Proposal for Land Consolidation Project Solutions for Selected Problem Areas

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Abstract. One of the economic tools for supporting agricultural policy are the activities implemented under the Rural Development Program (RDP). By encouraging agricultural activities and creating equal opportunities for development of farms, among others in areas with unfavourable environmental conditions characterized by low productivity of soils exposed to degradation, decision makers can contribute to improving the spatial structure of rural areas. In Poland, one of the major concerns are agricultural problem areas (regions). In view of this situation, the aim of this article was to characterize the problem areas in question and propose land consolidation project solutions for selected fragments of those areas. This paper presents the results of a review of literature and an analysis of geodetic and cartographic data regarding the problem areas. The process of land consolidation, which is one of the technical and legal instruments supporting the development of rural areas, was characterized. The study allowed the present authors to establish criteria for selecting agricultural problem areas for land consolidation. To develop a proposal for rational management of the problem areas, key general criteria (location, topography, soil quality and usefulness) and specific criteria were defined and assigned weights. A conception of alternative development of the agricultural problem areas was created as part of a land consolidation project. The results were used to create a methodology for the development of agricultural problem areas to be employed during land consolidation in rural areas. Every agricultural space includes areas with unfavourable environmental and soil conditions determined by natural or anthropogenic factors. Development of agricultural problem areas through land consolidation should take into account the specific functions assigned to these areas in land use plans, as well as to comply with legal regulations.

1. Introduction
The development of Polish agriculture and its production capacity differ from one region to another. The main reason for this is the long-term transformation of the agricultural economy in areas with different socio-economic status. Currently, there are areas in Poland which can compete agriculturally in many respects with other regions of the European Union. However, there are also areas in which the output of privately owned individual farms is at or below the threshold of profitability. It is, therefore, important to ensure equal development opportunities and maintain the agricultural character of areas with unfavourable natural and landscape conditions (areas at risk of depopulation and environmental degradation) and unfavourable farming conditions (LFAs) taking into account the overall quality of the agro-ecological environment, which can be assessed on the basis of the agricultural production space valorisation index and identification of agricultural problem areas.

In designing such measures, it is important to take into consideration the relationships between agricultural production and the quality of the natural environment, in particular the quality of the soil habitat and water as well as factors such as insolation and temperature. Historical conditions of social development in Poland have contributed, among other things, to the exploitation of agricultural areas
which are less useful and have a low production potential [6]. In this connection, it is important that agriculturally useless land, i.e., problem areas, be properly managed and developed in compliance with the local natural and economic situation. Land management interventions may contribute to the revival of these areas, making them more attractive [16]. All the changes that are introduced should be in harmony with the resources of the natural environment, as the principle of sustainable development is of great importance for rural development [18, 19, 22].

One process that can be used to improve the spatial structure of rural areas, and thus problem areas, is the land management measure known as land consolidation. Due to consolidation, rural areas gain in competitiveness and farming becomes a profitable business.

2. Definitions of problem areas
In scientific literature, agricultural problem areas are defined in a variety of ways [3]. What definition is proposed depends on the field of study and the approach of the specialists exploring the issue. Problem areas are referred to with such terms as conflict areas, areas of deprivation, depressed areas, difficult areas, risk areas, less developed areas, marginal areas, etc. [1].

An important aspect that is taken into account when identifying problem areas is the relationship between agricultural production and the quality of the natural environment, in particular the quality of the soil habitat and water as well as insolation and temperature. Another feature of problem areas is considerable fragmentation of agricultural land. Fragmented land can be found in different regions of south-eastern [14, 9, 10, 11], central [24] and eastern [7, 8, 21] Poland. An agrarian structure of this type, combined with the strongly varied landscape, has a positive impact on the natural environment and biodiversity, but in the era of technological and civilization progress it is the main barrier to further mechanization of production and increasing the level of income of people who earn their living only from farming.

Globally, land consolidation is typically viewed in the context of its economic impact on farm productivity. There are many literature reports devoted to this topic [20, 25, 4]. However, their authors do not address the issue of the development of problem areas through implementation of appropriate land management measures, including land consolidation.

The main factors that negatively affect problem areas are intense exploitation and unreasonable use of natural resources, which intensifies erosive degradation, acidification of soils, as well as accelerating the loss of organic matter in soil. Another hazard to the environment and agriculture is the concentration of cumbersome industrial production, construction of landfills and emission of dust, all of which contribute to local contamination of agricultural land [6]. In view of the above, attention should be paid to areas with limited production potential, lower incomes, and retarded economic development.

It is worth emphasizing that in the Polish literature of the subject, agricultural problem areas are defined in various ways [3, 26]. For example, Zagożdżon [26] describes problem areas as part of the geographical space characterized by negative social, economic and technical phenomena that cause certain internal anomalies (in the spatial structure) and lead to the abnormality of the area” [26].

It is important to point out that rural problem areas also include territories with a relatively small intrinsic development potential which need substantial support from external resources to develop economically.

A definition of problem areas from the perspective of agriculture was proposed by Falkowski [5], who stated that agricultural problem areas are characterized by low agricultural productivity relative to their natural, historical and economic resources and the amount of investment in fixed and current agricultural assets [5]. Skawinska [17] argues that agricultural problem areas are "(...) areas of land that currently do or may fulfil a leading agricultural function owing to the favourable quality of the agricultural production space and the efficiency of agricultural production, but which are at risk of losing this function" [17].

A review of the literature shows that different types of areas can be treated as problem areas. These territories are characterized by the occurrence of negative natural as well as demographic, social and economic factors.

Current legal understanding of the term is based on Article 2 Section 7 of the Act of 27 March 2003 on Spatial Planning and Development, according to which a problem area is "an area where a particular
spatial development or spatial conflicts occur as indicated in the provincial spatial development plan or as specified in a commune study of the conditions and directions of spatial development” [28].

The latest definition of agricultural problem areas, as related to land consolidation, was proposed by Wójcik-Leń [23], who characterizes those areas as territories that are still being used for farming purposes but no longer bring profit due to [23]:

I. their location in relation to the ready market and the labour market, with the associated problems related to their:
   - membership in a tax district (communities and towns/cities in Poland are assigned to four tax districts depending on their economic status and production and climatic conditions),
   - high unemployment rate,
   - high population density,
   - low income structure,

II. topography of the area, including:
   - location on high grade slopes,
   - unfavourable slope aspect,
   - risk of erosion,

III. Soil quality and suitability, in particular:
   - a low land valuation grade,
   - a poor complex of agricultural suitability,
   - excessive soil moisture or dryness.

3. Sources of information on problem areas

In order to properly plan and implement specific land management interventions, the existing status of the area should be estimated in terms of soil, water, physiographic, social and economic conditions and its ownership status. Particularly important is the assessment of natural conditions, i.e. the possibilities or barriers created by the natural environment. This type of analysis is usually based on different kinds of spatial data, but also descriptive data obtained, among others, from the Real Estate Cadastre, local spatial development plans or commune studies of the conditions and directions of spatial development, Spatial Registration of Utility Infrastructure, State Register of Borders, Register of Historic Monuments and information from classification maps, soil agricultural maps and environmental and hydrographic maps, etc.

The largest amounts of data can be found in Land and Buildings Registers:
- the boundaries and the name of the register unit and the name of the cadastral community,
- plot number, numerical description of plot boundaries and plot area,
- types of land use units, their boundaries and areas;
- for land covered in the soil-class-based classification of land, the boundaries and areas of land belonging to specific soil valuation classes,
- information about the owner of the plot,
- land and mortgage register identification details or details regarding other documents specifying the rights of an entity to a plot.

An inventory map is also an important tool in designing the spatial structure of rural areas. It allows one to analyze the structure of land ownership, land use, fragmentation or scattering of land as well as the structure of the road network.

Other major sources of information available in the National Land Surveying and Cartographic Database include the Digital Terrain Model (DTM), the Digital Elevation Model (DEM), and DTM and DEM Measurement Data.

4. Land consolidation as a geodetic measure for the development of rural areas

The definition of agricultural problem areas cited earlier in this article refers to rural areas, in which spatial structure can be comprehensively improved using the geodetic instrument of land consolidation. It should be borne in mind, however, that, due to financial constraints, land consolidation and exchange should be first carried out in areas with the greatest spatial structure defects. It is, therefore, advisable to identify areas which most badly need land management intervention [12]. The role of land consolidation and its legal implications in the context of geodetic tasks for updating cadastral data were
discussed in detail by Mika and Leń [11].

Land consolidation was the first tool used for the development of rural areas and agriculture. The 2014–2020 Rural Development Program promotes land consolidation interventions defining them as land surveying tasks consisting in "(...) the creation of new land parcels, having a different layout than the original ones, with a view to reducing the number of small, scattered parcels that make up a holding, and increasing their average size. As part of a consolidation project, land management activities are also conducted after land consolidation, which include the creation of a functional network of access roads to agricultural and forestry land and the regulation of hydrological regime in the consolidated area."

Currently, the main purpose of land consolidation is to create more favorable conditions for farming and forestry [27]. Consolidation is a set of design and technical activities that should result in an improvement of the living and working conditions in rural areas. An important part of land consolidation schemes is investment in village renewal, along with the construction of technical and social infrastructure facilities, as well as environmental protection activities and activities aimed at preserving the natural living conditions. An important goal is to reduce production costs in agriculture and forestry, as a result of reduced labor input and the elimination of structural barriers. Factors that have a significant impact on agriculture include topography, soil type, atmospheric precipitation, water, air temperature, and the wind. Rural development also has its demographic, economic, nature and landscape-related aspects as well as aspects associated with the public interest.

In view of this, it is vital that land consolidation schemes pay attention to the agricultural problem areas and to the proper management of those areas. It is expedient to promote alternatives for land use, taking into account various economic functions, and to identify the most attractive ways of using the problem areas during land consolidation. Land with poor agricultural potential can be designated, in the first place, for afforestation and tree planting as well as for non-agricultural and non-forest purposes, e.g. for development, transport infrastructure, eco-tourism, leisure, etc. After conversion into ecological agrarian land, problem areas can be used for energy crop production [16]. Also other uses, such as the creation of hunting plots [2] are possible.

5. Method
The analyses were conducted as part of implementation of a land consolidation scheme. Selected agricultural problem areas were characterized to obtain information necessary to develop a rational land use strategy for those areas.

In the study, we adopted three general criteria with specific sub-criteria proposed by Wójcik-Leń [23] for isolating and selecting problem areas during land consolidation. The selected areas were graded for each criterion on point scales, according to the following principle: the more disadvantaged an area was with respect to a given feature (criterion), such as risk of erosion or low soil valuation class, the more points it received [23].

**CRITERION I – LOCATION – 30 points:**
- tax district – division into tax districts,
- unemployment rate – division into percentage ranges,
- density of population – division into population density ranges, people/km²,
- income structure – division into numerical ranges.

**CRITERION II – TOPOGRAPHY – 40 points:**
- slope grade (land slope study) - division into percentage ranges,
- slope aspect – division into the cardinal directions in degrees, according to the compass rose,
- risk of erosion – division into degrees of erosion.

The analyses were conducted on the basis of the Digital Terrain Model (DMT) using QGIS software.

**CRITERION III – SOIL QUALITY AND SUITABILITY – 30 points:**
- soil valuation classes – division into arable land and grasslands,
- complexes of agricultural suitability – division into complexes was done in accordance with the agricultural space valorisation index,
- hydrological conditions – the division was determined on the basis of the above data taking into account the criterion of moisture content with respect to soil–agricultural complexes.

The criteria were assigned weights and a synthetic measure was calculated according to the formula given below, which allowed parameterization of the selected agricultural problem areas $W_{OPR_a}$.
As a next step, the total synthetic measure was calculated to parameterize the criterion of the selected problem areas, [23].

$$W_{OPR_n} = \frac{\sum_{i=1}^{k} (k_n \cdot p_n)}{P_w}$$

where:

- $W_{OPR_n}$ - synthetic measure that allows parameterization of the criterion of selected agricultural problem areas
- $k_n$ - weight of the isolated group of areas (depending on the criterion used)
- $p_n$ - size of the isolated group of problem areas (depending on the criterion used)
- $P_w$ - size of the study area

6. **Study area**

The cadastral community of Hucisko is located in Leżajsk, Commune of Leżajsk, in one of the voivodships of south-eastern Poland, in central Europe (Figure 1). The total size of the investigated area was 578.37 ha. The land that was consolidated was primarily agricultural land (338.12 ha). 2355 parcels were rearranged during the consolidation.

![Figure 1. Geographical situation of Hucisko in Europe, Poland, Podkarpackie Voivodship, and the Commune of Leżajsk](image)

Careful analysis of the examined village, aimed at isolating and selecting problem areas, yielded the following results (Table 1).
Table 1. Summary of the criteria for the analyzed study area

| No. | Name of cadastral community | Location | Topography | Soil quality and usefulness | Sum of indicators |
|-----|-----------------------------|----------|------------|-----------------------------|-------------------|
| 1.  | Hucisko                     | 22       | 15.33      | 21.36                       | 58.69             |

The village of Hucisko is located in the third tax district. It is characterized by a low population density and a high unemployment rate (15–18%). The village received 22 points on the scoring scale, which represented 73.3% of the total number of points. The topography of the village is fairly flat, with hilly areas. 81.6% of the terrain has a slope of less than 3 degrees, and 15.9% of the village land slopes at an angle between 3° and 6°. This is in conformity with the risk-of-erosion data, as over 81.0% of soils in the village of Hucisko have no risk of erosion. According to the analysis, 15.6% of the total area has a low risk of surface water erosion. Hucisko received a score of 15.33 points (38.3% of the total number of points) under the scoring criterion of Topography (0-40 points). The prevailing soil classes in the land use structure of the village are class V and VI soils, which occupy 39.4% of the total area of agricultural land in Hucisko. The present study shows that this area has strongly drying-out soils (18.6% of the total area) and soils that are generally very dry (18.3% of the total area). The total number of points under the scoring criterion of Soil Quality and Usefulness was 21.36, which constituted 71.2% of the total number of points. On the whole, the investigated village received 58.69 points (the total point range was 0–100 points). This shows that much of the area of the investigated village is agriculturally problematic and requires identification and introduction of land use alternatives.

7. Proposals for land consolidation solutions in light of the land quality criteria adopted for selected fragments of the investigated problem areas

Land consolidation plays an important role in the management of rural space, as it allows consolidated areas to better fulfil their economic, social and environmental functions. It brings numerous benefits to the community living in the consolidated area. A review of the geodetic and cartographic documentation for the village of Hucisko showed that consolidation was conducted without taking into account agriculturally problematic areas and possibilities of their alternative development.

The following four problems related to topography and soil conditions were identified (Table 2):
- **TOPOGRAPHY**
  1. very weak and weak erosion,
- **SOIL QUALITY AND USEFULNESS**
  2. low valuation class,
  3. poor agricultural suitability complex
  4. drying-out soils or generally very dry soils.

Due to the nature of the territory under study, the most effective alternative ways of managing its problem areas include (Figure 2):
1. allocation of land for afforestation and creation of hunting plots. An analysis of land use showed that the investigated village already had a high percentage of forestry land, which constituted 25.6% of the total area of the village. This meant that afforestation should not be used as the chief land-use improvement measure in Hucisko.
2. allocation of land for non-agricultural and non-forest purposes, such as eco-tourism or sport and leisure: designing of cycling, hiking and horse-riding routes and camping sites.
## Table 2. Evaluation of project solutions with respect to the adopted land quality criteria

| Name of cadastral community | Land quality criterion | Problem | Land consolidation measures proposed in the project |
|-----------------------------|------------------------|---------|--------------------------------------------------|
|                             | Location               | tax district unemployment rate population density income structure | - | - |
|                             | slope grade (land slope study) | - | - |
|                             | Topography             | slope aspect | - | - |
|                             |                       | risks of erosion, very weak and weak erosion, | - |
|                             |                       | land valuation classes a low land valuation grade, | - |
| HUCISO                      | Soil quality and suitability | a poor agricultural suitability complex | - |
|                             |                       | hydrological conditions strongly drying-out soils generally very dry soils | - |
| Source: Own elaboration | |

A land consolidation project for Hucisko should include creation of eco-tourism, tourism and leisure areas, and should thus pursue the following objectives:

- improve the external image of the entire village area,
- create accommodation facilities or renovate the existing ones, and provide service facilities (employment opportunities for the local people),
- provide road access,
- create new or improve the existing leisure facilities, including:
  - fitness trails in forested, wooded and bushy areas,
  - bicycle paths around natural or historical landmarks,
  - camping sites, fishing spots and beaches around water reservoirs,
- create cultural attractions in the village and its surroundings (churches, museums, open-air museums),
- use abandoned buildings,
- convert land to energy crop production

A good example of an energy crop that could be grown in Hucisko is the Pennsylvanian mallow, which originally comes from the subtropical regions of our globe. It grows in the form of clumps, has a strong root system and develops from several to a dozen stalks with a diameter of 5–35 mm and a height of more than 3.5 meters. Mallow plantations can be exploited for 15–20 years. This plant can be grown on drying-out or dry soils of all classes (except class VI and poor class V), with a neutral or slightly acidic pH. Depending on the region, biomass is harvested from February to April.
8. Conclusions
Rural areas in Poland, apart from providing space for agricultural production, fulfil many other functions. What land use they are assigned depends mainly on their location, topography and soil quality and suitability.

A land management measure that can be used to improve the spatial structure of rural areas, including problem areas, is land consolidation. Land consolidation activities provide an opportunity to characterize selected agriculturally problematic areas and propose alternative land uses for them. A reliable and solid characterization requires the analysis of relevant sources of information about the terrain and its problem areas. Any change in land use must depend, among others, on the quality and reliability of the data used, and the interpretation and utilization of these data must rest on the expertise of land management specialists and the knowledge of the participants of the consolidation scheme. To be able to fulfil new functions and tasks, rural areas must be adequately prepared: they must have appropriate technical, communication and social infrastructure, legally established ownership of property, provisions for the protection of environmental resources, etc. The state's structural policy and the tools for its implementation must enable sustainable development of these functions, also with respect to agricultural space.

It should be noted that so far land consolidation schemes have not taken into account the specification of agricultural problem areas and their land use potential, treating them as marginal issues. This situation is due to unadjusted legislation as well as a low level of public awareness. For this reason, it seems that the Act of 26 March 1982 on Land Consolidation and Exchange [1982 Act] needs to be amended as regards the specification of new consolidation objectives as well as the establishment of new land uses for problem areas during the preparation of a land consolidation project.

Land consolidation is an investment that must be treated in the broadest sense as a comprehensive solution to all problems related to the management of real estate resources in rural areas.

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