Analysis of the Impact of Features on the Ranking of Urgency of Land Consolidation Works

Justyna Wojcik-Len 1, Zanna Strek 1, Przemysław Len 1

1Department of Environmental Engineering and Geodesy, University of Life Sciences, 20-069 Lublin, 7 kr. St. Leszczyńskiego street, Poland

przemyslaw.len@up.lublin.pl

Abstract. In EU member states the restructuring of rural areas based on consolidation is a common measure, thus Poland’s membership of the EU provided an opportunity for developing such zones through the financial support of the measures. The development of agriculture in Poland and its production capacity is much differentiated in terms of space. One of the reasons for such a situation is the process of long-term transformations of agricultural management in areas with different social and economic situation continuing for many years. The objective of land consolidation works is creating more favourable management conditions in agriculture and forestry by improving the territorial structure of farms, forests and forestland, reasonable configuration of land, aligning the limits of real properties with the irrigation and drainage system, roads and terrain. The studies were carried out in the rural community (gmina of Poświętne), situated in Opoczno poviat in Central Poland, which consisted of 17 villages covering a total area of 14081.0 ha. For the purposes of creating the ranking of urgency of the land consolidation and exchange works in the community (gmina) of Poświętne, 26 most significant features characterizing respective villages were selected. Those features were calculated based on data obtained from the register of land and buildings maintained by the Poviat Administration in Opoczno. The ranking was created using the zero unitarization method. This method allows standardizing diagnostic variables by testing the range of the characteristic. Standardized measures fall within the range <0;1>. The results can be interpreted as an average of optimum values achieved by each of the objects. Thus, the higher the synthetic measure, the higher position of the object in the ranking being created. This paper is a continuation of surveys during which the authors studied the impact of single features on the position of respective villages in the ranking. This paper aimed to analyze the impact of features on the ranking of urgency of land consolidation works by leaving out 2 or 3 features which described the analyzed villages and checking their impact on the results of the ranking of urgency of land consolidation and exchange works in respective villages within the analyzed community.

1. Introduction
The problem of highly defective spatial structure of agricultural land is common in many countries. In the first place, it is a result of social, economic or historical transformations which have often continued for hundreds of years [13], [2], [1], [14], [3], [4], [9], [16], [11]. Consolidation and exchange of land is a tool for improving the defective spatial structure. With regard to limited funds allocated for the purposes of such measures, it is necessary to identify objects where such works should be carried out as a priority [6]. However, for the purposes of hierarchization of land consolidation and exchange works, it is necessary to carry out a number of surveys and analyses...
leading to the identification of a set of features characterizing the analyzed region [Leń 2018]. At present, the spatial structure of land in Poland is affected by the following factors: demographic relations, socio-economic and legal relations, arrangement of marriages, dividing large estates into parcels before and after World War II, agriculture, and the settlement of the ownership status of farms. Reconstruction of the spatial structure of rural areas is necessary to ensure permanent and sustainable development of such grounds [15]. Land consolidation, as a space management tool, leads to desirable structural changes but it must be carried out systematically and it must become an element of the long-term policy of regional governments with respect to the development of rural areas. Consolidation and exchange works should be comprehensive and they should be connected with post-consolidation management. Only then multi-functional development of rural areas is possible. Such works are an effective tool to rectify the identified defects and provide an option for alternative management of unfavourable, useless agricultural land – the so-called agricultural problem areas [18], [19], [17]. In order to identify areas where land consolidation and exchange works are the most urgent, it is necessary to carry out detailed surveys and select relevant features facilitating effective identification of areas with the most defective spatial structure [5], [8] within a specific village or group of villages. At the first stage of works undertaken to identify factors affecting the condition of spatial structure of the analyzed areas, it is necessary to gather current and reliable information about the object of study, including the maximum possible amount of quantitative data by means of which the analyzed area can be described to improve the utilization of rural space [12]. Here, it should be emphasized that rural areas can be described by means of many different features providing information about the degree of defectiveness of the spatial structure of land. Some features can be represented by means of synthetic measures describing their intensity, which facilitates partial reduction of the data set. This paper aims to analyze the impact of features on the ranking of urgency of land consolidation works by leaving out 2 or 3 features which describe the analyzed villages and checking their impact on the results of the ranking of urgency of land consolidation and exchange works in respective villages within the analyzed gmina.

After first paragraph, other paragraphs are indented as you can see in this paragraph. After Introduction, divide your article into clearly defined and numbered sections.

2. Materials and methods

For the purposes of creating the ranking of urgency of the consolidation and exchange of land in the gmina of Poświętne, 26 factors characterizing respective villages were identified. Those features were calculated based on data obtained from the register of land and buildings maintained by the Poviat Administration in Opoczno. Preliminary analysis covers a general description of the distribution of values of respective variables presented in the form of descriptive statistics (Tables 1, 2). Each variable was determined as either an LTB (larger-the-better) characteristic or an STB (smaller-the-better) characteristic for the needs of the consolidation process. With regard to the ranking method, all features were adopted as LTB characteristics. Six groups of features were classified as LTB characteristics. The first group is general information, including: x₁ – total area, x₂ – total number of plots, x₃ – number of residents, x₄ – number of residents per km², x₅ – % of the area of land owned by individual farmers, x₆ – % of the number of plots owned by individual farmers, x₇ – average area of the plot owned by individual farmers. Another group comprises information referring to land owned by individual farmers, such as: x₈ – number of registration units in subgroup 7.1, x₉ – % of registration units in subgroup 7.1, x₁₀ – number of plots of a registration unit in subgroup 7.1, x₁₁ – area of the plots of a registration unit in subgroup 7.1, x₁₂ – % of the number of plots in subgroup 7.1, in relation to group 7, x₁₃ – % of the area of the plots in subgroup 7.1, in relation to group 7, x₁₄ – average number of plots per registration unit, x₁₅ – average area of a registration unit. Another group is the productivity ratio calculated for x₁₆ – arable land and for x₁₇ – grassland. A further group is the structure of ownership, including: x₁₈ – % of land owned by the Agricultural Property Agency of the State Treasury and x₁₉ – land owned by gminas. One more group, i.e. plots without access to roads,
includes: x20 – % of the number of plots without access to roads and x21 – % of the area of plots without access to roads.

Table 1. Features adopted as LTB characteristics

| Selected features                                      | LTB charact. | Mean  | Me   | min    | max      | V       |
|--------------------------------------------------------|--------------|-------|------|--------|----------|---------|
| x1 – total area                                        | ↑            | 828.1530 | 616.2823 | 227.8799 | 3313.1911 | 89.2900 |
| x2 – total number of plots                             | ↑            | 926.8824 | 866.0000 | 317.0000 | 2097.0000 | 49.6956 |
| x3 – number of residents                                | ↑            | 210.7059 | 170.0000 | 32.0000 | 602.0000 | 73.8262 |
| x4 – number of residents per km2                       | ↑            | 32.6919  | 23.2917 | 8.3610  | 142.1520  | 96.0501 |
| x5 – % of the area of land owned by individual farmers  | ↑            | 69.4794  | 83.3400 | 26.4600 | 96.4200   | 38.7200 |
| x6 – % of the number of plots owned by individual farmers| ↑            | 88.1500  | 89.9700 | 74.4500 | 95.3200   | 7.0103  |
| x7 – average area of plots owned by individual farmers  | ↑            | 0.6106   | 0.5628 | 0.2900  | 1.5236    | 48.6444 |
| x8 – number of registration units in subgroup 7.1      | ↑            | 124.2353 | 116.0000 | 34.0000 | 260.0000 | 52.6269 |
| x9 – % of registration units in subgroup 7.1           | ↑            | 62.0979  | 67.5439 | 19.4757 | 85.2234   | 29.2477 |
| x10 – number of plots per registration unit in subgroup 7.1| ↑       | 718.5882 | 624.0000 | 187.0000 | 1849.0000 | 59.4184 |
| x11 – area of plots per registration unit in subgroup 7.1| ↑       | 424.9470 | 388.5660 | 178.6368 | 1125.6581 | 55.9632 |
| x12 - % of the number of plots in subgroup 7.1 in relation to group 7 | ↑       | 85.4459  | 89.4000 | 58.2700 | 96.5600   | 12.9814 |
| x13 - % of the area of plots in subgroup 7.1 in relation to group 7 | ↑   | 93.1753  | 95.1500 | 76.4800 | 98.8700   | 6.4771  |
| x14 – average number of plots per registration unit    | ↑            | 6.2815   | 5.3935 | 2.5616  | 14.9481   | 51.9700 |
| x15 – average area of a registration unit              | ↑            | 3.7304   | 3.3035 | 1.5783  | 8.2958    | 43.9270 |
| x16 – productivity ratio of cropland                   | ↑            | 28.5146  | 25.1789 | 22.7577 | 37.4526   | 18.0599 |
| x17 – productivity ratio of grassland                  | ↑            | 34.8197  | 35.6678 | 24.2452 | 45.4630   | 14.6519 |
| x18 - % of land owned by the Agricultural Property Agency of the State Treasury | ↑   | 0.0229   | 0.0000 | 0.0000  | 0.1200    | 184.1407 |
| x19 - % of land owned by the gminas                     | ↑            | 1.6735   | 1.6800 | 0.3300  | 4.3100    | 58.6780 |
| x20 - % of the number of plots without access to roads | ↑            | 16.3165  | 14.2500 | 2.7400  | 36.9500   | 59.9646 |
| x21 - % of the area of plots without access to roads   | ↑            | 16.5700  | 13.8500 | 4.0500  | 44.7500   | 69.5256 |

Source: Elaborated based on [10]
The STB characteristics were (Table 2): $x_{22}$ – fragmentation ratio, $x_{23}$ – % of orchards, $x_{24}$ – % of forests, $x_{25}$ – average elongation ratio and $x_{26}$ – synthetic ratio of plot elongation for the precinct.

Table 2. Features adopted as STB characteristics

| Selected features                                      | STB characteristics | Mean  | Me   | min  | max  | V    |
|--------------------------------------------------------|--------------------|-------|------|------|------|------|
| $x_{22}$ – fragmentation ratio                          | ↓                  | 4.0545| 4.0911| 3.3393| 4.7918| 9.9507|
| $x_{23}$ - % of orchards                               | ↓                  | 0.3674| 0.1858| 0.0000| 1.4700| 132.2613|
| $x_{24}$ - % of forests                                | ↓                  | 48.1053| 50.7400| 13.0100| 77.0700| 45.6128|
| $x_{25}$ – average elongation ratio                    | ↓                  | 2.4452| 2.4244| 1.0596| 4.1016| 32.6724|
| $x_{26}$ – synthetic ratio of plot elongation for the precinct | ↓                  | 2.6290| 2.8212| 1.4854| 3.7366| 30.8116|

Source: Elaborated based on [10]

Prior to preparing a synthetic ranking based on the output values of diagnostic features, they are often subject to preliminary selection. The most popular criteria refer to not including variables with low level of variation in the analysis (it is often assumed that these are the characteristics for which the coefficient of variation (V) is lower than 20%). They often assume the elimination of features that are highly correlated (with regard to the fact that they convey similar information about the hierarchy of the ordered objects) [7]. The criterion of the coefficient of variation is not satisfied by: % of the number of plots owned by individual farmers (V=7.0%), % of the number of plots in subgroup 7.1 in relation to group 7 (V=13.0%), % of the area of plots in subgroup 7.1 in relation to group 7 (V=6.5%), cropland productivity ratio (V=18.1%), grassland productivity ratio (V=14.7%) and fragmentation ratio (V=10.0%). Due to their substantive value, these features were retained for the purposes of objective analysis. For other variables the coefficient of variation exceeds 20%. A detailed calculation algorithm for the zero unitarization method is presented in the publication [8].

3. Results and discussions

Based on 15 tests in which 2 or 3 features were left out, one ranking was developed including the mean value from all tests. The results are illustrated in Table 3 and Figures 1 and 2. According to the surveys, the most urgent need for land consolidation works was identified in Brudzewice. The analyzed village was first in all rankings. However, in one case it was second when features such as: $x_1$ – total area and $x_3$ – number of residents were not included in the analysis, which is a proof that this is the largest precinct with a high percentage of residents.
Table 3. Ranking of urgency of land consolidation based on tests

| Ranking position | Value of synthetic measure | Village            |
|------------------|----------------------------|--------------------|
| 1                | 0.614                      | Brudzewice         |
| 2                | 0.553                      | Kolonia Gapinin    |
| 3                | 0.536                      | Buczek             |
| 4                | 0.532                      | Gapinin            |
| 5                | 0.489                      | Wólka Kuligowska   |
| 6                | 0.450                      | Dęba               |
| 7                | 0.433                      | Małoszyce          |
| 8                | 0.432                      | Dęborzeczka        |
| 9                | 0.429                      | Studzianna         |
| 10               | 0.413                      | Kolonia Brudzewice |
| 11               | 0.39                       | Stefanów           |
| 12               | 0.383                      | Kozłowiec          |
| 13               | 0.369                      | Poświętne          |
| 14               | 0.353                      | Poręby             |
| 15               | 0.341                      | Mysiakowice        |
| 16               | 0.282                      | Ponikła            |
| 17               | 0.266                      | Anielin            |

Kolonia Gapinin, which was second in most rankings when one variable was left out, comes first in the ranking in which: $x_1$ – total area and $x_3$ – number of residents were not included, which is a proof that this is a small village characterized by a low percentage of residents. On the other hand, this village comes third or fourth in rankings in which: $x_{17}$ – productivity ratio for grassland, $x_{26}$ – synthetic elongation ratio for plots within the precinct, $x_8$ – number of registration units in subgroup 7.1, $x_{23}$ – % of the area of plots without access to roads, $x_{23}$ – % of orchards, or $x_{18}$ – % of land owned by the Agricultural Property Agency of the State Treasury were not included. This testifies to a high productivity ratio for grassland, large elongation of plots, high number of registration units in subgroup 7.1, small area of plots without access to roads, small percentage of orchards and small area of land owned by the Agricultural Property Agency of the State Treasury in that village.

Buczek, which was the third or fourth village in the rankings when one variable was left out, comes second in the ranking in which: $x_{18}$ – % land owned by the Agricultural Property Agency of the State Treasury, $x_{21}$ – % of the area of plots without access to roads and $x_{23}$ – % of orchards were not included, which is a proof that the area of land owned by the Agricultural Property Agency of the State Treasury is small, that the area covered by plots without access to roads is small and that there are not many orchards in that village. Gapinin, which was the third or fourth village in most rankings when one variable was left out, comes second in the rankings in which: $x_{17}$ – productivity ratio for grassland, $x_{26}$ – synthetic elongation ratio for plots within the precinct, $x_8$ – number of registration units in subgroup 7.1, $x_{23}$ – % of the area of plots without access to roads, $x_{23}$ – % of orchards, were not included. It testifies to a high productivity ratio for grassland, small elongation of plots, small number of registration units in subgroup 7.1, average area of plots without access to roads, and the lack of orchards in that village. On the other hand, this village was fifth in rankings in which: $x_{18}$ – % of land owned by the Agricultural Property Agency of the State Treasury, $x_{22}$ – fragmentation ratio, $x_{21}$ – % of the area of plots without access to roads and $x_{23}$ – % of orchards were not included. It testifies
to a large area of land owned by the Agricultural Property Agency of the State Treasury, large fragmentation of plots, average area of plots without access to roads and the lack of orchards in that village. Wólka Kuligowska, which was the fifth or sixth village in the rankings when one variable was left out, comes fourth in the rankings in which: \(x_{18} - \%\) of land owned by the Agricultural Property Agency of the State Treasury, \(x_{22} - \text{fragmentation ratio}\), \(x_{21} - \%\) of the area of plots without access to roads or \(x_{23} - \%\) of orchards were not included. It testifies to the lack of land owned by the Agricultural Property Agency of the State Treasury, small fragmentation of plots, small area of plots without access to roads and the lack of orchards in that village.

Figure 2. Chart presenting position changes in 15 rankings for respective villages in the gmina of Poświętne

In turn, Ponikła, which alternately with Anielin, was sixteenth and seventeenth in the rankings when one variable was left out, comes sixteenth in the rankings in which more than one variable was left out, except rankings in which: \(x_{18} - \%\) of land owned by the Agricultural Property Agency of the State Treasury, \(x_{22} - \text{fragmentation ratio}\), \(x_{5} - \%\) of the area of land owned by individual farmers and \(x_{6} - \%\) of the number of plots owned by individual farmers, were not included. It testifies to the lack of land owned by the Agricultural Property Agency of the State Treasury, large fragmentation of plots and large area and number of plots owned by individual farmers in that village. The village comes seventeenth in such rankings. Anielin, which alternately with Ponikła, was sixteenth and seventeenth in the rankings when one variable was left out, comes seventeenth in the rankings in which more than one variable was left out, except rankings in which: \(x_{18} - \%\) of land owned by the Agricultural Property Agency of the State Treasury, \(x_{22} - \text{fragmentation ratio}\), \(x_{5} - \%\) of the area of land owned by individual farmers and \(x_{6} - \%\) of the number of plots owned by individual farmers, were not included. It testifies to the lack of land owned by the Agricultural Property Agency of the State Treasury, small fragmentation of plots and small area and number of plots owned by individual farmers in that village.

4. Conclusions
Surveys regarding the analysis of the impact of features on the ranking of urgency of land consolidation works showed that the selection of features was very significant for creating the rankings of urgency of works since correctly collected data provides reliable information regarding the
analyzed object. The results of tests showed that villages characterized by a very defective spatial structure, despite leaving out 2 or 3 features, were still high in the ranking of the needs for land consolidation works (Brudzewice, Kolonia Gapinina, Buczek, Gapinina). The same was applicable to villages which occupied end positions in the rankings (Poświętne, Poręby). Such a state of affairs shows that if any features are left out accidentally, the position in the ranking should not differ much from that of objects where land consolidation and exchange works are the most urgent. The situation is slightly different in villages in the middle of the ranking because for them leaving out 2 or 3 features led to huge changes in the ranking positions. Such a state of affairs is due to the fact that in those villages the value of the synthetic measure ranges from 0.341 in Mysiakowiec to 0.489 in Wólka Kuligowska. The small span of the measure contributes to large changes in the hierarchization of the consolidation works. The authors propose that an additional, independent statistical method should be used in order to verify the results of analyses.

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