s future economic promotion is in the rural areas, and that overall urban–rural development is the foundation of the long-term sustainable development of China’s economy. To achieve the coordinated development of urban and rural areas, it is necessary to carry out an in-depth reform of the land system in rural areas, which is the third phase of China’s land system reform.

The construction of a harmonious society is one of the Chinese government’s social goals. The Chinese characters for ‘harmony’ have their own structural characteristics – both left and right and up and down. ‘Harmony’ in Chinese has a left-and-right structure, which can be split into ‘禾’ (‘seedling’, ‘grain’) and ‘口’ (mouth). Thus, ‘harmony’ means having enough food to eat – a harmonious society’s top priority. Hence, food security is extremely important. Chinese scientists estimate that guaranteeing food security requires 1.8 billion mu\(^2\) of cultivated land resources. This amount is called the ‘red line’ of Chinese land. China began urbanisation with the implementation of the reform and opening-up policy in 1978, and entered a stage of rapid urbanisation in 2000 (Figure 3). China’s urbanisation began with the expansion of the scope of cities. Expanding cities inevitably occupy arable land. To ensure food security, China implemented a strict system for the protection of cultivated land – the ‘demand–supply’ equilibrium system, which mandates that no construction project can reduce the quantity of cultivated land. If a project uses an acre of arable land, a different acre of arable land must be provided in compensation. The second China land resources survey, which was conducted from 2007 to 2009, found that China had 135.385 million hectares (2.03077 billion acres)\(^3\) of cultivated land, 200 million mu more than the ‘red line’ of protection for farmland. In this regard, it seems that the conflict between humans and

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\(^2\) About 120 million hectares.

\(^3\) The results of the second land survey, which identified arable land of 135.385 million hectares (20.3077 million mu).
the land in China is not serious and that the cultivated land protection measures are satisfactory. However, while a great deal of high-quality cultivated land is occupied, the quality of newly added cultivated land is unsatisfactory, while pollution and other environmental problems remain serious. Attempts are being made to establish ‘ecological balance’ measures in addition to ‘farmland balance’. In 2017, China will conduct a third land resources survey; the results will provide more reliable data for the deep reform of the land system.

3.2. The challenge of the urbanisation of rural land in China

According to the result of the sixth census (November 2010), China’s population is 1.37 billion people, 620 million of whom live in rural areas, and the urbanisation rate is 54.8%. The urbanisation rate is one of the most important measures of whether a country’s economy is developed. Nearly half of China’s population is now engaged in agricultural production. However, China has not urbanised to the extent of economically developed countries, as the following comparison clearly shows (Table 1).

In sharp contrast to China’s urbanisation level, except for Germany (73.9%), the urbanisation levels of these developed countries are 80% or higher. In the government working report of the twelfth session of the fourth meeting of the National People’s Congress, Premier Li Keqiang stated that China’s goal was ‘to promote new types of urbanisation and agricultural modernisation [and] to promote coordinated development of urban and rural areas’. Narrowing the gap between urban and rural areas is important for achieving the country’s development potential. China seeks to achieve an agricultural transfer population of 100 million permanent residents in towns in the central and western regions, and to complete the reconstruction of shanty towns and villages this population inhabits. By 2020, the urbanised population will reach 60%, and as per the census register, urbanisation will reach 45%. According to the report,

![Fig. 3. China’s urbanisation development (1949–2014)](source: China Statistical Yearbook 2015)
China’s urbanisation speed will reach 1% per year by 2020. This means that each year, more than 6 million members of the agricultural population will move to cities. A predictive study, focused on China’s urbanisation and the construction of residential housing, indicates that by 2020, 800 million people will live in cities; they will require 30.5 billion square meters of residential area, and the expansion of residential areas will increase to 4% per year on average (Table 2). This means that urban construction and urbanisation require a great deal of land, most of which will come from rural areas.

Table 1. Comparison of urbanisation levels between China and developed countries

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<td>64.90</td>
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<td>31.00</td>
<td>35.90</td>
<td>42.50</td>
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</table>

Source: [Analysis… 2016]

Table 2. China’s urban housing construction forecast

<table>
<thead>
<tr>
<th>Year</th>
<th>Total population (10 thousand)</th>
<th>Urban population (10 thousand)</th>
<th>Urban housing area (100 million m²)</th>
</tr>
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<tbody>
<tr>
<td>2009</td>
<td>133,474</td>
<td>62,186</td>
<td>185.13</td>
</tr>
<tr>
<td>2010</td>
<td>134,117</td>
<td>63,727</td>
<td>195.58</td>
</tr>
<tr>
<td>2011</td>
<td>134,732</td>
<td>65,291</td>
<td>205.84</td>
</tr>
<tr>
<td>2015</td>
<td>136,889</td>
<td>71,764</td>
<td>249.08</td>
</tr>
<tr>
<td>2020</td>
<td>138,886</td>
<td>80,322</td>
<td>305.42</td>
</tr>
<tr>
<td>2025</td>
<td>140,071</td>
<td>89,353</td>
<td>365.64</td>
</tr>
<tr>
<td>2030</td>
<td>140,421</td>
<td>98,793</td>
<td>428.69</td>
</tr>
<tr>
<td>2011–2030 Average</td>
<td>0.2%</td>
<td>2.2%</td>
<td>4.0%</td>
</tr>
</tbody>
</table>

Source: REICO Studios Research Report
In the second phase, the supply of land for real estate development was arranged by the city government, which served as a representative of State-owned land use rights sold by bidding, auction or listing. The new land needed for urban expansion came from the surrounding rural areas, which was owned by the rural collective. However, by law, the State had to use land expropriation to obtain collectively owned land for real estate development. In this ownership conversion process, land values rose sharply, and the local governments took most of the proceeds as land finance. Many land conflicts occurred because of insufficient compensation for farmers and rural collectives. Over the course of nearly 20 years of land ownership conversion, local governments largely deprived farmers of their interests, which constituted the main source of capital for urban development. During this time, Chinese farmers made great sacrifices and contributions to China’s urban development. The increasingly sharp social conflicts and the growing gap between urban and rural development (Figure 4) made it impossible to perpetuate this land supply model in China in the future, which will force the government to deepen the reform of the land system in rural areas.

![Fig. 4. Income gap between urban and rural areas in China (Unit: RMB/person · year⁻¹)](source: China Statistical Yearbook 2014)

### 3.3. The core problems with China’s future rural land system reform

The growth point of China’s future economy is in rural areas; thus, both urban and rural development are key factors to solving economic downturns. Land management is an important means to release the substantial productivity of rural areas and the labour resources thereof. The core of the land problems in rural China lies in its ‘three kinds of rural land’, including rural land ownership, land contract rights and land management rights, and the ‘division of three rights’, including the division of ownership, contract and management rights. Rural land ownership and rural contract and management rights were clearly separate at the beginning of China’s rural land system
reform, as contract and management rights were owned by farmers. In 1988, China began to improve the rural land contracting relationship by implementing the first round of contracting, which included a contract period of 10 years. In 1997, the State issued a policy to further stabilise and improve the contracting relationship of rural land and required that the contract period be extended to 30 years, from 1998 to 2027. The Decision of the Third Plenary Session of the Seventeenth Central Committee of the Communist Party of China (CPC) on Several Major Issues Concerning the Promotion of Rural Reform and Development gave farmers fuller and more secure land contractual management rights. Thus, farmers can continue to contract rural land after the 30-year land contract period expires. The recent rural land policy stipulates that the original land contractual management right can be divided into the contract right, which is still owned by the farmers, and the management right, which can be transferred to others, even to non-agricultural households. The division of the land contractual management rights will have far-reaching impact on farmers’ vital interests. Thus, the current land reform in rural areas should aim to solve the management of the ‘three kinds of rural land’ and protect the vital interests of farmers.

3.3.1. ‘Three Kinds of Rural Land’

The management issues of ‘three kinds of rural land’ concern agricultural land, rural collective land for construction, and rural residential land. The core aim of farmland management is to protect the amount of cultivated land from decreasing and its quality from declining, as well as to maintain ecological and environmental protection mechanisms. Some scholars have suggested replacing construction land indexes in different places in favour of occupied arable indexes in underdeveloped areas because economically developed areas need more construction land. We strongly oppose this view. Southern Yangtze is often called a land of plenty because the Jiangsu and Zhejiang regions have high-quality land and abundant water resources. No matter how the national climate and rainfall change, these regions always have a bumper grain harvest. We must not allow Jiangsu and Zhejiang to use arable land resources for industry without restraint or consideration for the environmental and ecological effects, just because their economies are higher than China’s average level and they have greater demand for construction land. Doing so would lead to the destruction of the natural environment of the region. Farmland management must be strengthened through protection mechanisms, and development should occur within these protective measures.

The issue of the management of rural collective land for construction is the strongest aspect of the rural land reform. China’s two kinds of land ownership have long entailed different rights and prices for the same land. \(^4\) Collective construction land cannot be used for real estate development; it must first be converted into State-owned construction land. As mentioned earlier, land value increases greatly in this conversion.

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\(^4\) ‘The same land’ refers to both urban and rural land ownership being types of public ownership with the same nature. ‘Different rights’ means that land use rights have different connotations: the same land can have a different right to use, right to earning, easement and so on.
process, and most of the value-added income is taken by the local government, which is unfair to the farmers. In the past, rural collective construction land was allowed on the land market without being converted into State-owned construction land. Rural collective economic organisations may, according to their needs, allocate all of the land for construction use that conforms to land use planning to the land users through bidding, auction or listing, leaving the land value-added gains mainly to the rural collective economic organisations and to farmers, who use them for urban and rural infrastructure construction, rural environmental remediation, land development and other aspects of pre-expenditures. In 2015, the Ministry of Land and Resources selected 33 regions in which to conduct experiments. The land reform measures in the pilot areas basically achieved the goal of ‘same land, same rights and same price’. The Ministry of Land and Resources will thus amend the relevant laws and regulations and improve the construction land management approach in the near future.

Withdrawal from rural residential land is a problem. Many farmers come to the cities looking for work and never return to the countryside. However, they retain their rural residential land, which stands idle. This is a tremendous waste of resources, and it does not increase the capital of these farmers. New adult farmers are assigned to new rural residential land, even as large numbers of vacant houses remain in these areas. This results in the bizarre increases in both the number of vacant houses and the supply of housing construction for new farmers. Studies into the reform of rural residential land must be conducted to appropriately transfer idle rural residential land to those who will actually use it. People who do not need rural residential land can transfer idle houses for currency, which could help them to purchase new houses in towns.

There are different kinds of rural residential land transfer and circulation modes in China, and the ‘exchange isolated farmers’ residential land for well-planned houses’ model is one of the more successful ones. Old rural housing is dismantled in favour of new planned communities, with new housing allocated in accordance with the size of the original residential land. Although rural residential land replacement has proved successful in some rural areas, this model is not suitable for all rural areas in China. For example, this model will not work in rural areas that are far from urban areas or in economically underdeveloped areas. The successful implementation of rural residential land replacement requires the government to give farmers more financial subsidies, which come mainly from the construction land saved from the relative concentration of farmer housing. When the saved construction land is used for real estate development, the added land value can meet farmers’ requirements for rural residential land replacement subsidies. In remote rural areas, the savings from the layout of the construction land have no value for real estate development, because no one wants to invest in houses in these areas. Thus, feasible models should combine the characteristics of the transfer and circulation of rural residential land in different areas. However, the mortgage problem of rural residential land must be considered. Under current law, rural residential land cannot be mortgaged, and the bank financing available for housing owned by

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5 The size of the peasant housing built on the rural residential land.
farmers to support agricultural production activities is limited. The main reason for restricting mortgages of the rural residential land is that if farmers with loans become unable to repay the loans, the banks cannot dispose of the mortgages. However, studies should consider whether rural residential land can be mortgaged with increasing numbers of farmers coming into cities to work and live.

3.3.2. ‘Division of three rights’

The ‘division of three rights’ is the core of China’s rural land system and economic reform. The conflict between the people and the land is serious in China. The amount of arable land per capita globally is 4.8 \text{mu}, \text{ but it is only } 1.3 \text{ mu in China, which ranks } 126^{th} \text{ in the world. Yet the amount of unused cultivated land in China’s rural areas has increased, mainly because of the large number of farmers leaving the countryside.}

The improvement of the agricultural production mechanisation has freed a large portion of the rural labour force to come to cities looking for jobs, thus leaving the original contract farmland abandoned. However, medical security and social security policies are different for farmers than for urban residents, and the farmers do not assume the identity of urban dwellers. This means that although their living space has changed, their identity has not changed substantially. Thus, farmers want to maintain their land contract rights and keep their rural residential land in order to protect their interests and retain the opportunity to return.

The ‘division of three rights’ separates the contract rights from management rights, enabling the farmers who come to cities to transfer their long-term management rights for farmland to other people who cultivate arable land, and to gain rents. Farmers are also able to entrust their contracted land to modern agricultural economic organisations through shares, and to gain dividends. This not only protects valuable arable land resources, but also allows farmers to come into cities with additional income, reducing the economic pressure placed on them.

The separation of contract and management rights is beneficial not only for farmers who come to cities to make inventories of their contracted land assets, but also for those farmers who stay in rural areas. In the process of new rural construction, a growing number of modern agricultural production organisations have appeared; these have contributed to the centralisation of the distributed contract land, and farmers can voluntarily transfer the management rights on contract land to these economic organisations. In some provinces of north-western China, poor-quality arable land and low yields of grain indicate that land is unsuitable for cultivation. Modern agricultural enterprises have benefited by renting contracted land, constructing modern agricultural production equipment and facilities, and providing other non-grain products through scale management. This innovative mode of development of new rural areas benefits farmers and profoundly affects the development of rural areas with poor natural conditions. Thus, the separation of contract and management rights plays a protective role in the land property system.

\text{6} \text{ 1 km}^2 = 10,000 \text{ m}^2 = 15 \text{ mu.}
4. Conclusions and recommendations

In the next 20 years, China’s urbanisation will continue to develop at an annual rate of 1%, and more than 120 million farmers will want to change their identities, which may change China’s rural areas dramatically. This is also a key factor in the development of China’s economy.

Rural land management must participate in economic reform, and coordinate with other factors of production. As a result, the management of rural areas should pay attention to the following aspects:

4.1. Accelerating the registration of land certification work

Land management is based on property rights. However, the ownership of land in rural areas in China is not sufficiently clear, and is even confusing at times. The ratio of land certificates according to the land registration method on contracted rural land is still very low, and many farmers have a weak understanding of their land registration certificates and the protections of property rights. Survey results7 showed that more than 40% of surveyed farmers had not participated in any propaganda meetings on farmland rights and that 30% of the land right certificates were not standardised and were invalid. These issues must be resolved through rural cadastral management.

4.2. Adhering to both farmland protection and natural environment protection

China’s land management has protected cultivated land with the ‘red line’ of 18 million mu of arable land. However, the survey found that while the quantity of arable land was being protected, its quality was declining. Thus, farmland protection should balance quantity and quality. Another serious problem is the deterioration of the natural environment in rural areas, which has increased the degree of soil pollution. In the future, land management in rural areas must be strengthened through the protection of cultivated land and the sustainable development of cultivated and natural land balance.

4.3. Stressing the use of land management measures

Land problems in rural areas are complex, and land management measures such as land planning, land consolidation, the transformation of old villages, the construction of new villages and the protection of property rights must be comprehensive.

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7 This survey, conducted by Ye Jianping, Professor of Land Resource Management at Renmin University of China, investigates the agricultural land property right issues of 17 Chinese provinces every two years. The results of the latest survey were released in November 2016.
4.4. Prioritising farmers’ interests

For the benefit of China’s economic development, rural, agricultural and peasants’ issues must be solved. This article mainly discusses the issue of farmland management. The core of rural, agricultural and peasants’ issues is the problem of peasants – the farmers themselves. The future urbanisation of China entails the urbanisation of people rather than the expansion of urban areas. Farmers’ interests must be protected between the economic development of rural areas and the reform and restructuring of the land system – their incomes must continue to grow and the income gap between urban and rural areas must be narrowed (Figure 4). The survey of agricultural land property rights in 17 Chinese provinces found that farmers’ incomes did not increase with the transfer of farmland. We should pay attention to this phenomenon, find its cause through research and try to solve it.

4.5. Implementing public participation initiatives

Good policy – including good land management systems and measures – requires both top-level design and public participation. Rural development should solve the problem of the relation between farmers and agricultural land. Only by securing the participation of a wide range of farmers can the government fully solve the problem.

4.6. Building a unified urban and rural construction land market and fulfilling ‘same land, same rights, and same price’ principle

Whether owned by the State or collectively, the land used for construction should be subject to the same rights and values. The construction of a unified construction land market is necessary to achieve this goal. Current policy has allowed the establishment of a rural collective-owned construction land market for the construction of factories and commercial real estate, but it does not allow for the development and construction of housing. In the past, a large number of houses were built without approval on collective-owned land. Compared with houses built on State-owned land – ‘houses with full property’ – these ‘houses with limited property’ are not protected by the national policy. The development of a unified urban and rural construction land market can only occur if this problem is solved.

References

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PROPOSAL FOR THE MODIFICATION OF THE OECD AND EUROSTAT-BASED TYPOLOGIES FOR RURAL AREAS

Marian Skorupka

Summary

According to the regionalisation procedure based upon OECD and EUROSTAT typologies, the land of EU Member States is subdivided into rural areas (ca. 90 per cent of the total EU territory) and urban areas (ca. 10 per cent thereof), generally based on the criterion of population density, with a threshold of 150 (OECD) or 300 (EUROSTAT) inhabitants per square kilometre. The proposed modification of both typologies relies on distinguishing, on the local level, of the third type of areas, called “natural areas,” and characterized as follows:

- zero density of population;
- occurrence of dense areas with habitats of natural type (forests, lakes, mountains, swamps etc.) within the given area; combined with;
- low (negligible) level of human intervention.

Desirability of distinguishing between the “natural area” type as opposed to the “rural area” type results from:

- its functionality, which is wholly different from that of other types of “rural areas”;
- high share of such land in the total area of the EU (more than 40 per cent);
- the fact that the share of such areas in current type of rural areas – estimated as ca. 40 to 50 per cent – varies between the member states, from ca. 10 per cent (Benelux, Ireland) up to 80 and more per cent (Finland, Sweden), with less than 40 per cent share in Poland;
- possibility to obtain a better approximation of the actual condition, reflected in quality data, including spatial data, describing the environment of natural areas and the remaining rural areas.

As a consequence of distinguishing the “natural areas” on local level, we would be able to classify a region/sub-region type of “MOSTLY NATURAL” at regional level, with the share of “natural areas” on a threshold, e.g. 80 or 85 per cent, but no less than two thirds.

Implementation of the aforementioned modification of methodology in both types is simple, and it could be performed fast. This is because all of the EU Member States (including Poland) already possess the necessary data in the framework of their IT systems including spatial data systems such as GIS (Geographic Information Systems) included, inter alia, in the IACS (Integrated Administration and Control System), which is mandatory for all the EU Member States for the implementation of the Common Agricultural Policy; as well as other relevant ortho-photos and airborne imagery.
Moreover, each of the EU Member States possesses, in digital form, a “cadastre” or an equivalent thereof (such as the “records of land and buildings” in Poland) as well as a system of the State’s administrative division (TERYT in Poland) down to the level of a village/town/settlement. Furthermore, the proposed modification for both typologies is not contrary to the provisions of the existing EU’s and Poland’s regulations on regionalisation.

Keywords
land • rural areas • modification of OECD and EUROSTAT typologies • natural areas • mostly natural regions

1. Introduction

The impulse to take up the topic associated with approaching the essence of rural areas with a methodology different than before included: the current practice of describing almost the whole territory of the country under one concept, called the rural areas, despite the fundamental functional diversity present in this three-dimensional spatial entity; the inclusion in rural areas of all the territory of the country which is nor classified as urban areas, that is, inclusion in one category of both the lands significantly transformed by human activity and irreversibly deprived of the characteristics of the environment, and the land still constituting unspoilt natural environment or having the characteristics of the natural environment and remaining close to the natural state; the fast paced urbanization, or industrial and agricultural transformation of the land, in its initial phase usually taking place at the expense of environmentally valuable parts of rural areas within the meaning of their previous classification; the use of ambiguous nomenclature in relation to the same parts of the country classified as rural areas, in legal, economic, social, and linguistic terms.

2. Land and related terms, with the view to the modification of the existing classification of land, used in the context of EU regionalization

“Land” (or another synonymous term) is naturally adopted as the basic concept describing the surface of the Earth and its environment, to denote a multi-functional and, unfortunately, not very precisely defined spatial existence. Depending on the context used, there are different synonyms of the word: land, space, areas, territories – usually with the addition of the adjective “urban” or “rural” (area); meant to succinctly define the geo-climatic and socio-economic functions performed by the given space. Due to the imperfection of the above concepts, in the present study we shall use the terms “rural areas” and “urban areas”, as clearly defined in the existing typology of the OECD and the EUROSTAT, which we propose to modify. The proposed modification is the subject of the present study.
3. Basic solutions adopted in the typologies of the regions by the OECD\textsuperscript{1} and EUROSTAT\textsuperscript{2}, setting the principles of regionalization within the European Union

One of the primary spatial conventions is assigning individual parts of the country’s territory the characteristics that classify these parts based on a relatively simple and universal criterion for possible use in diverse socio-economic conditions. Such a criterion, adopted in the framework of the EU, is the degree of urbanization, expressed in essentially one key indicator, which – in most cases – is the population, typically described as population density per area unit. Based on this criterion, procedures are implemented within the typology of regionalization of particular countries. Within the EU, currently two typologies of regions are used, i.e. the “Typology of regions according to the OECD standard” and the “Typology of regions according to the Eurostat standard.”

The assignment of a particular area of the country to the type of area, under both adopted typologies, takes place on two levels. The first level is the local one, providing segmentation of space in micro scale, with subdivision into rural and urban areas, while the second level is the regional / sub-regional one, aggregating the areas from the local level into types: predominantly rural, intermediate and predominantly urban.

According to the OECD typology, at the local level, the criterion for identifying and dividing of areas is the degree of urbanization, expressed with the measure resulting from population density, thus dividing land into:

- urban areas, where the population density is at least 150 people / km\textsuperscript{2};
- rural areas, where the population density does not exceed the limit of 150 people / km\textsuperscript{2}.

As an elementary part of the land (space) within the local level typology, unit of the territorial division of the country has been adopted.

In connection with the occurrence of certain weaknesses in the OECD typology, related to difficulties in the comparability of individual categories of spatial units throughout the EU, in order to eliminate these weaknesses, a new typology has been developed, following the EUROSTAT standard, based on the primary element, the so-called “grid”, which is a square with the side of the 1x1 km, set by the map grid lines.

Here, too, there is a subdivision into two types i.e. urban and rural, in which:

1. Urban areas are the “grids”, which fulfil two conditions
   - population density of over 300 people / km\textsuperscript{2},
   - minimum population exceeding 5 thousand persons to a square with the side of 3 km, created by grouping the centrally placed, classified “grid” with eight neighbouring “grids”.

2. Rural areas are those “grids” that do not meet the above criteria.

\textsuperscript{1} Organization for Economic Cooperation and Development

\textsuperscript{2} European Statistical Office
Due to the fact that at higher levels of aggregation, the territory of a country usually consists of a conglomerate of area types occurring at the local level, in order to maintain a conceptually similar subdivision into types, both in the OECD and EUROSTAT typologies, regions have been subdivided into 3 types, respectively named “predominantly rural – PR”, “intermediate – I”, and “predominantly urban – PU.” Classification under the given type of the region depends essentially on the percentage of the rural population.

When, in a given region, there is a city with a population of over 200 thousand or over 500 thousand respectively, it is possible to correct the classification and upgrade the region, assigning it a higher degree of urbanization, when the city’s population is at least 25% of the total population of the region.

Below are diagrams of both typologies (Figures 1, 2).

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**Fig. 1. Outline of the OECD typology**

Because – when using the OECD typology – too large functional variation occurred in the “predominantly rural” and “intermediate” types, a further differentiation was introduced for these types, by incorporating a parameter that defined the criterion of accessibility of rural areas to the nearest town, which is the distance from urban centres with the populations of over 50 thousand people, calculated according to the travel time to such cities, with a value of up to one hour, or more than an hour.

Within this division, intermediate type “I” was divided into “intermediate, located close to the city – IC” and “intermediate, located away from the city – IA” and the type
of predominantly rural “PR” was divided into “predominantly rural, located close to the city – PRC” and “predominantly rural, located away from the city – PRA.”

It should be noted, however, that situations may also arise, where the adopted methodology in the current methodological framework gives a result, in which areas at the local level, covering countryside and cities, are classified into the wrong type, that is to say, according to the typology, countryside is classified as a city, and the city is classified as a village.

For example, in the context of the paper on “A revised urban-rural typology” presented at the meeting of the Committee for the Structural Development of Agriculture and of Rural Areas (STAR) on 20 October 2010, it has been reported that within the OECD typology, if the population density threshold is set at 150 inhabitants per km² at the local level, then due to the variety of the size of administrative units, some areas will be incorrectly classified, and therefore:

- small villages such Aldea de Trujillo in Spain – due to the area which is strictly limited by the administrative boundaries, and a sufficiently high density of population – should be classified as urban areas, despite having a population of just 439 inhabitants;
• the type of the city such as Badajoz and Cáceres in Spain, or Uppsala in Sweden despite having the population of 150,000 inhabitants each or more, must be classified as rural, due to the low population density within the larger area subject to classification.

In Poland, the classification of rural areas results from the typology of the division of areas, which adopts the OECD standard, where at the local level, the criterion for identification and division was adopted as the degree of urbanization, expressed by the criteria arising from the population density, and subdivided into:

• urban areas (at least 150 people / km\(^2\)) representing approx. 7% of Poland's territory;
• rural areas (up to 150 people / km\(^2\)), that is, in connection with the division into only two types of areas, constituting the remaining part of Poland’s territory, which does not qualify as urban areas, i.e. approx. 93% of the country’s territory.

_Gmina_ (municipality), that is, the unit of the country’s territorial division, having its own representative (self-government) bodies of the local population, was adopted as an elementary unit of space (land) within the local level typology.

4. The concept for modifying the typology of regions according to OECD and EUROSTAT, based on distinguishing, among the rural areas, of a new type of zero-population density areas, retaining the character of natural habitats

Methodologies adopted in both typologies cause the situation that both the OECD typology and the EUROSTAT typology suffer a significant deficiency, namely: the concept of rural areas covers both some densely populated areas, extensively used in the context of human activities, and some totally unpopulated areas or zero population density with natural features subjected to minimal human interference. This also applies when such areas are a significant part or even the vast majority of the rural areas of the given country.

Furthermore, under both adopted typologies, despite the introduction of additional criteria on the regional level – such as existence in rural areas of towns with populations of hundreds of thousands people, or travel time to the cities – still not included in these typologies are the issues related to the existence and protection of natural environment habitats, which in the era of rapid acceleration of urbanization and the continuing process of economic exploitation of natural type environments also should have a significant impact on the methodology of developing area types, including those areas currently considered rural.

The postulate of including in the typology the issue of the occurrence of natural environment habitats becomes all the more significant, as due to the disappearance of such habitats, they only exist as compact, still non-urbanized areas and remain fairly unexploited economically, and therefore they in fact become priceless assets.

Assuming ultimately the need for a high level of protection of natural environments, it would be advisable to consider distinguishing them in these typologies already at the stage of the subdivision of space into elementary parts, that is, at the local level.
This would provide better opportunities for the protection of such areas, already at the initial stage of the validation, and at further stages of spatial planning activities.

The solution to the above problems can be the modification of the OECD typology and the Eurostat typology, as proposed in the present study, according to the principle (common for both these typologies) of distinguishing from among the rural areas, of a new type of areas (already at the local level), characterized by:

- essentially zero population density;
- existence of the natural (or very close to natural) state of the environment/habitat;
- the lack of interference of human economic activity, or minimum level of such interference.

At the same time, it would be sensible to introduce the modification in such a way, that the changes would not fundamentally affect other principles and criteria contained in the OECD and the Eurostat typologies.

Distinguishing, at the local level, of rural areas of the new type, characterized by zero population density, taking into account the conditions described above, should be carried out so that it is also possible to seamlessly create a new type of regions at the regional level, characterized by a dominant share of environment of natural type.

5. Methodology for the assessment of expediency of distinguishing the new type of areas among the rural areas

In order to establish the expediency of the proposed concept for the modification of the discussed typologies, it is proposed that we analyse the functional cohesion in terms of space and utility, of the land types occurring in both typologies.

Performing such analysis is based on the proposition of basic functional features, characterizing the types of areas within the OECD typology and the EUROSTAT typology, followed by the evaluation of the functions of these areas, in terms of homogeneity. For the assessment of these features, we shall employ parameters describing the economic and social usefulness as well as the visual features thereof. Within the scope of these parameters, the evaluation will be performed with the view to simplified gradation of the occurrence of a given parameter in relation to the given function. Collating together the degrees of compliance of gradation will facilitate the assessment of functional and usable uniformity, of the current allocation of land into area types, as adopted within the European Union. The occurrence of homogeneity or heterogeneity of functional use of respective area types will be the premise testifying to the expediency of distinguishing the given type as a new type of area.

On the basis of a similar analysis, we will also assess the homogeneity of the two types of areas, resulting from the further subdivision of the given area type. If the assessment of functional cohesion under both newly established types of areas, resulting from the further subdivision of the area, brings a considerably improved result, then it will testify to the desirability of the proposed modifications to the typology of the division of the country based on the standards of the OECD and Eurostat.
As part of the present study, in relation to the Polish territory, we also propose to establish the approximate area (size) of the proposed new area type that could arise from distinguishing it from among rural areas according to their current definition.

Another important issue is also the feasibility of practical application of the division into three types of areas to replace the current two, along with determining the conditions related thereto, and checking the compatibility of the proposed modifications to the typology of both the existing EU legislation and Polish regulations.

6. Analysis of spatial and land use functions for the types of areas present in regional typologies according to OECD and to EUROSTAT

Analysis of the spatial and land use functions of the areas in question should be the starting point for demonstrating the expediency of the proposal for creating a new type of areas.

6.1. Spatial and land use functions present within the area types distinguished in the OECD and EUROSTAT regional typologies

When analysing the previously existing division into two types of land, i.e. rural areas and urban areas, it would be advisable to establish and to consider, in the context of this division resulting from the degree of urbanization / population density, the basic functions of spatial utility (land use), hereinafter referred to as “functions”, describing these areas in terms of community functioning.

Within rural areas, there are four basic land use functions:

- agriculture;
- housing, including residential housing;
- forests, which usually also include land that is functionally integrated with forests, located above the upper limit of forest, land covered with shrub and mountain vegetation, and rocky terrain;
- water: lakes, bed of large rivers, artificial lakes.

Within the urban space, we can distinguish two basic, major functions:

- housing, including integrated functional areas of communication and leisure;
- industrial function.

In order to characterize the influence of these basic functions on the types of areas, their description was adopted using several standardized basic parameters relating to their economic and social utility, and visual properties.

The following parameters, proposed in the framework of the present study, meet the conditions of economic and social utility and visual properties:

1) population density;
2) the degree of transformation of the natural environment;
3) the intensity of land use by man (human activity);
4) the homogeneity of the landscape within the given function;
5) “friendliness” to human inhabitation;
6) “friendliness” to animal existence;
7) the existence of specific social and cultural ties;
8) the size – compared to the scale of the country.

We could multiply the number of parameters, but given that the ones listed above are the parameters that are generally understood, that the evaluation thereof is simple, and that simplicity has its advantages, we have decide to confine ourselves to the parameters mentioned above.

In order to evaluate the occurrence/presence of the above listed parameters, in respective functions, we have decided to adopt simple and generally understandable terms: high, medium, low – defining a consequence of the occurrence, in other words, the degree of intensity or gradation (grade).

Where a given parameter in the analysed type of area (land, space) is not present, such a situation is described by the symbol “n/a” – not applicable.

Taking into account the argument of simplicity and understanding at every intellectual level, it can be assumed that both the quantity and factual content of the parameters, as well as the adopted “gradations” or grades at the level of the evaluation remain sufficient for the purpose of determining the cohesion of the functional types of area (land, space) in the OECD and EUROSTAT typologies.

6.2. Functional assessment of cohesion for two types of areas present in the OECD and EUROSTAT typologies of regions

Rating the functional homogeneity (cohesion) for the types of areas – i.e. rural and urban – found in the regional typologies of OECD and EUROSTAT, will be done by identifying in the specific type of areas, the frequency of occurrence for all the functions within each given parameter: one kind of grade; the immediate neighbourhood gradation of the “low-medium” or “medium-high” type; or the occurrence of all types of grades for a given parameter. The functional homogeneity assessment takes into account also those cases in which – within the given parameter – a function parameter that is not applicable (“n/a”) occurs next to the given type of grade.

The occurrence of each grade, and neighbourhood (adjacent) grades, evaluating the functions within both land typologies existing in the European Union, is presented in Table 1.

Table 2 presents the report on the occurrence of: full compliance grades within particular parameters, immediate neighbourhood within the grades such as “low-medium” or “medium-high”, total diversity of grades within a single parameter, as well as the occurrence of the given grade within the neighbourhood where the parameter is not present – for each type of area.
Table 1. Types of areas in the functional aspect, in reference to parameters described in section 6.1, with respective gradations (grades)

<table>
<thead>
<tr>
<th>Area type (according to OECD, EUROSTAT)</th>
<th>Basic functions performed by the given type of area</th>
<th>Gradation values in relation to parameters 1–8 (described in section 6.1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Basic functions performed by the given type of area</td>
<td>1  2  3  4  5  6  7  8</td>
</tr>
<tr>
<td>Rural</td>
<td>housing medium medium low low low low low low</td>
<td>low</td>
</tr>
<tr>
<td></td>
<td>agricultural n/a medium medium medium n/a medium n/a high</td>
<td>high</td>
</tr>
<tr>
<td></td>
<td>forest n/a low low low low high n/a medium</td>
<td>medium</td>
</tr>
<tr>
<td></td>
<td>water n/a low low low low high n/a low</td>
<td>low</td>
</tr>
<tr>
<td>Urban</td>
<td>housing high high high high medium low low low low</td>
<td>low</td>
</tr>
<tr>
<td></td>
<td>industry n/a high high high n/a low medium low</td>
<td>low</td>
</tr>
</tbody>
</table>

Table 2. Report on the cohesive/adjacent occurrence of “grids” within each parameter (as described in section 6.1) for the given type of area

<table>
<thead>
<tr>
<th>Area type</th>
<th>Number of “grids” occurring within each parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>With identical values</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Rural</td>
<td>0</td>
</tr>
<tr>
<td>Urban</td>
<td>5</td>
</tr>
</tbody>
</table>

The results presented in Table 1 and Table 2 indicate that under the rural type of area, there is a very significant internal functional differentiation, as evidenced by: zero incidence of grades which are wholly cohesive / uniform; four cases of adjacent grades; one case of all kinds of grades occurring within the given parameter; and three cases where next to any kind of grade the situation arises where the given function does not occur under the given parameter.

For urban areas, the results were just the opposite, that is, we meet with almost total functional cohesion, as evidenced by: the five cases of cohesive / uniform grades; one case of adjacent grade; zero cases when all kinds of grades occur within one parameter; and two cases where next to any kind grade, situation arises that the function does not exist under the given parameter.

The results presented above indicate that in the OECD and Eurostat typologies, the principles for determining the types of areas are not methodologically comparable in terms of uniform parameters (for both types of areas) describing the functions of these area types. It can therefore be concluded that the above classification, adopted in the
European Union, into just two types of areas – i.e. rural areas and urban areas – already at the local level, is too general and that distinguishing an additional type of area is justified.

Due to the very significant internal functional diversity of the current type of rural areas (see the analysis above), it would be advisable to consider the subdivision of this type of area, in order to provide the rural area/space with the functional homogeneity analogous to that found within the urban area/space category. The existence of the uniformity (cohesion) of functional utility for all three types of areas can allow for a more rational and efficient use of these areas, both in economic and social terms, and in the aspect of environmental protection.

7. Proposal for achieving functional cohesion of the types of areas within the OECD and EUROSTAT typologies of regions, by distinguishing a separate area type within the rural area type

With a view to achieving the internal functional uniformity (cohesion) within the subdivision into the basic types of areas, where the basic criterion of division within the European Union is the population density, and the borderline (threshold) dividing the two types of areas is 150 or 300 people / km² respectively; combined with the occurrence of significant, compact unpopulated areas i.e. areas with population density of 0 (zero) persons / km² or areas with population practically oscillating around this value (these representing a total of approx. 1/3 of Europe’s territory), it seems pertinent to consider adopting precisely this parameter i.e. 0 people / km², as the basis for a new type of area in the proposed modification to the OECD and Eurostat typology of regions.

The proposed zero population density, in the framework of the functions under consideration, may only apply to rural areas, and to relate to the functions of the forest, water and agriculture, as within the urban typologies of the OECD and EUROSTAT, in principle the possibility of zero population density is ruled out. It should also be noted that the currently accepted divisions between types of areas also allow the existence of parallel conditions in the socio-economic framework of subdivision into basic types of areas, however, in the era of accelerated and even violent changes to the environment, presently there is no additional requirement that would apply to the issue of protecting the existing natural environment.

Following the rapid acceleration of urbanization, and the progressive process of economic exploitation of unoccupied habitats of natural type, compact sections of areas, remaining in their natural or close-to-natural condition become a virtually invaluable asset, and because of the need for their increased protection, they must necessarily be distinguished already at the stage of subdivision of space (areas) into elementary parts, that is, linked to the local level in both existing typologies.

Due to the very high multi-functionality of space (areas) previously classified as rural, it seems feasible to distinguish compact areas, preferably linked by a common feature, and based on zero or close-to-zero degree of urbanization, which shall translate to zero or close-to-zero population density. In the era of environmental protection,
with zero population, for instance the preservation of the natural features of the area’s natural environment may serve as such a common feature, within the given function.

In the context of the discussed functions of rural areas (residential, agricultural, forest, water), the condition of zero population density while preserving the natural features of the environment is met only by the functions of forest and water. The agricultural function, despite having zero population density, does not meet the condition of the preservation of the natural features of the environment – due to the intense, increasingly industrial exploitation by man, on annual basis – while the housing function by definition can not be characterized by zero population density.

8. Analysis of the solution aimed at ensuring functional uniformity (cohesion) of both types of areas already existing in the OECD and EUROSTAT regional typologies, and the proposed third area type with zero or close-to-zero population density, created from the subdivision of the rural land type

In conducting functional analysis similar to that presented in Table 1, when distinguishing – from the rural areas – the functions of forest and water as an area type under the working name of “natural area”, we obtain the results shown in Table 3.

Table 3. Types of areas, according to functional approach, in relation to parameters described in section 6.1, when applying three types of areas (land/spaces)

<table>
<thead>
<tr>
<th>Area type</th>
<th>Basic functions performed by the given type of area</th>
<th>Gradation values in relation to parameters 1–8 (described in section 6.1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3 4 5 6 7 8</td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>housing  medium medium medium medium high medium medium low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>agriculture n/a medium medium medium n/a medium n/a low</td>
<td></td>
</tr>
<tr>
<td>Natural</td>
<td>forest n/a low low low n/a high n/a medium</td>
<td></td>
</tr>
<tr>
<td></td>
<td>water n/a low low low n/a high n/a low</td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>housing high high high high medium low low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>industry n/a high high high n/a low medium low</td>
<td></td>
</tr>
</tbody>
</table>

When we compare the occurrence of variation between different parameters for particular types of areas, within the above listed pairs of functions (excluding the situations where the given parameters does not apply to either of the functions), we shall obtain the result presented in Table 4.

As shown in the table above, the introduction of an additional type of areas tentatively called “natural areas” brings the classification of space into three types of areas into an almost complete functional compatibility, as testified by almost equal number
of “grades” of identical value, for the parameters of the functions performed by these areas. It can therefore be concluded that these areas, described by the above pairs of functions, are almost comparable in terms of homogeneity within the given area type, while the types become functionally homogeneous in practical terms – if we define homogeneity as the presence of the greatest number of grades of the same value, combined with minimising situations described by other settings of grade values, linked to land functions within the given type of area.

Table 4. List of cohesion/neighbourhood of “grids” within each parameter (as described in section 6.1) when applying three types of areas

<table>
<thead>
<tr>
<th>Area type</th>
<th>Number of “grids” occurring within each parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>With identical values</td>
</tr>
<tr>
<td>Rural</td>
<td>4</td>
</tr>
<tr>
<td>Natural</td>
<td>4</td>
</tr>
<tr>
<td>Urban</td>
<td>5</td>
</tr>
</tbody>
</table>

Below, score for the type of rural areas when we distinguish just two types of areas (rural and urban) – for a better visual comparison of the proposed solution

| Rural | 0 | 4 | 1 | 3 |

When we divide the space into three types of areas, i.e.: natural areas (characterized by zero or close-to-zero population density), rural areas, and urban areas, we obtain a very high internal functional homogeneity for each of these three types of areas, which is not possible with the previously existing classification into two types of areas i.e. rural and urban.

Furthermore, subsequent isolation of the area type – provisionally named the “natural areas” is achieved, which, in principle, might be subjected to a homogeneous regime of environmental protection, due to its significantly less intense economic exploitation than in the case of the other two types of areas.

9. Determination, in the context of Polish conditions, of the estimated size of the proposed area type (i.e. natural areas)

In order to illustrate the scale of area changes that would occur if Poland’s territory were to be subdivided into three types of areas, instead of two, in reference to the accepted assumption that the type of natural areas should include those areas that are uninhabited and those areas having the features of the natural environment or much similar, with a minimum human interference with economic activity, in the context of Polish conditions, natural areas could include, primarily and in principle: forests understood
as compact complexes, watercourses, lakes and large rivers, mountainous areas above the boundary of forest, as well as compact swamp and desert areas.

Due to the illustrative character of the “size of the natural areas” term, adopted for the purpose of the present study, combined with the availability of partial data, and the impact of the data on determining the size of natural areas within Poland’s territory, in the following table we have included only: forests without wooded land and lakes, while excluding the surface of large rivers. Mountainous areas above the boundary of forest were also omitted, due to their overall area being relatively insignificant in relation to the size of forest and lake areas.

In order to illustrate the size of the proposed type of natural areas in the context of Poland’s territory, taking into account the position of such areas within the regions/voivodships (in the framework of the OECD typology, one of the levels of regional sub-division of space), the above approximation is sufficient, as testified by the relative proportions of surface data, presented in Table 5.

Table 5. Estimated size of the proposed type of “natural areas” in the scale of Poland’s territory, with subdivision into regions (voivodships)

<table>
<thead>
<tr>
<th>Region voivodship</th>
<th>Size of “natural areas” [km²]</th>
<th>Size of the region”’’ [km²]</th>
<th>Share of the “natural area” type in the total area of the region [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Forests’ Lakes” Total</td>
<td>2 + 3</td>
<td></td>
</tr>
<tr>
<td>Poland</td>
<td>91980 2 328 94 308 312 679</td>
<td>5 6</td>
<td>30</td>
</tr>
<tr>
<td>including</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dolnośląskie</td>
<td>5 928 2 5930 19 947 30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kujawsko-pomorskie</td>
<td>4 212 168 4 380 17 972 24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lubelskie</td>
<td>5 830 16 5 846 25 122 23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lubuskie</td>
<td>6 881 80 6 961 13 988 50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Łódzkie</td>
<td>3 878 – 3 878 18 219 21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Małopolskie</td>
<td>4 353 – 4 353 15 183 29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mazowieckie</td>
<td>8 219 11 8 230 35 558 23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opolskie</td>
<td>2 504 – 2 504 9 412 27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Podkarpackie</td>
<td>6 780 – 6 780 17 846 38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Podlaskie</td>
<td>6 201 136 6 337 20 187 31</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pomorskie</td>
<td>6 655 344 6 999 18 310 38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Śląskie</td>
<td>3 939 – 3 939 12 333 32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Świętokrzyskie</td>
<td>3 301 – 3 301 11 711 28</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The above presentation indicates that even with this very approximate definition of the size of “natural areas”, they constitute approx. 30% of Poland’s territory, and according to the subdivision by voivodships/regions, they total between 21% in the Łódź region to 50% in the Lubuskie region.

Such significant (i.e. amounting to approximately 1/3) surface share of “natural areas” in the country’s and regions’ territory also points to the desirability of creating a distinct area type within the typology that sub-divide and classify space/land within the country.

10. Assessing the impact of the introduction of “natural area” type upon the change in the value of sample statistical data, linked to the area size and population, using Poland’s example

The following are the examples of possible impact of adopting the solution of dividing the country, at the local level, into three types of areas, i.e.: natural, rural and urban areas – impact in terms of changing the spatial data pertaining to Poland’s territory, within the OECD typology, in relation to: the size of respective area types, the population, including population density, and the average area of towns and villages.

Within statistical data, the basic parameters describing the given country include data on its area size and population numbers, including the representation of population density (approximating the actual population density) on a predefined part or all of the territory of the country.

Table 6 shows the changes in the size of area types throughout Poland, and changes in the population density of rural areas that would occur when adopting the new type of the subdivision of areas – by distinguishing areas of zero population density – as well as changes in the statistical average area of towns / villages resulting from the introduction of the concept of natural areas.

When analysing the data on rural areas, in the case of division into three types of areas, i.e. natural, rural and urban, rather than dividing two types of areas, i.e. rural and urban, we can conclude that the surface of rural areas in the new type will be reduced by 32%, the population density will increase by 48%, while the average size of the village in these areas will be reduced by 32%.

<table>
<thead>
<tr>
<th>Warmińsko-mazurskie</th>
<th>7 505</th>
<th>978</th>
<th>8 483</th>
<th>24 173</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wielkopolskie</td>
<td>7 675</td>
<td>189</td>
<td>7 864</td>
<td>29 826</td>
<td>26</td>
</tr>
<tr>
<td>Zachodniopomorskie</td>
<td>8 119</td>
<td>404</td>
<td>8 523</td>
<td>22 892</td>
<td>37</td>
</tr>
</tbody>
</table>

* [Leśnictwo 2015, p. 36]
** [Sobolewski et al. 2014, p. 54]
*** [Powierzchnia i ludność… 2015, p. 17]
Table 6. Area and population of Poland and the number of towns/villages, subdivided into regions/voivodships, according to the current OECD typology (with the division into two types of areas, i.e. rural and urban areas), and according to the modified typology (with the division into three types of areas, i.e. rural, natural and urban areas)

<table>
<thead>
<tr>
<th>Area type (functions)</th>
<th>Area size [km²]</th>
<th>All land of the country [%]</th>
<th>Population [thousands]</th>
<th>Population density [per km²]</th>
<th>Number of towns/villages/cities</th>
<th>Average area of towns/villages/cities [km²]</th>
<th>Number of municipalities¹</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>CURRENT SUBDIVISION – into rural areas and urban areas (2 types)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural² (housing, agriculture, forests and water)</td>
<td>291 109</td>
<td>93.1</td>
<td>15 238</td>
<td>52</td>
<td>52 543</td>
<td>5.54</td>
<td>2 174*</td>
<td>* 1566 rural municipalities and 608 mixed rural-urban municipalities</td>
</tr>
<tr>
<td>Urban¹ (housing and industry)</td>
<td>21 571</td>
<td>6.9</td>
<td>23 241</td>
<td>1077</td>
<td>911*</td>
<td>23.67*</td>
<td>303</td>
<td>* 608 towns located within mixed rural-urban municipalities</td>
</tr>
<tr>
<td>Poland – total</td>
<td>312 680</td>
<td>100</td>
<td>38 479</td>
<td>123</td>
<td>53 464</td>
<td>–</td>
<td>2477</td>
<td></td>
</tr>
<tr>
<td>NEW SUBDIVISION – into rural areas, natural areas and urban areas (3 types)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural (housing and agriculture)</td>
<td>196 801</td>
<td>62.9</td>
<td>15 238</td>
<td>77</td>
<td>52 543</td>
<td>3.75</td>
<td>2 174</td>
<td></td>
</tr>
<tr>
<td>Natural³ (forests and water)</td>
<td>94 308</td>
<td>30.2</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban (housing and industry)</td>
<td>21 571</td>
<td>6.9</td>
<td>23 241</td>
<td>1065</td>
<td>911</td>
<td>23.67</td>
<td>303</td>
<td></td>
</tr>
<tr>
<td>Poland – total</td>
<td>312 680</td>
<td>100</td>
<td>38 479</td>
<td>123</td>
<td>53 444</td>
<td>–</td>
<td>2477</td>
<td></td>
</tr>
</tbody>
</table>

¹ [Powierzchnia i ludność… 2015]
² [Rocznik statystyczny… 2014, p. 142]
³ Data pertaining to the size of urban areas is obtained as a result of subtracting the area of rural areas from the total territory of Poland
⁴ [Rocznik statystyczny… 2014, p. 83]
⁵ Geodesic reports and directions of land use within the territory of the country
⁶ data on the size of natural areas based on Table 5
⁷ * there are no towns/villages/cities in natural areas
Much larger discrepancies would occur in relation to the voivodships/regions. The relevant calculations were carried out by the author (in aggregate tables), but due to limited space of this presentation, the tables themselves were not included; instead, we only listed the basic data describing the numbers and percentage of the scale of changes.

For example, change in the size of the new type of rural areas, as compared to the size under the previous classification, would amount to 52% for the Lubuskie region, to 23% in the Łódź region, with the country-wide average of 32%.

The actual population density of the areas which are "truly rural", i.e. defined as the areas which perform agricultural function (including habitats/residential) as well as residential function for the population not connected with agriculture, calculated as a percentage in the country-wide scale, is 48%, with an increase in the national average from 52 to 77 people per km², or by 25 people per km². In the regional scale, the largest increase in performance will be noted in Lubuskie region, as much as by 111% – calculated as the number of persons per km² that would amount to 31 people per km², i.e. from 28 people per km² to 59 people per km², while the smallest increase would be noted in the Łódź region – only 30%, i.e. from 54 to 70 inhabitants per km².

In real numbers, i.e. number of persons per km², the largest increase would occur in the region of Silesia, as many as 104 people per km², i.e. from 122 to 226 persons per km² (this is 85% increase), while the smallest change expressed in the number of persons would occur in the region of Podlasie – namely, only approx. 12 persons per km², i.e. from 25 to about 32 persons per km², which is 48% increase.

The above quoted increases in population density for the new type of rural areas, in relation to the provinces, are informative in terms of the scale of actual differences, related to the value of the primary statistical indicator, when we eliminate from the calculation those areas that by definition are characterized by zero or close-to-zero population.

Another very characteristic feature of rural areas is an average surface per capita of these areas, linked to the fact that this surface (area) is the basis of existence i.e. the agricultural use within the given settlement unit (locality) for the majority of its inhabitants. In the context of the national average, this would mean the reduction in the size of rural areas per one inhabitant of Poland by approx. 35%, i.e. from 1.91 hectares to 1.29 hectares, that is, as much as 0.62 ha less.

In the scale of regions (voivodships), the discrepancies are even greater in comparison to the current calculation methodology. The largest reduction – calculated both as percentage, and in real numbers – in the rural area per one inhabitant would occur in the Lubuskie voivodship, by as much as 52%, or about 1.85 ha, i.e. from 3.54 hectares down to 1.69 hectares. The smallest percentage decrease in the average size of rural areas per capita, i.e. per inhabitant of a rural town / village, would occur in the Łódź voivodship, with the reduction of about 23%, that is, about 0.42 ha, i.e. from 1.85 hectares down to 1.43 hectares. The smallest decrease in real terms, i.e. in hectares per capita (per inhabitant of a rural town/village) would occur in the Małopolska region, namely about 0.25 ha, that is, from 0.78 hectares down to 0.53 hectares, which signifies reduction rate of 32%.

It should also be noted that, for example, for the currently assumed subdivision into two types of areas, in relation to the countryside, we obtain lowered results that deviate
from the facts (from the actual status), when the ratios are calculated with respect to the unit area such as 1 km² or 100 km² (for instance example for the infrastructure such as water, sewage and gas networks). The reason for this is that we divide the total length of the given network by the size of rural areas covering also forests and lakes (where that type of infrastructure, in principle, does not exist or is only minimally present, as directly linked to the residential function). If we apply this in the calculation of indicators computed per capita, it also distorts the image of the spatial occurrence of the phenomenon, because the areas understood in this paper as a “natural type” (forests, lakes, etc.) are, in principle, uninhabited.

An analogous situation occurs also in connection to rural areas, e.g. when calculating the spatial image for the level of air pollution, sewage, waste, including municipal waste, etc. For the rural areas, these indicators also include the forests, where air pollution, generation of wastewater and other waste are absent. In the Polish context, the relevant indicators should be approx. 30% lower than they would have been if they related to the actual rural space, which in principle should be bound with agriculture. The more favourable “statistics” results from including, for example, forests in the rural areas – forests that do not produce waste, wastewater, air pollution, etc.

The above sample analyses indicate that for rural areas currently defined as incorporating areas with zero population density, such as forests, lakes, etc., the spatial data for this type of areas under the currently adopted OECD and EUROSTAT typologies are subject to significant disparities with regard to the facts, usually as much as several dozen per cent, and in extreme cases even more than 100 per cent, both on the higher levels of the typologies, i.e. at the national level, and on local i.e. regional level.

The proposed modification, adopted as part of the change in typology, involving the separation of a new type of areas, tentatively named “natural areas” with zero population density, would bring the data indicators related to space, both in statistical and in other terms, much closer to the truth (to the actual situation) – because in fact, only the areas of agricultural and residential functions are truly functionally linked to rural localities/villages.

Included in the framework of the existing typology, areas such as forests, lakes, etc. with zero population, in fact represent distinct environmental-spatial and functional entities, as indicated in section 6 of the present study. Therefore, in principle, there is no rational or clear justification for their inclusion within the category of rural areas – also because the natural areas are equally used by the residents of urban, and of rural areas.

These considerations are also relevant for other Member States of the European Union, in relation to the rural areas in their current definition – with the reservation that the percentage over- or lower rates depend on the occurrence of forest land and water areas, of which for instance Sweden and Finland have a disproportionately larger territorial share (about 80%) than, say, France, Germany or the countries of the “Benelux” (between 10 and 20%).

Analogous results would also be obtained for the rural areas defined within the typology of EUROSTAT, since this typology also applies the principle of including rural areas with a population of zero.
It should be noted that the above-described discrepancies, associated with the problem of unbundling the zero population density areas under the new typology, in no way apply to urban areas, as the rate for these areas amounts to at least 150 or 300 people per km².

11. Assessment of the feasibility of practical application of the subdivision of space into three types of areas, in relation to the typologies assumed in the Member States of the European Union

Any proposed modification to the already implemented solutions, in order to be justified and not merely substantively correct, should also be conceptually consistent with the solution that is being modified. Moreover, the chances of implementing the modifications in practice increase substantially if at the start there exists appropriate databases, preferably in digital format, and the application of these databases is easy and does not require major financial investments.

It should be noted that the proposed solution is very simple to implement in practice, both in the OECD typology and the EUROSTAT typology.

Within the OECD typology, distinguishing the third type of areas at local level would not pose any major difficulties – this is true for almost all of the EU Member States. The reason for this is because, as a part of the existing typology, the classification into the two types of areas did not adopt the lowest levels of administrative divisions, but their aggregated areas instead – for instance, based on the existence of joint organs of self-government at the local level. This results in a situation where the existing territorial division at the lowest level may be used in order to extract the new, so-called “natural” type of areas from the previous type of rural areas.

It greatly simplifies the situation – indeed, it provides the basis for this type of operation, that digital systems exist in all EU member states, related to the payments for agriculture under the Common Agricultural Policy. Namely, we refer to the IACS (Integrated Administration and Control Systems) and other GIS digital systems, for example, of cadastral kind.

As part of the EUROSTAT typology, extraction at the local level of a third type of area is even easier, because it is enough to segregate the existing rural-type “grids” with the view to inclusion in the range of zero or close-to-zero population; and performing the analysis for these grids for a maximum population within eight neighbouring (adjoining) “grids”. The maximum number of people for 8 adjacent “grids”, representing the second criterion alongside the population size in the middle (central) “grid”, would be advisable also at a lower level, in connection with the issues of environmental protection.

As a consequence of distinguishing the type of natural areas at the local level with zero population density, or – for practical reasons – with a close-to-zero value, we would see the separation at the regional level of a new type of region / sub-region called “predominantly natural” or “including natural areas” such as those arising from the assumed degree of environmental protection pertaining to the areas of natural type. In order not to disrupt, in any substantial way, the methodology for classifying regions.
sub-regions within the framework of the existing solutions, based on the share of the rural population in determining the type of the region/sub-region, the proposed solution is to carry out classification of the regions/sub-regions in the context of two sets of activities. In the first, the level of the share of natural areas within the classified area would be agreed. If this share reached the assumed value, for instance 85/80% (or another, lower level, determined as a result of scientific research), then the given region would be qualified as “predominantly natural.”

In the second step, the classification for all the remaining regions/sub-regions would be left unchanged, i.e. it would remain the same, based on the share of the rural population. This way of achieving the diversification of regions/sub-regions would take into account the fact of distinguishing areas with zero (or virtually zero) population at the local level, and the creation of “predominantly natural” regions/sub-regions while retaining the current methodology for all other regions/sub-regions.

Source: author’s study

Fig. 3. Diagram of the modified OECD typology, titled: Typology of regions OECD. Polish version
12. Assessment of the feasibility of application in relation to Poland’s territory

Also in Poland, where the classification of areas and regions basically uses the OECD typology, the application of considerations described in the proposed modification should not pose much difficulty, because the current classification of rural areas employs
the level of territorial division with municipality (Polish: *gmina*) as the basic unit, which is the level resulting from the aggregation of spatial data found in the National Register of the Territorial Administrative Division of the country – the so-called TERYT. The aforementioned register, however, includes detailed data brought to a lower level, i.e. at least to the level of towns and villages and village councils (Polish: *sołectwo*), which are auxiliary units of the territorial division of Poland. These units, as defined in TERYT, are closely related in terms of borders and area sizes with other public and mutually compatible official records, including:

- The national system of records of farms operated by the ARMA (IACS) related to payments for agriculture under the Common Agricultural Policy,
- Records of Land and Buildings (EGiB), maintained and constantly updated by the mayors and supervised by the Surveyor General of Poland.

All of the above are systems in full digital format, and they are compatible in terms of data exchange, which – when using the GIS-type digital applications – facilitates the operation of extracting the new type of areas with zero or close-to-zero population density within the current type of rural areas, making it relatively simple in technical terms, and basically almost automatic.

The discussed extraction, from the current rural areas, of a new area type named here tentatively the “natural areas” is basically possible/available already, because the public forests that account for over 80% of the total forest, are already distinguished as forest sections within the precincts (counterparts of auxiliary units).

In a similar manner, in the framework of public records, the following are distinguished: lakes, beds of large rivers (as category of watercourses), large bodies of water, and marshlands.

Also in the framework of the existing legislation, introducing the new type of natural areas should not be difficult, since the existing regulations on the territorial division of the country under TERYT and EGiB provide for the division of rural localities into new units of the same legal status. This allows for the new units defined within the natural areas to exist in the official records and registers, kept by the public administration.

Furthermore, it would be a great and useful simplification if the boundaries of these units ran along the actual, existing borders, as registered in the IACS System, whose status would change from the internal border, existing and recorded in the information systems of official records, into the border of a village/village council or precinct.

The proposed name of “natural areas” – in a manner understandable also to the general public – well describes the nature and characteristics of these areas, and clearly distinguishes them within the country’s territory as such areas where economic activity is not present, or where it is minimal. This, in turn, creates very favourable conditions for the practical implementation of the proposed modifications to the OECD typology.
13. Compliance of the proposed modifications to the OECD and EUROSTAT typologies with the EU and Poland’s legislation pertaining to the regionalization of the country’s territory

The issue of regionalization within the EU, and more precisely the legal aspect of regionalization, is governed by the Regulation (EC) No 1059/2003 of the European Parliament and of the Council of 26 May 2003. The aforementioned Regulation does not apply directly to the definition of types of areas and of regions / sub-regions; instead, it introduces restrictions as to the population size within various levels of the NUTS (Nomenclature of Territorial Units for Statistics) of the EU.

In article 5, paragraph 2 of the abovementioned Regulation, it is stated that in order to establish the relevant NUTS level, which is to include a particular class of administrative units in a Member State, the average size of this class of administrative units in the given country will be within the limits of the population status, as set by the Regulation.

This provision would result in the need for substantive changes, in the case of practical application of the proposed modifications to the OECD and EUROSTAT typologies, if there were no provisions for exemptions. However, because such provisions do exist, the change of the Regulation is not necessary, in view of the article, 3 paragraphs 5, where the third sentence reads: “Some non-administrative units may deviate from these thresholds because of particular geographical, socio-economic, historical, cultural or environmental circumstances, especially in the islands and the most remote regions. Those measures, designed to amend the non-essential elements of this Regulation by supplementing it, shall be adopted in accordance with the regulatory procedure with scrutiny referred to in Article 7, paragraph 2.”

This opens the possibility for creating within the EU, at all levels, of the “predominantly natural” regions / sub-regions, due to the environmental conditions, and even due to the socio-economic conditions. Many EU Member States, including Poland, took advantage of this opportunity, even though it did not concern islands or most remote regions. In the case of Poland, this procedure was used, among others, for dividing the Warsaw Region (Voivodship) into Warsaw City and the surrounding counties as one unit, and the remaining part of the region as another.

It should be noted that:

- the division of a separate part within an area/region, as natural environment, is environmentally conditioned,
- zero population density is socially conditioned,
- minimal human interference in the natural environment is economically conditioned.

Therefore, the existence of the new type of region / sub-region will remain in accordance with the present EU Regulation. Also the statement that that provision applies in particular to the islands and outermost regions, does not preclude its application, because
it includes the expression “in particular” – if those words were missing, only that would prevent us from applying the structures based on Article 3, paragraphs 5, sentence 3.

Taking the above provisions as our basis, it is therefore possible to implement the proposed modifications in practice, throughout the EU.

Within the Polish legislation, the issue of regionalization is governed by the Regulation of the Council of Ministers of 13 July 2000, on the introduction of the Nomenclature of Territorial Units for Statistics (NUTS). The Regulation governs, in principle, the technical issues pertaining to the assignment of administrative units to different levels of regions / sub-regions – at regional level (3 levels), as well as areas at local level (2 levels).

Due to the increased amount of detail associated with the local level, the Regulation would require a minor update, but in relation to the direct validity of the EU law in the area of Poland, and the related principle of the annual update of the Regulation following the changes in the boundaries of administrative units, this would not constitute a major problem. It would, however, pose a problem that is basically just technical, because it would simply entail the implementation of the EU law, even without the need to amend the Law on official statistics which is the basis for issuing a Regulation – as the statutory delegation covers a wide range of classifications and nomenclatures, the relationship between them and their interpretation relating to the conduct and description of economic and social processes, without listing them more specifically.

Taking into account the above comments upon the introduction of the proposed modifications to the OECD and EUROSTAT typologies, in principle, no substantive changes to EU legislation or to Polish legislation will be required at statutory level. Within the Polish legislation, changes shall be required only at the level of the implementing regulation, regarding some technical issues at the local level, related to the correction of the nomenclature of the rural versus natural areas.

14. Conclusions

The presented solution is proposing to replace the existing division of the country, based in part on the OECD or EUROSTAT typologies and two basic types of spatial areas, with another division, based on three basic types, with regard to identifying and subdividing “natural” from the “rural” areas. It is taking into account the actual spatial and socio-economic conditions, existing within the geo-economic territory of the country, and the changes taking place in these conditions. The situation in which one area type (of combined areas) covers more than 9/10 the country, of which almost 1/3 of the total area of the country possesses radically different natural, functional and economic characteristics, seems to point to a legacy from the period when growth and profit were prioritised over environmental protection. In the current socio-economic and economic context, we seek to revaluate and replace these priorities.
The creation of a third type of areas, tentatively called “natural” areas:

1) would not be inconsistent with the current basic principles adopted in the typologies of the OECD and Eurostat, based on the population density parameter – with the reservation that in the case of a new area, this parameter would in practice equal zero;

2) would provide the possibility of calculating the actual (or approximating the actual) values for a large number of statistical indicators based on unit areas;

3) would be feasible to use within the entire European Union, both in the framework of the EUROSTAT or OECD typology of regions, because it is based on those typologies with the indicator of “population density”, and only provides, within the framework of the methodology for identifying and creating regions, the creation of two area types within the rural areas;

4) would be simple to apply under the EUROSTAT typology of regions, as it does not require any re-determination of “grids”; while under the OECD it provides for the use of the existing territorial divisions, cadastral systems and mandatory digital system of IACS, maintained in all EU countries for direct payments under the Common Agricultural Policy;

5) would refer to the historical classification space, which for millennia had included the division into: forest that also included related bodies of water and watercourses; villages covering the areas functionally associated with the notion of farming; and cities, including heavily urbanized areas with functionally related places of work and production;

6) would introduce the issues of environmental protection directly into both typologies.

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THE USE OF NETWORK ANALYST TOOL AND 2SFCA METHOD TO ASSESS FIRE SERVICE EFFECTIVENESS IN A CITY, AS EXEMPLIFIED BY ŁÓDŹ

Szymon Wiśniewski

Summary

The article presents the results of research aimed at defining the potential effectiveness of fire services in the city space. The spatial scope of the analysis comprised the city of Łódź and a 20-kilometre ring around it, which was introduced in order to avoid an artificial barrier in the form of a city boundary. The study comprised all fire departments located within this area as well as individual elements of its built environment, which may be subjected to or otherwise pertinent to interventions of fire fighters. The use of the ArcMap Network Analyst tool and the 2SFCA method allowed us to specify time accessibility of fire service operations; spatial accessibility of individual elements of the city infrastructure to fire service activities; the load of individual fire stations; and the minimum number of departments necessary to take action within the assumed, defined arrival time for intervention.

Keywords

Network Analyst • 2SFCA • spatial accessibility • fire service • Łódź

1. Introduction

The Fire Service in Poland functions as an organization based on professional fire service (the State Fire Service and the Military Fire Service) as well as community fire service (the Volunteer Fire Service). Professional fire service, as a uniformed unit with specialist equipment, came into existence with the aim of fighting fires, natural disasters and other local hazards [article 1 paragraph 1 of the Act on the State Fire Service].

The tasks of volunteer fire departments result from the Act of August 24, 1991 on fire protection. The volunteer fire departments work for the benefit of civil protection, fire protection and rescue services, but they also take preventive action aimed mainly at young people on a broad scale. The main aims and tasks of volunteer fire departments, resulting from their charters, include activities aimed at fire prevention, participation in rescue missions conducted in the event of fires, other dangerous events and natural disasters as well as notification of the population about the existing hazards [msw.gov.pl, accessed: 04.08.2015].
The State Fire Service, combined with its volunteer counterpart, constitute the core of the National Fire and Rescue System. The goal of the said system is to standardize rescue activities undertaken in situations, which pose a threat to life, health, property or the natural environment [Żuber vel Michałowski 1995].

The basis for the elaboration of this article was an attempt to specify, with the use of spatial statistical methods, how the tasks imposed on the fire service by the legislator are accomplished in a big city from the theoretical and spatial viewpoint. In this way, the formulated research assumption conditions both the methodological and the cognitive aim of the analysis. The first concerns the elaboration of research results on the basis of aggregating Network Analyst in ArcMap and the two-step floating catchment area method [Cheng et al. 2015] so as to assess how the uniformed services function. The latter, in turn, evaluates the effectiveness of fire services in Łódź, at the same time, constituting the verification of the algorithm adopted in the research results.

Each of the subsequent stages of the research entailed the use of new research tools, the aggregation of which brought synergy effects. These stages included: defining time accessibility [Gutierrez et al. 1998; Escobar-García et al. 2015] of fire departments; classifying various structures (land use elements) in Łódź according to fire fighters’ arrival time; indication of spatial adjustment of the distribution and rank of fire departments to the distribution of buildings and the city’s road network; specification of the minimal number of fire departments necessary to ensure potential safety of Łódź, according to individual arrival time ranges in the event of intervention.

Upon including volunteer fire departments in the National Fire and Rescue System, i.e. since 1995, the range of activities of volunteer fire fighters increased greatly. Volunteer fire departments co-operate closely with the State Fire Service and other entities and institutions in order to ensure safety of citizens on their area (towns and municipalities), as well as to support the neighbouring areas as a part of operating reserves, or in the scope of agreements on mutual help. It is also worth pointing out that, in everyday practice of a volunteer formation, we observe is a shift from the earlier dominance of the issue of fire prevention and fire extinguishing to other forms of rescue services, including, most of all, technical rescue during road events where other techniques of rescue operations are put into practice [msw.gov.pl, accessed: 06.08.2015]. Such a broad scope of activities of volunteer fire departments resulted in including them in the present study on par with the State Fire Service.

2. Materials and research methods

To accomplish the methodological and cognitive aims of the research, it was necessary to include in the analysis the data illustrating land development in Łódź, and showing the local structure of fire service operations. The analysis includes, therefore, the vector data illustrating the distribution of land development as well as road, tram and rail infrastructure together with the distribution of forests, reservoirs, and watercourses in Łódź and within the 20-kilometre buffer around the city. This allowed us to avoid the impact of the boundary on the accessibility of a fire department situated in the area.
of a neighbouring municipality even if it is located near this boundary [Anselin 1988; Guagliardo 2004], and the boundary alone does not represent a barrier and has only an administrative nature. Such a research variant dismisses the unrealistic assumption of border impenetrability (e.g. in the case of municipality borders). Researching accessibility of fire services to each of the above-mentioned elements was supposed to specify the overall effectiveness of the functioning of this service in the most comprehensive manner possible. Data on their distribution, surface, or course were imported from the database of topographical objects showing the current situation as of the end of 2014.

The research also included all State and volunteer fire departments situated within the adopted spatial scope of the analysis, which were listed in the register of departments co-operating with the system of Emergency Medical Services in the Operating Plan of Emergency Medical Services for the Łódź province as of June, 2015. Operation of fire services on the analysed area is based on 11 fire and rescue departments in Łódź (city headquarters), district headquarters in towns of the Łódź agglomeration, and numerous fire stations of the volunteer fire service. Fire departments were classified according to the number of professional and volunteer fire fighters serving in them.

On the basis of the input data collected in this way, it was possible to accomplish the subsequent research assumptions. The analysis was commenced by including vector data, showing the road network of the area in question, in the research. Each network segment was characterized by means of such features as class, category, length, maximum speed (in accordance with traffic regulations), journey time (assuming that journeys were made at maximum speed) and possible one-way traffic. Individual attributes of the database were obtained from the Emapa Transport + Europe application (application dedicated to the service of transport companies). The Network Dataset was created on the basis of the database developed in this way. Then the New Service Area (tool for determining the course of isolines, e.g. travel time isochrones) from the Network Analyst (tool package in ArcMap program, primarily designed for the analysis of transport) was used. It was necessary to introduce vector data concerning the location of fire departments additionally characterized by the number of fire fighters serving in the given fire station. The New Service Area tool was calibrated, pointing to subsequent isochrones of maximum fire engine arrival time (up to half an hour in 5-minute intervals) and excluding limitations resulting from one-way roads, which do not concern emergency vehicles. As a result, surface vector data were obtained representing joined areas marked by the isochrones of identical arrival time to every fire department (joined rings of identical time values) (see Figure 1).

The next stage of the study, which consisted of defining the elements of built structures within the city, considering their location in individual fire service arrival time zones, required the introduction of vector data concerning road, train and tram networks, built-up areas as well as watercourses and forests. In addition, point data concerning the location of crossroads were introduced, as in accordance with the Police Accident and Collision Register System these are precisely the spots where road events with fire service intervention tend to occur. Each object from the abovementioned thematic layers was given an attribute of belonging to a relevant fire service arrival time
scope. This allowed us to sum up the objects in the same zones, and to specify what percentage they constitute in the total number of objects (see Table 1).

Spatial adjustment of fire department distribution to the distribution of potential fire service intervention spots was analysed for the city’s built environment and its road network. Databases of the provincial headquarters in Łódź indicated that a clear majority of fire service activities on urban areas consisted in road accident rescue in places where roads cross, or in various types of interventions in buildings. The New Service Area tool of the Network Analyst package was employed at this stage. This time, however, polygons marking areas of fire service arrival time were generated individually for each fire department. The subsequent steps in this part of the research were the result of using the two-step floating catchment area method (2SFCA) [Albert and Butar 2005; Langford and Higgs 2006; Cervigni et al. 2008]. Spatial accessibility defined by using this method refers both to the factor of supply (size of the given fire department) and demand (surface of buildings or number of crossroads). This method was first used in the analysis of spatial accessibility of labour market in the USA [Peng 1997].

In the first stage of the 2SFCA, the activity area of each fire department was defined, assuming the borderline value of arrival time. Then the individual indicator $R_j$ was calculated, being the quotient of weight (number of fire fighters) of individual departments and the Volunteer Fire Service to the surface of buildings or the number of the city’s crossroads in the area designated by the given isochrones of fire fighters’ arrival from the particular department:

$$R_j = \frac{S_j}{\sum_{i \in \{d_{pj} \leq d_{max}\}} \frac{P_{pi}}{P_{pi}}}$$

where:

- $S_j$ – weight (number of fire fighters) in the fire department $j$
- $P_{pi}$ – surface of building/crossroads $p$ in the studied polygon $i$
- $d_{pj}$ – arrival time between fire department $j$ and building/crossroads $p$
- $d_{max}$ – isochrone marking the maximum arrival time of a fire engine for individual research variants

The distance between each analysed fire department and individual city infrastructure elements was expressed in time units of fire engine arrival to the intervention spot. It was assumed that changes in vehicle speed during intervention were affected solely by traffic regulations concerning maximum allowed speeds. Despite the fact that speed limits do not concern emergency vehicles, it may be assumed that design speeds determine the maximum speed, which allows the vehicle to reach the intervention spot safely. As a result, all other factors, such as congestion or weather conditions, were excluded from the study. It was assumed arbitrarily that the speed of arrival during intervention has values higher by 20 km · h$^{-1}$ than those allowed on the given road section. The fire engine travels on the shortest travel route between the two points.
Thus, calculations were made concerning the theoretical load of individual fire departments with potential interventions in relation to built structures and road traffic. This was a particularly important stage of the study, as it should be assumed that fire fighters intervening in one place are excluded from effective rescue operations in other areas, which naturally decreases safety levels of the population living there. Consequently, the coordination between neighbouring units seems to be of key importance.

In the second stage of the two-step floating catchment area method, the attention shifts to the area of the city within which built structures and road network are located. Hence it is necessary to introduce the basic unit into the research. The arbitrary use of a figure grid (e.g. hexagons) or districts and sub-districts is artificial, and it may considerably distort the real spatial relations [Benenson et al. 2011; Vale et al. 2016], which is why primary fields, which tend to be more “natural” for the researched phenomenon, were introduced. They were formed by “cutting” the city surface and the 20-kilometre buffer with a grid of isochrones of access to individual fire departments. This allowed us to observe the extent to which the distribution of fire stations corresponded to the factual distribution of buildings and crossroads in individual primary units. This is particularly important in situations when analyses are based on data aggregated to large space units in which fire stations are located on the peripheries rather than in the centre [Geronimus et al. 1996]. The results of the conducted analyses were strongly affected by the choice of primary units for the analysis, the so-called MAUP phenomenon or Modifiable Areal Unit Problem [Anselin 1988; Fortney et al. 2000; Martin et al. 2002]. According to Openshaw and Taylor [1981], the MAUP issue consists of two dimensions, which have an impact on research results: arbitrary boundary delineation (zoning dimension) and the choice of scale (size) of the primary unit of the analysis (scale dimension). In the case of the adopted solution, both dimensions of the MAUP phenomenon do not represent a threat to the correct interpretation of the results obtained.

The superimposition of subsequent areas of fire service arrival on the studied area resulted in polygons covered by a different number of fire departments. Each such polygon was given an individual number.

Then an area was delineated for each polygon (individual number) within the boundaries of the analysed area, as in the first stage of the study, using the adopted border value of fire engine arrival time. Subsequently, for each polygon, the author calculated the accessibility indicator $A_i$, which is the sum of the value $R_j$ (1) obtained for all fire departments distributed within the area of the individual polygon $i$:

$$A_i = \sum_{j \in \{d_{pj} \leq d_{max}\}} R_j$$ (2)

The last stage of the research focused on specifying the minimum number of fire departments from the analysed area, which are necessary to ensure theoretical safety with the assumption of different time scopes of arrival for intervention. This fire station effectiveness test was carried out in relation to the accessibility to the given area’s built
environment. Centroids were generated for every fire department and every building, which may require intervention. Subsequently, a matrix of fire engine arrival time for all possible relations between the fire station and the building was generated, using the New OD Cost Matrix tool (a tool to generate the connection matrix between the identified starting points and end-point) of the Network Analyst package. This, in turn, made it possible to use the New Location-Allocation tool (a tool for determining the optimal location of objects on the basis of the input spatial data analysis), which – based on the previously formulated matrix – chose such a set of fire stations whence the arrival time to the buildings did not exceed the adopted value of the maximum isochrones, and at the same time the accumulated journey time of this group was the smallest. This tool selected the minimum number of fire stations necessary to cover all or the largest value of the demand below the adopted border values of fire engine arrival time to the place of intervention.

3. Results

The methodological approach presented above was tested on the example of Łódź. Delineating isochrones of access to fire station network of the analysed area (Figure 1) made it possible to subsequently specify the structure of the city’s spatial development elements according to the arrival time of fire fighters (1) (Table 1).

The satisfactory level of fire service time accessibility to the individual elements of the city’s built infrastructure is represented by an almost negligible share of those elements, in the case of which arrival time is longer than 15 minutes.

Table 1. Structure of spatial development elements in the city of Łódź according to fire service arrival time

<table>
<thead>
<tr>
<th>Share of elements in time zones of fire service arrival</th>
<th>Fire service arrival time [min]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0–5</td>
</tr>
<tr>
<td>Built environment [number of buildings]</td>
<td>34%</td>
</tr>
<tr>
<td>Built environment [surface of buildings]</td>
<td>48%</td>
</tr>
<tr>
<td>Road network</td>
<td>38%</td>
</tr>
<tr>
<td>Crossroads</td>
<td>42%</td>
</tr>
<tr>
<td>Train network</td>
<td>35%</td>
</tr>
<tr>
<td>Tram network</td>
<td>65%</td>
</tr>
<tr>
<td>Watercourses</td>
<td>27%</td>
</tr>
<tr>
<td>Forests</td>
<td>3%</td>
</tr>
<tr>
<td>City surface [area of land within the administrative borders of Łódź]</td>
<td>29%</td>
</tr>
</tbody>
</table>

Source: author’s study
Such consistently good results are not obtained from analysing the adjustment in the distribution and number of fire fighters from individual fire departments to the distribution of built environment (Figure 2) and road network crossroads (Figure 3). Areas of particularly low adjustment levels were revealed in the course of the research (2). Considering the results presented earlier, it seems justified to increase the staffing of these departments from which arrival time to objects in the problematic areas is the shortest.
The study assumed that the fire departments, which are involved in rescue action, have sufficient quantities of extinguishing agent (e.g. water). Implementation of the survey data on the distribution of fire hydrants increases the accuracy of the analysis. However, it was assumed that in urban areas, access to water supply was not a problem.

Fig. 2. Spatial differentiation of fire service accessibility to spots of potential intervention in relation to built environment

The study assumed that the fire departments, which are involved in rescue action, have sufficient quantities of extinguishing agent (e.g. water). Implementation of the survey data on the distribution of fire hydrants increases the accuracy of the analysis. However, it was assumed that in urban areas, access to water supply was not a problem.
Analysis aimed at establishing the minimum number and location of fire stations (Figure 4) confirms the indispensability of all the existing departments. It also shows that, in theory, the fire departments in Łódź are incapable of providing adequate safety levels. In order to ensure protection, it is necessary to include also the departments from the neighbouring municipalities.
4. Conclusions

The research we have conducted allowed us to accomplish the two aims, which were established initially. In the cognitive scope, the analysis indicated satisfactory effectiveness levels of the fire service operations in the city of Łódź (see: Table 1). It must be said that the existing system of fire rescue is efficient as far as the number of departments is concerned (see: Figure 4). Nevertheless, in order to increase the level of adjustment to spatial differentiation of potential hazard supply spots, consideration must be given to the

Fig. 4. Minimum number of fire departments necessary to ensure potential safety of Łódź built environment in the individual ranges of arrival time for intervention
development of these departments, which provide services to the city’s space on a particularly low level – predominantly in the eastern part of the city (see: Figure 3). From the methodological perspective, in turn, the research confirms the relevance of combining spatial information system tools with methods of spatial statistics. High calculating capacity, together with logical and theoretically-rooted gravitation model (which is used by the New Location-Allocation tool), brings results which are easy to interpret and free from distortions arising from artificial boundaries of the primary field.

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