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Analysis of Selected Indicators that Are Useful in Assessing Farming Conditions in Agriculture on Example of Masovian Voivodeship

Abstract: The aim of this research was to analyze selected indicators that may be useful in assessing the farming conditions of agriculture in municipalities as well as assessing the agricultural production spaces. The indicators that were selected for analysis were considered in the literature to be among the most important indicators that allowed for the assessment of the above-mentioned conditions; these were the agricultural production space valorization index (WWRPP), the soil valuation index (WBG), the forest cover index, the number of tractors per 100 ha of agricultural land, the numbers of farm animals in large head index (PL) per 100 ha of agricultural land, and the share of the agricultural farms that owned land in ten or more plots in their total areas. The study of the distribution values of the above-mentioned indicators covered municipalities that are located in Masovian Voivodeship.

The obtained research results showed in which municipalities there were barriers to the development of agriculture – in which municipalities there were large forest covers, soils of poor quality, low levels of mechanization, and high fragmentations of land. The identified strengths and weaknesses in terms of farming conditions in agriculture can be used, for example, by local authorities. The selected set of indicators is an open set and can be expanded with further indicators; with the selection of an appropriate methodology, it can be used to assess the farming conditions in the agricultural areas of the individual municipalities.

Keywords: farming conditions in agriculture, agricultural production space valorization index (WWRPP), soil valuation index (WBG), land pattern

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1. Introduction

Assessing farming conditions in agriculture is important for identifying those factors that slow down the development of agriculture as well as barriers of its further development.

There is no specific valid method for assessing farming conditions in agriculture; there is also no strictly defined set of indicators that would be used to achieve the above-mentioned goal. The author of the publication attempt to select a set of indicators and a method for achieving this goal.

The development of agriculture is influenced by various types of factors, which can be divided into natural factors and non-natural factors – anthropogenic. Similarly, indicators for assessing farming conditions in agriculture can be divided into those indicators that result from natural conditions and those that result from non-natural conditions. This division was indicated by M. Dudzińska, among others [1].

Natural factors that affect agriculture include soil conditions, climatic conditions, water conditions, and landforms. Among others, A. Kołodziejczak [2], R. Kulikowski [3], and J. Bański [4] indicated that soil conditions should be considered together with water conditions.

The interdependencies between the above-mentioned factors have long been known. As W. Biegajło wrote [5], "the relief of the land in connection with the climatic, water, and soil conditions determines the potential suitability of the land for various forms of its use – its intended use for arable land, grasslands, forests, or wastelands".

Taking the above-mentioned factors into account, they should be considered together in order to assess the farming conditions in agriculture due to the relationships among them. This has also been indicated by M. Dudzińska, among others [1].

A commonly known and used indicator that synthesizes the indicated factors is the agricultural production space valorization index (WWRPP). It was selected first for analysis. According to [6], this indicator is an integrated indicator that consists of the following:

– quality and agricultural suitability of soil,
– agroclimate,
– landform,
– soil water relationship.

This indicator was developed at the Institute of Soil Science and Plant Cultivation – State Research Institute (IUNG-PIB); it was intended to allow for the quantitative and spatial assessments of natural factors that determine the potential yields of crops at the local level [6].

The second indicator that indicates soil quality is the soil quality index (WBG); this takes the economic, production, and climatic conditions of municipalities into account. It determines the quality of agricultural land and is the basis for assessing agricultural taxes. "The quality of Polish soil is among the lowest in Europe; the production potential of an average hectare of our soil corresponds to the potential of an average 0.6 ha of arable land in the European Union" [7].

As J. Bański wrote [4], Statistics Poland – the Central Statistical Office (GUS) undertook research in 2002 on the value of this indicator as the quotient of the conversion hectares (used to calculate the amount of agricultural taxes) to the physical hectares of agricultural land on a farm. Research has shown that the higher the value of this indicator, the higher the usable quality of the land. As J. Bański wrote [4]: "The areas with the highest values of the indicator corresponded to the areas with the best soil qualities".

The forest cover index is indirectly related to the soil.

"Forests in Poland grow on the weakest soils; this is related to the development of agriculture in previous centuries" [8]. Moreover, in accordance with Art. 14.2 of Act [9], wasteland, agricultural land that is unsuitable for agricultural production and agricultural land that is not used for agricultural purposes and other land that is suitable for afforestation may be designated for afforestation; in particular:

- land that is located at springs of rivers or streams, on watersheds, along river banks, and on outskirts of lakes and water reservoirs;
- volatile sands and sand dunes;
- steep slopes, slopes, cliffs, and sinkholes;
- heaps and areas of exploited sand, gravel, peat, and clay.

Therefore, the higher the forest cover index, the less favorable the farming conditions in agriculture will be.

Non-natural (anthropogenic) factors that affect agriculture include the following:

- ownership structure of farms,
- area structure and use of farms,
- level of agricultural mechanization,
- land fertilization level,
- number of farm animals.

A. Harasim [10] presented the important analytical factors that are most often used to assess the resources of production factors in agriculture. They are used to assess the production potentials of farms and rural areas (agricultural regions). The author listed the following factors in the following division:

- soil:
  - farm area (hectares of agricultural land),
  - soil quality index (points),
  - index of agricultural production space valorization (points),
  - structure of agricultural land (percentages),
  - sowing structure (percent of arable land),
  - share of permanent grassland (percent of agricultural land),
  - share of fallow and uncultivated land (percent of arable land),
  - forest cover rate (percentages);

- work:
  - village population density (number of people per 1 km^2),
  - share of rural population (percentages),
  - employment in agriculture (percent of all employed people),
  - employment level (number of full-time employees per 100 ha of agricultural land or per farm),
  - registered unemployment rate (percentages),
  - farmers' qualification level (education),
  - draft force resources (in kilowatts or draft units per 100 ha of agricultural land);
- capital:
  - equipment with fixed assets (PLN per 1 ha of agricultural land or per farm),
  - number of tractors (pieces per 100 ha of agricultural land or per farm),
  - investment outlays (PLN per 1 ha of agricultural land or per 1 full-time employee),
  - animal density (in large pieces per 1 ha of agricultural land, per agricultural land farm, or per farm).

Taking the above list into account and the availability of data for analysis, the following indicators were selected: the number of tractors per 100 ha of agricultural land, and the number of farm animals in large head index (PL) per 100 ha of agricultural land.

Land patterns also influence farming conditions in agriculture. As M. Dudzińska wrote [11], this is a factor "that limits the possibilities of using agricultural land". The layout of the land is also a factor that influences the conditions in question. Pursuant to Art. 1.2 Point 3 of Act [12], an area's land layout means the distribution of its farm land in relation to its built-up land. In accordance to Art. 1.2 Point 3a of Act [12], an agricultural holding is understood as a farm within the meaning of Art. 553 of the Act of April 23, 1964 – Civil Code (Journal of Laws of 2022 [Items 1360, 2337, and 2339] and 2023 [Item 326]), in which the agricultural area or forested land is not less than 1 ha.

As S. Kokoszka and Z. Daniel wrote [13], "the distance of a field from the economic center combined with the quality of roads are important elements that influence the economics of production". Therefore, the large fragmentations of plots on farms and large layouts have negative impacts on farming conditions in agriculture.

Taking the above conditions into account, another indicator whose value was analyzed was the share of the agricultural land of those farms that own land in ten or more plots in their total areas.

In the European Union, there is the concept of less-favored areas (LFA); in Poland, these areas currently include natural or other specific constraints. This concept was introduced by the European Union as part of the development of the Common Agricultural Policy, which was aimed at supporting the development of rural areas, among other things. Directives that were introduced in the subsequent years defined the types of areas with unfavorable management conditions and which criteria they must meet. Farmers who conducted agricultural activities in those areas that were classified as less-favored areas (LFA) could receive appropriate financial support. Due to changes in the European regulations, new rules for designating LFA areas were introduced in Poland by the Regulation of the Minister of Agriculture and Rural Development of February 1, 2019, thus amending the regulation on the detailed conditions and procedures for granting financial aid under the measure "Payments for areas with natural or other specific restrictions," which was covered by the Rural Development Program for 2014–2020.

LFAs are divided into the following types:
- LFAs with natural limitations zone I,
- LFAs with natural limitations zone II,
- LFAs of specific type zone I (unfavorable conditions with natural and tourist values),
- LFAs of specific type zone II (foothills),
- LFAs mountain type.

In accordance with [6] for determining the ranges of LFAs with natural limitations, such biophysical criteria as the following were used in Poland:
- low air temperatures,
- unfavorable textures and stoniness of soils,
- limited rooting depths,
- unfavorable chemical properties,
- large slopes of terrain.

In accordance with [6] for determining the ranges of LFAs of a specific type zone I used a combination of indicators, such as the following:
- agricultural production space index (WWRPP),
- natural and tourist valuable index (WCTP).

In accordance with [6] for determining the ranges of LFAs of a specific type zone II were assumed to include communes and registration districts of foothill regions in which the following applied:
- at least 50% of agricultural area is located above 350 m above sea level;
- according to digital terrain model (DEM), they meet condition "at least 50% of agricultural area is located above 350 m above sea level";
- structural criteria were also checked (e.g., farm area, share of grasslands, erosion).

In accordance with [6] mountain-type LFAs include communes and registration districts where more than half of the agricultural land is located above 500 m above sea level. The location of a commune or registration district in an LFA zone is already a signal that farming conditions are unfavorable; this affects the agricultural activities in this area.

2. Material and Methods

The research on the selected indicators was carried out as part of the implementation of Product No. 1-1.1.2 entitled 'Assessment of farming conditions in agriculture in municipalities,' which was prepared as part of Task No. 1 ('Preparation of a diagnosis of the economic, social and environmental condition') of subtask No. 1.1. ('Research on the current status in the context of introducing new functions in rural areas of Masovian Voivodeship') based on a contract for research services (entitled 'Implementation of the Smart Villages concept in Masovian Voivodeship') that was financed from the budget of Masovian Voivodeship. These indicators were used to assess the farming conditions in agriculture in the municipalities of Masovian Voivodeship.

The method of selecting the indicators, the method of their calculation, the methodology that was used, and the final results of the assessment of the farming conditions in agriculture in the municipalities of Masovian Voivodeship are described in [14]. The methodology was as follows: in accordance with [14], indicators were selected to assess the farming conditions in agriculture in communes; then, the selected indicators were divided into two groups of indicators (spatial and natural indicators, and production indicators); in the next stage, the group of spatial and natural indicators was assigned a weight of 80 (due to its great impact on the development of agriculture), and the group of production indicators was assigned a weight of 20. A point-evaluation method was used to assess the farming conditions, assigning appropriate point assessments to the individual ranges of the indicator values that were selected for analysis. On the basis of the partial indicators, the value of the synthetic indicator for assessing the farming conditions in agriculture in the communes was calculated according to the following formula:

$$Ws = \frac{\sum_{n=1}^{6} P_n \cdot w_1 + \sum_{n=1}^{2} P_n \cdot w_2}{N_1 \cdot P_{\max} \cdot w_1 + N_2 \cdot P_{\max} \cdot w_2},$$

where:

Ws – synthetic indicator for assessing farming conditions in agriculture in communes,
P_n – number of obtained points for n-th indicator,
w_1 – weight of spatial and natural indicators,
w_2 – weight of production indicators,
N_1 – number of spatial and natural indicators,
N_2 – number of production indicators,
$P_{\max}$ – maximum number of points that can be obtained for given indicator.

Depending on the value of the synthetic indicator, the farming conditions in agriculture were assessed according to the following ranges:

- 90.0% – very favorable conditions,
- 70.1–90.0% – favorable conditions,
- 50.1–70.0% – average conditions,
- 25.0–50.0% – unfavorable conditions,
- <25.0% – very unfavorable conditions.

Table 1 presents the materials that were used to analyze the selected indicators.

Table 1. Indicators selected for analysis and materials that were used

No.	Name of indicator	Materials used
1	Agricultural production space valorization index (WWRPP)	[15, 16]
2	Soil valuation index (WBG)	[17, 18] Data from the Central Statistical Office (GUS) (available in the Local Data Bank of the Central Statistical Office [19]) from 2020
3	Forest cover index	Data from the Central Statistical Office (GUS) (available in the Local Data Bank of the Central Statistical Office [19]) from 2020
4	Number of tractors per 100 ha of agricultural land	Data from the Central Statistical Office (GUS) (available in the Local Data Bank of the Central Statistical Office [19]) from the 2010 General Agricultural Census
5	Number of farm animals in large head index (PL) per 100 ha of agricultural land	Data from the Central Statistical Office (GUS) (available in the Local Data Bank of the Central Statistical Office [19]) from the 2010 General Agricultural Census
6	Share of agricultural land of farms owning land in ten or more plots in their total areas	Based on [20] – additional data from B. Głębocki

Table 2 presents the point ranges for the individual partial indicators that made up the WWRPP, the data sources on the basis of which their indexations were made, and the method of their determinations. The adopted point values were adopted according to their importance in shaping the yield [6]. The sum of the partial factors that are listed in Table 2 gives the WWRPP.

Table 2. Score ranges for individual partial indicators that made up WWRPP, sources of data for their valorization, and method of their determination

Partial indicator	Score range	Data source	Method of determining indicator
Quality and agricultural suitability of soil	18–95	Area of valuation classes – data from the land register. Areas of agricultural suitability complexes – digital soil and agricultural map with resolution of 1: 25,000	Estimated on basis of valuation classes and agricultural suitability complexes of soil
Agroclimate	1–15	Multi-year meteorological data (precipitation, temperature, and length of growing season)	Yields in given area were expressed as function of meteorological parameters – these functions explain observed variability of yields
Terrain relief	0–5	Digital terrain model (with 5 m × 5 m resolution)	Measurable valorization index was derived based on classification of terrain slopes and relief type – classification and calculation of relief scores were carried out using algorithms that were based on digital terrain model
Soil water relations	0.5–5	Digital soil and agricultural map	This was determined on basis of amount of water that soil profile can retain due to granulometric compositions of individual soil levels and locations in relief of land
Sum	19.5–120	Source: [6]	Source: [6]

Source: own study based on [6]

The agricultural production space valorization index (WWRPP) was calculated according to the following formula:

$$WWRPP = W_1 + W_2 + W_3 + W_4,$$

where:

W_1 – quality and agricultural suitability of soil indicator,
W_2 – agroclimate indicator,
W_3 – terrain relief indicator,
W_4 – soil water relationships.

The sum of the above-mentioned partial indicators results in the WWRPP (in points).

In the agricultural production space valorization index, the partial index that proves the quality and agricultural suitability of soil has the greatest importance (as much as 18–95 out of the 120 possible points). Therefore, the higher the value of the agricultural production space valorization index, the better the soil and, consequently, the more favorable the farming conditions in agriculture.

The rules for adopting threshold values for the agricultural production space valorization index (WWRPP) are presented in Table 3.

Table 3. Score ranges for individual ranges of agricultural production space valorization index (WWRPP)

Score range of WWRPP agricultural production space index	Farming conditions in agriculture
≤52* points	unfavorable conditions
52.1–66** points	satisfactory conditions
66.1–72.5** points	favorable conditions
>72.5 points	very favorable conditions

* According to IUNG-PIB criteria, which were used to delimit areas with natural constraints or other detailed restrictions (ONW) – area was eligible for ONW lowland zone II when agricultural production space valorization index are available for more than 52 points.

** Related to average value of WWRPP in Poland (which was 66.6 points according to [21]).

Source: own study based on [6, 14]

The soil quality index (WBG) was calculated according to the following formula [14]:

$$WBG = \frac{\sum ha\ conversion}{\sum ha\ physical} = \frac{conversion\ \ factor \cdot ha\ physical}{ha\ physical}.$$

According to Art. 4.1 of Act [17], tax base for agricultural tax is as follows: for agricultural land – number of conversion hectares determined on basis of area, types, and classes of agricultural land resulting from real estate cadastre and inclusion in tax district; for other lands – number of hectares resulting from real estate cadaster.

Table 4 shows conversion factors for agricultural land – arable land and meadows and pastures.

Table 4. Conversion factors for agricultural land – arable land and meadows and pastures

Classes of uses	Conversion factor*							
	arable land				meadows and pastures			
	Taxing districts**							
	I	II	III	IV	I	II	III	IV
	Conversion rates							
I	1.95	1.80	1.65	1.45	1.75	1.60	1.45	1.35
II	1.80	1.65	1.50	1.35	1.45	1.35	1.25	1.10
IIIa	1.65	1.50	1.40	1.25	–	–	–	–
III	–	–	–	–	1.25	1.15	1.05	0.95
IIIb	1.35	1.25	1.15	1.00	–	–	–	–
IVa	1.10	1.00	0.90	0.80	-	-	-	-
IV	–	–	–	–	0.75	0.70	0.60	0.55
IVb	0.80	0.75	0.65	0.60	–	–	–	–
V	0.35	0.30	0.25	0.20	0.20	0.20	0.15	0.15
VI	0.20	0.15	0.10	0.05	0.15	0.15	0.10	0.05

Source: * Act [17], ** based on Regulation [18]

According to Art. 4.6 of Act [17] orchards converted into conversion hectares according to conversion rates for arable land; however, for Class III and IV orchards, conversion rates for Class IIIa and IVa apply, respectively.

According to Art. 4.7 of Act [17] land under ponds, covered with trees and shrubs on agricultural land, under ditches, and agriculturally developed is converted into conversion hectares regardless of whether it is included in tax district according to following conversion factors:

- 1 ha of land under ponds that are stocked with salmon, sea trout, huchen, lake trout, and trout as well as developed agricultural land – 1 conversion ha;
- 1 ha of land under ponds that are stocked with other fish species, under ponds not stocked with fish, covered with trees and shrubs on agricultural land, and under ditches – 0.20 conversion ha.

If agricultural land area conversion factor cannot be determined on basis of above-mentioned rules, according to Art. 4.9 of Act [17] it is assumed that 1 physical ha corresponds to 1 computational ha.

As written in [14], the forest cover index was calculated according to the following formula:

$$WL = \frac{forest\ area\,[\text{ha}]}{total\ area\,[\text{ha}]} \cdot 100\% .$$

Analysis of the selected indicators was carried out for municipalities that are located in Poland's Masovian Voivodeship. Masovian Voivodeship is located in the central-eastern part of Poland; it is divided into 37 districts, 5 cities with district rights, and 314 municipalities.

The administrative division of Masovian Voivodeship is presented in Figure 1.

Due to the readability of the resulting maps, the names of the districts and municipalities were not included.

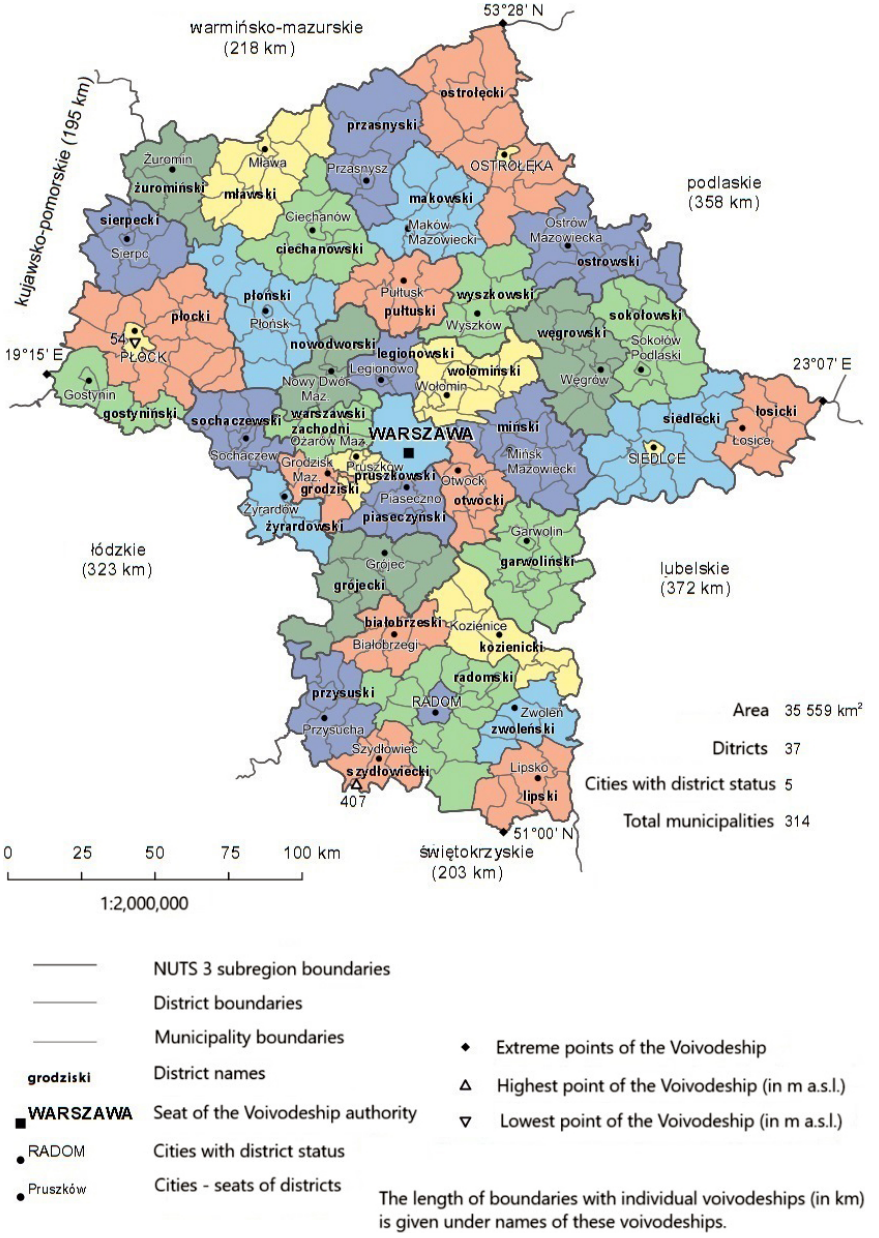

Fig. 1. Administrative division of Masovian Voivodeship according to data from 2022

Source: [22] – excluding outdated information

3. Analysis of Selected Indicators

The first of the analyzed indicators is the agricultural production space valorization index (WWRPP); these values could be found in the text *Waloryzacja rolniczej przestrzeni produkcyjnej Polski według gmin* [15]. The value of the WWRPP index that was included in this study was compared with the values that were included in the summary [16]. For some of the municipalities, the indicator values were not consistent; there were differences. Ultimately, the data that was contained in the study [15] was accepted as a reliable source for further analyses with the exception of the following municipalities: Młynarze, Szulborze Wielkie, Joniec, and Domanice (for which no WWRPP index values could be found in the study). After analyzing the reasons for the lack of this data, the WWRPP index values were adopted for these municipalities according to the summary [16].

In Figure 2 the distribution of the above information is presented in the designated ranges in the municipalities of Masovian Voivodeship.

The obtained results showed that the greatest number (i.e., 131 municipalities – 47%) had average qualities and potentials of their agricultural production spaces (WWRPP levels within a range of 52.1–66 points). Another 79 municipalities (28.3%) had low qualities and potentials of their agricultural production spaces and, therefore, unfavorable farming conditions (WWRPP levels ≤52 points). The remaining 38 municipalities (13.6%) had good qualities and potentials (WWRPP levels within a range of 66.1–72.5 points). The smallest number of municipalities (i.e., 31–11.1%), had very good potentials for their agricultural production spaces and, thus, very favorable farming conditions (WWRPP levels >72.5 points). The higher the value of the indicator, the more favorable the farming conditions were in the area's agriculture.

It can be observed that a low quality of the potential of agricultural production spaces concern, among others, all of the municipalities that are located in the Wołomin and Legionowo districts.

The lowest value of the agricultural production space index was 37 points for the Łyse municipality (in the Ostrołęka district), while the highest value was 91.4 points for the Ożarów Mazowiecki municipality (in the Western Warsaw district). The calculated average value for the voivodeship was 58.6 points.

As M. Zieliński, A. Łopatka, and P. Koza wrote [23], the highest WWRPP indicator in Poland was achieved by the Żórawina municipality (located in the Lower Silesian Voivodeship); i.e., 108.3 points, which was 11.7 points below the highest-achievable WWRPP value.

The largest number of assessed municipalities that achieved agricultural production space valorization indexes that feel within the range of favorable and very favorable conditions were located in municipalities from the following districts: Ciechanów, Płock, Grójec, Lipsk, Sokołów, Łosice, and (partly) Western Warsaw. The lowest values of the valorization index occurred in the zone from Warsaw to the north and northwest (including municipalities in the Wołomin, Legionowo, and

Ostrołęka districts). This result was mainly related to the quality and agricultural suitability of soil index (i.e., the WWRPP partial indicator), which held the greatest weight in the synthetic indicator.

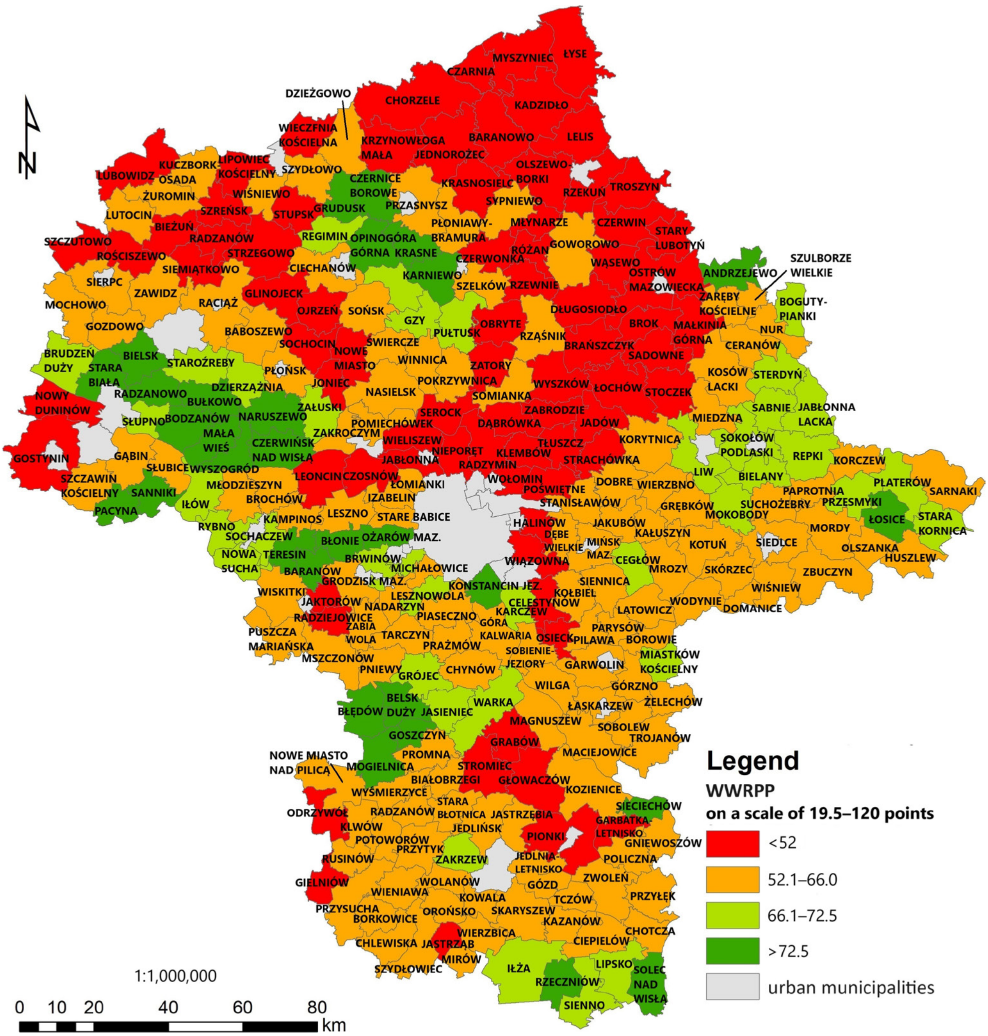

Fig. 2. Agricultural production space valorization index (WWRPP) levels in municipalities of Masovian Voivodeship – results

Source: own study based on data that was contained in [15, 16]

Hence, the distribution of the values of the quality and agricultural suitability of soil index in the designated ranges in the municipalities of Masovian Voivodeship is shown in Figure 3.

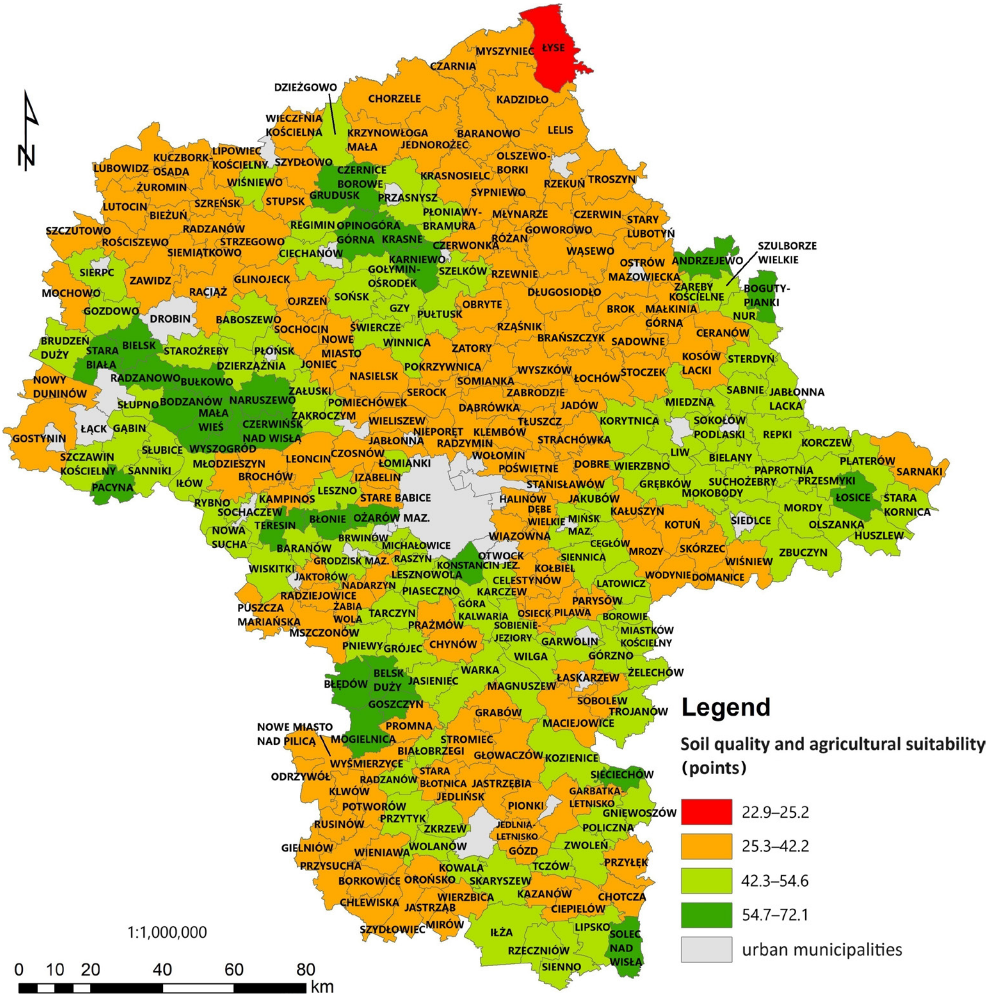

Fig. 3. Quality and agricultural suitability of soil index levels in municipalities of Masovian Voivodeship

Source: own study based on data that was contained in [15, 16]

The largest number of assessed municipalities that achieved agricultural quality and suitability indexes that fell within the ranges of 54.7–72.1 and 42.3–54.6 were located in municipalities from the following districts: Ciechanów, Płock, Grójec, Lipsk, Sokołów, Łosice, and (partly) Western Warsaw. As Figure 3 shows, the lowest values of the quality and suitability index occurred in the zone from Warsaw to the north and northwest (including municipalities in the Wołomin, Żuromin, Wyszków, Legionowo, and Ostrołęka districts).

The lowest value of the agricultural quality and suitability index was 22.9 points for the Łyse municipality (in the Ostrołęka district), while the highest value of the indicator was 91.4 points for the Ożarów Mazowiecki municipality (in the Western Warsaw district). The calculated average value for the voivodeship was 72.1 points.

Figure 4 presents complexes of the agricultural soil suitability and agroecological conditions in Masovian Voivodeship.

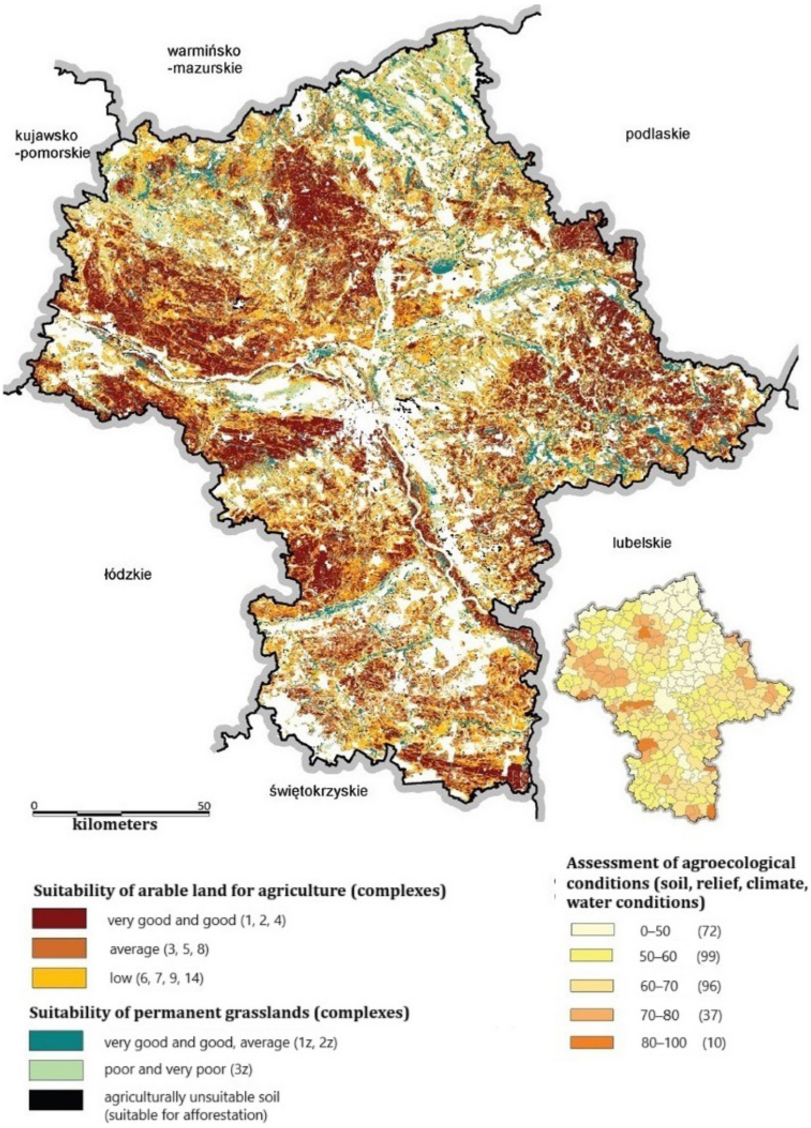

Fig. 4. Complexes of agricultural suitability of soils; agroecological conditions in Masovian Voivodeship

Source: study by Masovian Regional Planning Office based on data from Masovian Spatial Information System and Institute of Soil Science and Plant Cultivation in Puławy, which were included in [24] (own study – translated into English)

When comparing the obtained results with Figure 3, which shows the partial index of soil quality and agricultural suitability, and from Figure 4, which illustrates the complexes (i.e., the suitability of arable lands for agriculture), there was a clear relationship in those parts of the voivodeship where the soils with the highest suitability for agriculture were concentrated (agricultural quality and suitability index at levels within a range of 54.7–72.1 [dark-green color in Figure 3]; very good and good soils [dark-brown and brown colors in Figure 4]).

The second analyzed indicator was the soil quality index (WBG).

Figure 5 presents the distribution of the soil quality indexes in the designated ranges in the municipalities of Masovian Voivodeship.

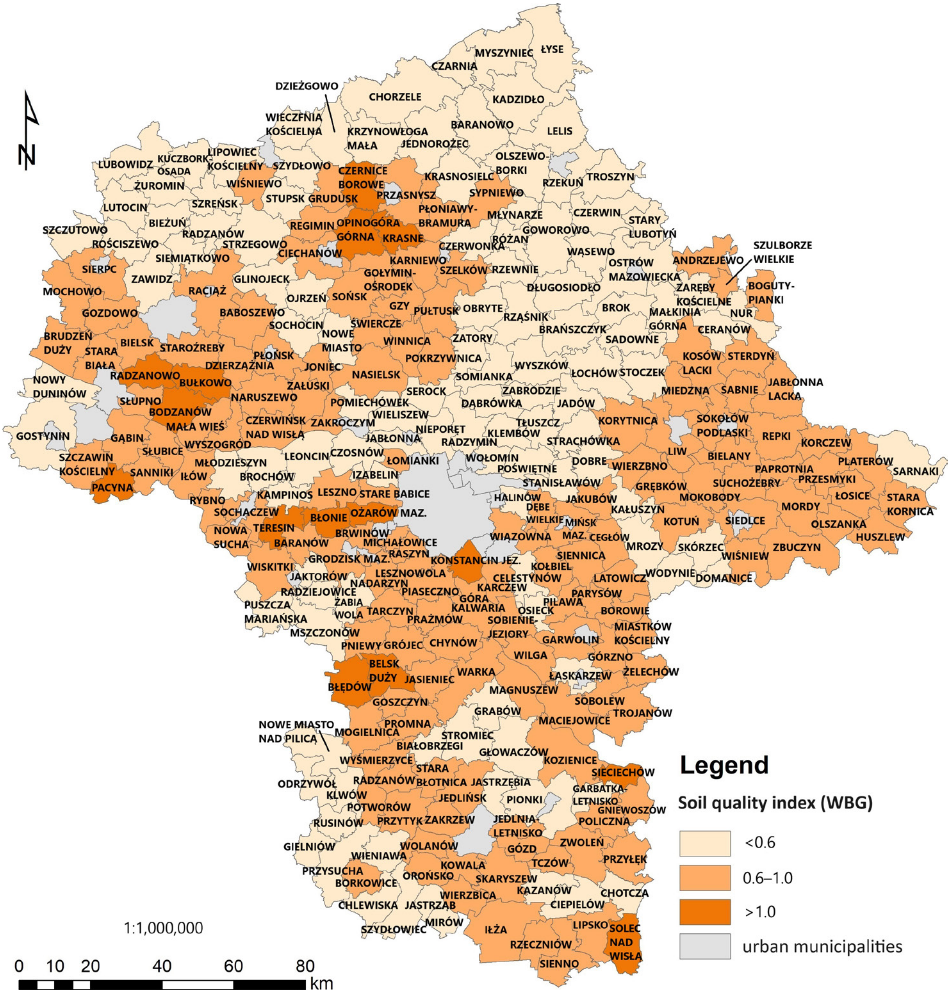

Fig. 5. Soil quality index levels in municipalities of Masovian Voivodeship

Source: own study based on [17–19], among others

Taking the obtained results into account, the greatest number (i.e., 135 municipalities – 48.4%) had mostly medium-quality soils; so, their agricultural conditions were average (WBG levels within a range of 0.60–1.00). A comparable number (129 municipalities – 46.2%) had mostly poor-quality soils (WBG levels <0.60), therefore, their farming conditions were unfavorable. The smallest number (i.e., only 15 municipalities – 5.4%) had mostly good and very good soil qualities (WBG levels >1.00); therefore, favorable conditions for the development of agriculture.

It could be observed that poor-quality soils (WBG levels <0.60) occurred in all of the municipalities that were located in the Legionowo, Ostrołęka, Szydłowiec, Wołomin, Wyszków, and Żuromin districts and most of the municipalities that were located in the Mława, Nowy Dwór, Przysucha, and Żyrardów districts.

The lowest values of the soil quality index were 0.12 (for the Czarnia municipality – Ostrołęka district) and 0.15 (for the Łyse and Myszyniec municipalities – Ostrołęka district). The highest value of the indicator was 1.45 for the Ożarów Mazowiecki municipality – Western Warsaw district. The calculated average value was 0.64.

The third analyzed indicator was the forest cover index. Data from the Local Data Bank of the Central Statistical Office (GUS) [19] from 2020 was used for the calculations.

Figure 6 presents the distribution of the forest cover index values in the designated ranges in the municipalities of Masovian Voivodeship.

As shown by the results that were obtained in 215 municipalities (77.1%), the forest cover rate was below 30%; so, the farming conditions in the agriculture as related to the presence of forests were favorable. It could be observed that this applied to all of the municipalities that were located in the districts of Grodzisk, Grójec, Lipsk, Piaseczno, Pruszków, Płońsk, Sierpc, and Zwoleń (among others).

In the remaining 64 municipalities (22.9%), the forest cover rate was ≥30%; this was an indication that the farming conditions could be difficult and unfavorable.

The lowest forest cover index (0.2%) concerned the Baranów municipality (in the Grodzisk district) and the Błonie municipality (in the Western Warsaw district), while the highest rate (75.7%) concerned the Izabelin municipality (in the Western Warsaw district). The average forest cover rate for the assessed municipalities was 22.2%.

The large forest cover in some of the municipalities resulted from the presence of Kampinoski National Park as well as 189 nature reserves in Masovian Voivodeship (based on [25]).

The fourth indicator that was analyzed was the number of tractors per 100 ha of agricultural land. The value of this indicator was adopted according to data from the Central Statistical Office (GUS) from the 2010 General Agricultural Census. This was made available in the Local Data Bank of the Central Statistical Office [19] due to the lack of current data from the 2020 General Agricultural Census at the analyzed level of detail.

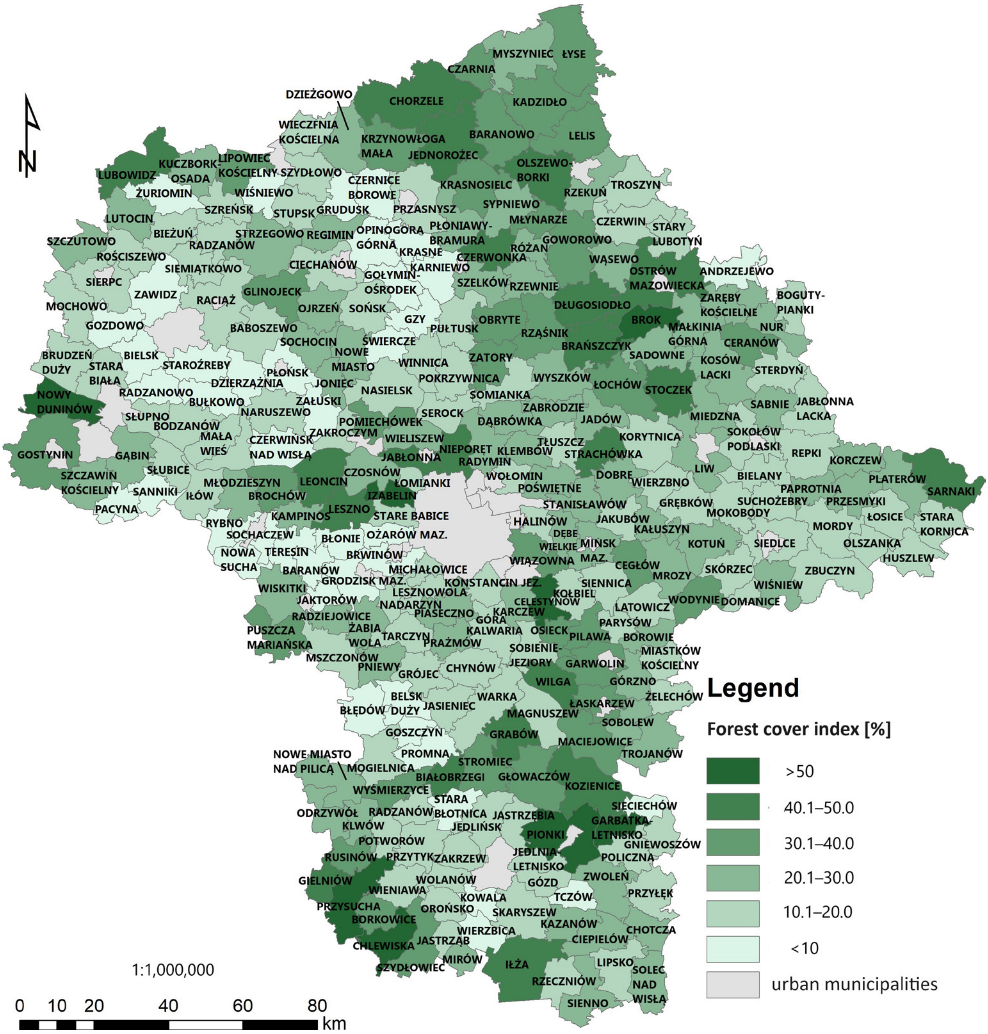

Fig. 6. Forest cover index levels in municipalities of Masovian Voivodeship – results

Source: own study based on [19]

Figure 7 presents the distribution of the values of the indicator that represented the number of tractors per 100 ha of agricultural land in the designated ranges in the municipalities of Masovian Voivodeship.

The obtained results indicated that in only one municipality (0.4%) was the number of tractors per 100 ha of agricultural land within the lowest range (<6 pieces); this applied to the Jabłonna municipality (in the Legionowski district), where the number of tractors per 100 ha of agricultural land was 0.4 pieces. In 180 municipalities (64.5%), the numbers of tractors per 100 ha of agricultural land were at average levels (within a range of 6–12 pieces); this mainly applied to those municipalities that were located in the central, northern, northwestern and northeastern parts of the voivodeship. In 98 municipalities (35.1%), the analyzed number was above average (>12 pieces); this mainly applied to those municipalities that were located south of Warsaw and in the southern part of the voivodeship. The greatest number of tractors per 100 ha of agricultural land could be found in the Raszyn municipality (in the Pruszków district) – 24.6 pieces. The average number of analyzed tractors was 11.5 pieces.

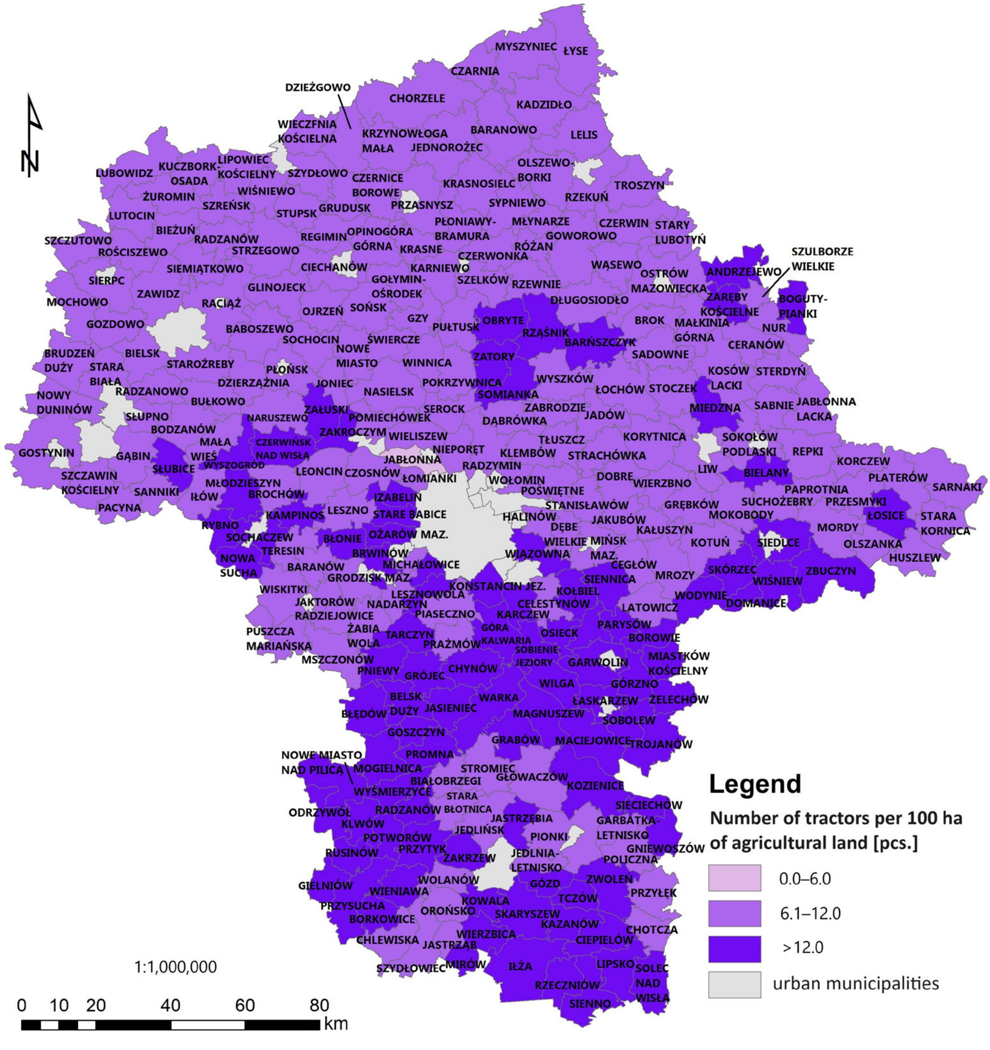

Fig. 7. Number of tractors per 100 ha of agricultural land in municipalities of Masovian Voivodeship – results

Source: own study based on [19]

The fifth indicator that was analyzed was the number of farm animals in large heads index (PL) per 100 ha of agricultural land. The value of this indicator was adopted according to data from the 2010 General Agricultural Census, which was made available in the Local Data Bank of the Central Statistical Office [19] due to the lack of current data from the 2020 General Agricultural Census at the analyzed level of detail.

Figure 8 presents the distribution of the values of the numbers of farm animals in large heads index (PL) per 100 ha of agricultural land.

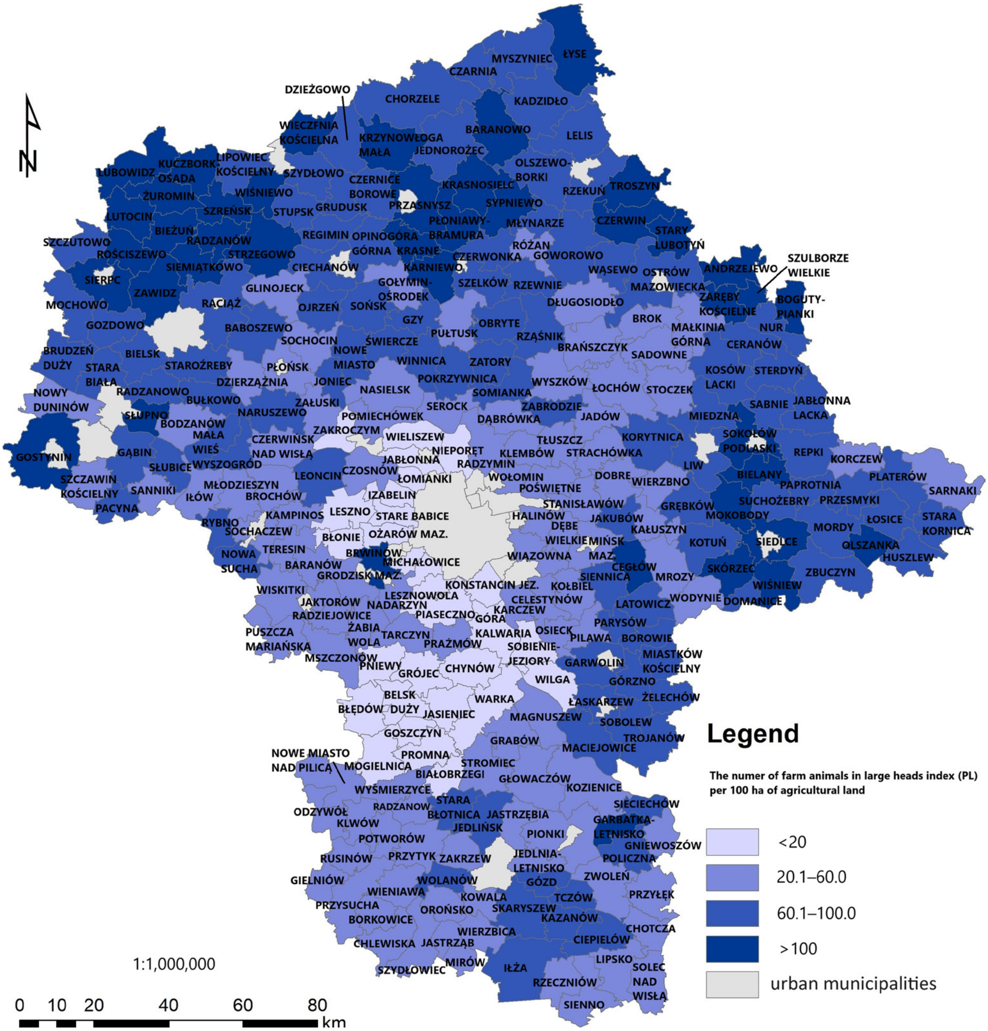

Fig. 8. Number of farm animals in large heads index (PL) per 100 ha of agricultural land in municipalities of Masovian Voivodeship – results

Source: own study based on data from [19]

As the presented analysis showed, the numbers of farm animals in large heads index (PL) per 100 ha of agricultural land were very low (below 20 animals) in the smallest number of municipalities; i.e., 29 (10.4%); this mainly concerned municipalities that were located west and south of the central part of the voivodeship (Warsaw).

In the cases of 42 municipalities (15.1%), the examined populations exceeded 100 animals; this mainly applied to municipalities that were located in the north and west parts of the voivodeship. The remaining two ranges included 104 municipalities (37.3%).

It could be observed that the examined value of the indicator increased with distance from the central part of the voivodeship; this was related to the presence of urban areas in this part.

The smallest number of farm animals in large heads index (PL) per 100 ha of agricultural land was 0.9 animals (in the Belsk Duży municipality – Grójec district), while the greatest value of the examined indicator was 554.5 items (in the Bieżuń municipality – Żuromin district). The average population for all of the assessed municipalities was 69.8 animals.

The sixth of the analyzed indicators was the share of the agricultural land of farms with land in ten or more plots in their total areas.

Figure 9 presents the distribution of the value of the indicator – the share of the agricultural land of farms with land in ten or more plots in their total areas.

As the analysis that was carried out showed, the share of the agricultural land of farms with land in ten or more plots in their total areas was at an average level (shares within a range of 20–40%) in the greatest number of municipalities; i.e. 157 (56.3%). In 52 municipalities (18.6%), this share was lower than 20%; in the cases of 70 municipalities (representing 25.1%), this share exceeded 40%.

The smallest share of the agricultural land of farms with land in ten or more plots in their total areas (amounting to 0.6%) concerned the Izabelin municipality (in the Western Warsaw district), while the greatest amount (66.4%) concerned the Ceranów municipality (in the Sokołów district).

A very large land pattern could be observed in most of the Sokołów, Żuromin, and Mława districts (among others).

The obtained research results showed the distribution of values the most important indicators allowing for the assessment of the faming conditions in agriculture. These indicators are:

- agricultural production space valorization index (WWRPP),
- soil valuation index (WBG),
- forest cover index,
- number of tractors per 100 ha of agricultural land,
- number of farm animals in large head index (PL) per 100 ha of agricultural land,
- share of agricultural land of farms owning land in ten or more plots in their total area.

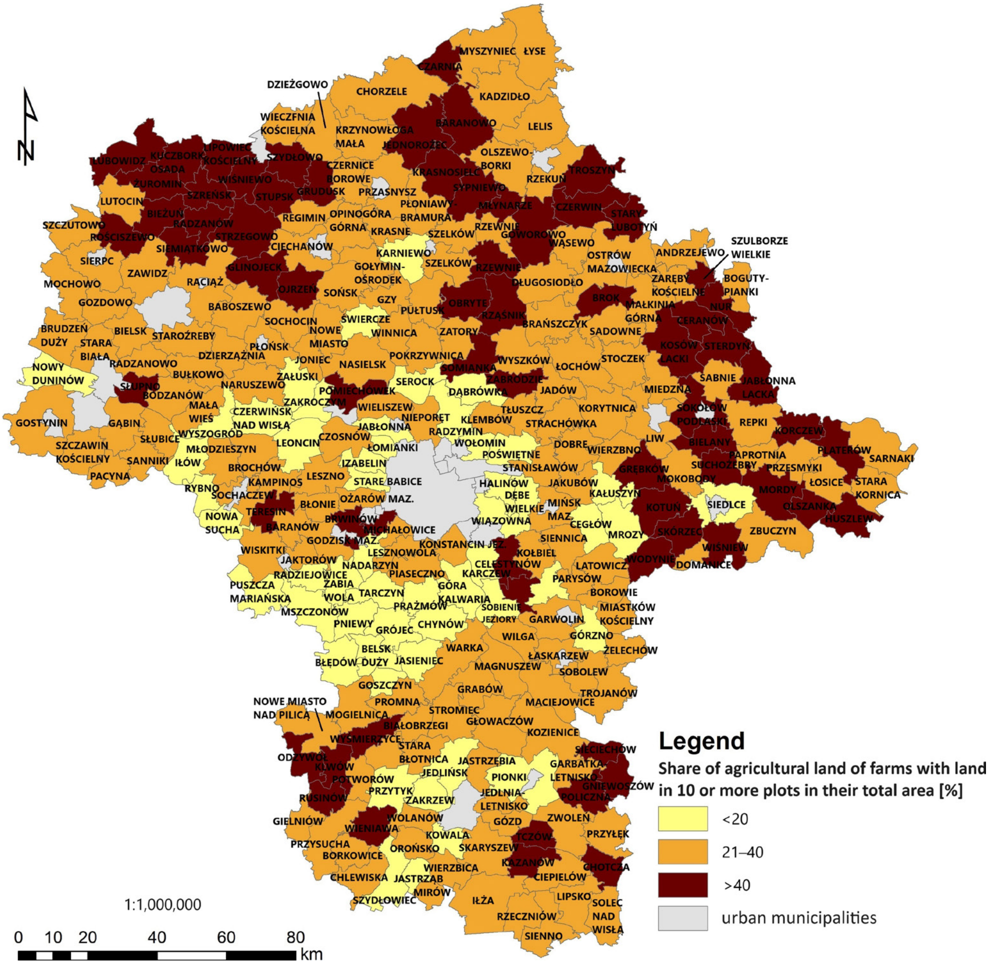

Fig. 9. Share of agricultural land of farms with land in ten or more plots in their total areas in municipalities of Masovian Voivodeship – results

Source: own study based on [20] – additional data from B. Głębocki

4. Conclusions and Final Remarks

The obtained research results showed in which municipalities were there barriers to the development of agriculture – in these municipalities, there were large forest covers, the soils were of poor quality, the levels of mechanization were low, and there were high fragmentations of land. The identified strengths and weaknesses in terms of farming conditions in agriculture can be used, for example, by local authorities.

In those areas that are used for agriculture where the soil is of poor quality, actions should be taken to improve their quality or water conditions.

In those areas where the levels of mechanization are low, actions should be taken to support farmers in the development of their farms so that their levels of mechanization are at appropriate levels to ensure production efficiency.

In those areas where there are large fragmentations of plots on farms, the scope of the analysis should be expanded in order to consider the possibility of land consolidation; this would significantly improve farming conditions.

A major difficulty in carrying out these analyses was the availability of data. Shared data from the last General Agricultural Census of 2020 often concerned entire voivodeships, not municipalities (as was the case in 2010).

The most complex of the analyzed indicators was the agricultural production space valorization index (WWRPP), which consisted of the following factors: quality and agricultural suitability of soil, agroclimate, landform, and soil water relationships. According to the author as well as the authors of other publications, the above-mentioned partial factors should be considered together in order to assess the farming conditions in agriculture due to the relationships between them. Hence, this was the most important indicator among those that were analyzed.

The second-most-complex indicator was the soil quality index (WBG); this took the economic, production, and climatic conditions of the municipalities into account. The WBG determines the quality of agricultural lands and is the basis for assessing agricultural taxes.

The remaining analyzed indicators were not so complex; they each describe one specific factor that influences the assessment of farming conditions in agriculture. However, they are also significant.

There are many factors that influence farming conditions in agriculture; these are natural, production, spatial, and other factors. The set of indicators that were proposed by the author are, in the author's opinion, crucial in assessing farming conditions. The selected set of indicators is an open set and can be expanded with further indicators.

When selecting the appropriate methodology, the analyzed indicators can be used in a synthetic approach toward assessing the farming conditions in agriculture in individual municipalities as well as assessing agricultural production spaces. It is recommended to use the methodology that was proposed in [14].

The assessment of the farming conditions in agriculture in municipalities allows for the identification of municipalities where the agricultural conditions are difficult, which will prompt further decisions to be made about the possibility of agricultural development or setting new directions for the developments of these areas. It would be necessary to verify whether agriculture is profitable in these areas.

Regardless of the chosen method, the disadvantage of the used method is the analysis of data at the municipality level; this should concern smaller areas (e.g., registration districts) so that the locations of areas with unfavorable farming conditions could be better determined. Unfortunately, this is currently not possible due to the lack of data that is aggregated to the level of registration districts.

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Declaration of Competing Interest

The author declares that she has no known competing financial interests or personal relationships that could have appeared to influence the work that is reported in this paper.

Data Availability

According to Table 1, the data either were publicly accessible or came directly from the Author of the indicated publication (these data cannot be shared without the Author's consent).

Use of Generative AI and AI-assisted Technologies

No generative AI or AI-assisted technologies were employed in the preparation of this manuscript.

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