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The proposed algorithm for identifying agricultural problem areas for the needs of their reasonable management under land consolidation works

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ABSTRACT

The development of agriculture in the territory of Poland and its production capacity is considerably differentiated in terms of space. At present, the country under discussion has agricultural areas which in many respects can compete with agriculture in the member states of the European Union. However, in some areas agricultural production run by private farms owned by individuals is on the verge of or falls below the limit of profitability. Such areas are called agricultural problem areas. These areas are increasingly exposed to marginalization and they are referred to as areas without a potential for development. Agriculture in such areas is doomed to failure. Therefore, it justifies promoting the alternative economic functions of problem areas in a rural setting. Such solutions include: allocating land for forest planting, building development, transport infrastructure, agritourism, and leisure, transformation into ecological areas, growing energy crops, wildlife food plots or gardening.

Land consolidation is a process improving the spatial structure of rural areas, including problem areas. This geodesic operation makes it possible to describe the specific characteristics of selected agricultural problem areas and propose the most effective alternative methods of managing the described area. Thanks to rural management works, rural areas become competitive and cultivation of crops in such areas generates financial benefits and improves the living standard of their inhabitants.

The universal algorithm for identifying problem areas, designed in this paper, can be a useful tool for programming land consolidation works because the results will make it possible to indicate options for the optimum management of such land. This paper takes into account criteria referring to a detailed description of the above-mentioned areas. Its advantage is that it can be used in different regions, no matter where the land consolidation object is located.

1. Introduction

One of the main priorities of the common agricultural policy in the European Union (EU) is improvement of the quality of life in rural areas and effective utilization of their resources. Social and economic disparities in EU member states have been maintained despite numerous measures being undertaken by the European Commission. The level of diversification is higher on a local and regional scale than on a national one. This fact was already mentioned in the first report on economic and social cohesion developed by the European Commission in 1996 (First Cohesion Report, 1996). In order to reduce such disparities, various measures are undertaken under the European policy but they do not bring the expected results in full, a fact mentioned by (Bachtler and Turok (ed.), 1997; Maura, 2002; Moussis, 2002). In its second report on economic and social cohesion (Second Report on Economic, 2001), the European Commission claims that, despite strong convergence trends, economic disparities between the present member states have still been maintained. In October 2002, in Brussels, the EU decided to add ten new member states, including Poland. Then, the conclusion of accession negotiations with candidate states in December 2002 in Copenhagen created completely new conditions for regional policy in the EU (Amin, 1999, Manzocchi (ed.), 2002). The projected extension of the EU means accepting states and regions poorer than those currently included in the Community.

Therefore, a significant goal of the policy in Poland implemented under the Rural Development Programme (RDP, 2007–2020, 2014–2020) is to align the chances for development and preservation of the agricultural nature of areas with unfavourable natural and

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landscape conditions. In most cases these areas are subject to depopulation and harmful environmental degradation processes. It should be emphasized that every rural area is unique, thus it is particularly important to find solutions matching the natural and landscape status of each area on a case-by-case basis.

Abiotic factors such as: terrain relief, soil type, precipitation – water, air temperature, and wind are significant to agriculture. The development of rural areas also involves demographic, economic as well as natural and landscape aspects.

However, the occurrence of agricultural problem areas in Poland is not a precedent. Long-term member states of the EU also experienced similar problems upon integration. France, Austria and Italy have mountain soils that are much less fertile than typical soils occurring in the EU member states. In Sweden and Finland a problem of northern region soils occurs, which is equivalent to agricultural production space characterized by short days and low temperatures.

Scientific literature contains numerous proposed definitions of problem areas. Approaches to this issue are determined by the research discipline of authors. Scientific discourse related to that topic uses a number of terms such as: agricultural problem areas, conflict areas, shortage areas, depressed areas, difficult areas, production reserve areas, underprivileged areas, risk areas, pathological areas, less developed areas, backward areas, marginal areas etc. (Bański, 1999). Normally, these words are deemed synonymous with ‘problem areas’. However, it seems that freedom in using them can lead to misunderstandings and even errors. The historical conditions of social development such as, for example: population growth rate, low crops and continuing deficiency of food, have contributed to adapting less also useful areas with a low production potential for agricultural purposes (Jadczyszyn, 2009).

In addition, in rural areas agricultural land is considerably fragmented and production is oriented at satisfying the farmers’ own needs. In Poland this problem is particularly difficult to solve due to historical circumstances (Leń and Król, 2016) which have resulted in excessive fragmentation of land (Leń et al., 2016; Leń and Mika, 2016), defective spatial structure of land (Leń, 2017a; 2017b) and poor quality of cadastral information (Mika and Leń, 2016; Mika et al., 2016, Dawidowicz and Kulawiak, 2016). Many authors have presented a negative effect of land fragmentation in terms of decreasing the effectiveness of agricultural activities (King and Burton, 1982; Gulinck and Wagendorp, 2002; Van Dijk, 2003; Hudecová, 2005; Niroula and Thapa, 2005; Tan et al., 2006; van Hung et al., 2007; Rahman and Rahman, 2008; Kawasaki, 2010; Hudecová, 2015; Hudecová et al., 2016; Kwinta and Gniadek, 2017).

The main factors contributing to the formation of problem areas are, among other things, intensity of use and unreasonable utilization of natural resources, which intensify erosive degradation, soil acidity as well as depletion of soil organic matter. Another hazard to the environment and agriculture is the concentration of industrial production, location of landfill sites and dust emissions contributing to local pollution of agricultural soils (Jadczyszyn, 2009). In connection with the aforesaid, according to the authors, attention should be paid to areas with limited production potential, lower income per capita and delayed economic development. These areas are increasingly exposed to marginalization and exclusion from the list of areas with a potential for development. Agriculture in such areas is doomed to failure. Therefore, it justifies promoting the alternative economic functions of problem areas in a rural setting. Such solutions include allocating land for forest planting, building development, transport infrastructure, agritourism, leisure, transformation into ecological areas, growing energy crops, wildlife food plots or gardening.

It should be mentioned that given a variety of land surveying works – land consolidation was the first instrument to support the development of rural areas and agriculture, mainly through improving the spatial structure of farmland. At present, improved agricultural and forestry management conditions are also created for the purposes of land consolidation.

This paper aims at developing a universal algorithm for picking agricultural problem areas in order to ensure their reasonable management under land consolidation works as the multi-functional development of problem areas in the long run can inhibit negative processes in agriculture and provide an alternative source of income to the inhabitants of such areas.

2. Materials and methods

Detailed surveys regarding agricultural problem areas (Sajnóg and Wójcik, 2013; Wójcik et al., 2014; Wójcik-Leń and Sobolewska-Mikulska, 2017) made it possible to develop a universal algorithm for identifying such areas as well as indicating ways of their alternative management during comprehensive land consolidation works.

The developed algorithm provides information about the studied object based on three main criteria referring to: location, terrain relief and soil conditions with respect to soil quality and usefulness. Sub-criteria were adopted to ensure the most adequate parameterization of the above-mentioned criteria. This facilitates further specification of the criteria. Next, their features were determined and relevant weights were assigned to them. Thus, a numerical value was obtained – a ratio describing the specific criteria and then the study area.

Selected criteria were assigned specific scores: location (30 points), terrain relief (40 points), soil conditions with respect to soil quality and usefulness (30 points). The general and specific criteria, as well as weights assigned to them, were adopted based on expert knowledge and analysis of collected data.

On the other hand, sub-criteria were assigned weights following the principle that the worse the value of a feature (e.g. location, risk of erosion or poor soil class), the higher numerical value of the weight.

CRITERION I – LOCATION

This criterion includes four sub-criteria: tax district – split into four sub-districts: I, II, III, IV (Regulation 2001), rate of unemployment – split into four percentage ranges (%): 7–10, 11–14, 15–18, 19 > , data sourced from the Central Statistical Office (GUS), density of population – split into three people/km^2 ranges: 0–100, 101–200, 201–18, 19 > , data sourced from the Central Statistical Office (GUS), and structure of income – split into four numerical ranges: 0–1000, 1001–2000, 2001–3000, 3001 > , data sourced from the Central Statistical Office (GUS) and from municipal authorities.

CRITERION II – TERRAIN RELIEF

This criterion was based on the Digital Terrain Model – DTM. Measurement data was used in ARC/INFO ASCII GRID formats (text files contain altitudes of points in a regular 1 m mesh screen, interpolated based on a cloud of points from an airborne laser scanning system (LIDAR). The mean altitude error is up to 0.2 m.) and ASCII_TBD formats (Respective files correspond to the ranges of sheets in a flat, rectangular coordinate system “1992” in the scale 1:10 000. Mesh interval ranges from 10 to 50 m, and the mean altitude error falls within the range 0.8–2.0 m. The data was sourced from aerial photographs or topographic maps). The data was provided by the Geodesy and Cartography Documentation Centre in Warsaw. All area calculations were performed with GIS tools using QGIS software.

The second criterion consisted of three sub-criteria. The first one is terrain slope (study of downslopes) which is split into five ranges to which weights were assigned: up to 3° – weight 3; 3–6° – weight 6; 6–10° – weight 9; 10–15° – weight 12; > 15° – weight 15. The second feature refers to slope exposure determined according to the main directions in eight graduation ranges (Fig. 1). The third feature referring to the risk of erosion was determined based on the terrain slope (DTM), soil type (data from the Institute of Soil Science and Plant Cultivation in