# The use of the concept of Smart Villages in the multifunctional development of rural areas on the example of the Mazowieckie Voivodeship

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**Key words**: smart villages, rural areas, multifunctional development, development transformations

## SUMMARY

The concept of Smart Villages does not offer a single solution but allows to build on the potential of each territory, its unique cultural environment and needs and desires of local community. Ideally, it is also the community, in cooperation with the local authorities, that drives changes in the local area with the aim to preserve the viability of the area and to improve the quality of life. The Smart Villages concept also implies that rural development should be stimulated by unique local characteristics and economic opportunities with view to diversifying incomes of rural holdings.

Rural areas in Poland are highly diversified in terms of their spatial structure. The intensive social and economic changes in rural areas in the recent years have underpinned the necessity of spatial restructuring to meet the challenges of the present.

The aim of the study is to diagnose the main problems which result in spatial conflicts and to offer the possibility of mitigating them with the use of innovative digital technologies and public participation, in line with the Smart Village concept. The research conducted in Mazowieckie region has identified areas where dedicated measures are needed to adapt rural space to rural development. The underlying assumption of the study is that the key barrier to multifunctional development of rural areas is the spatial structure of land plots and holdings which is not adapted to the present needs, technologies and potential land use.

The adopted research methodology has allowed to identify municipalities in most urgent need of change, including those where agricultural holdings should transition to intensive farming, as well as those likely to undergo a change from farming to residential or other land use, which requires the spatial structure to be adapted to present needs. Identification and evaluation of the areas in the region that require land-use transformation and the areas which are not in such need of spatial restructuring have helped define thematic software applications that should be dedicated to different areas of the region to foster their optimal growth.

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## 1. INTRODUCTION

Currently, the development of rural areas is associated with two trends - globalization and the need to maintain the diversity of regions. This rural and agricultural development should become the so-called sustainable development defined in the Brundtland Commission report (Rigby et al., 2000). A modification of this definition is also cited in the Polish strategy for sustainable development of Poland until 2025 (Strategy, 1999).
Sustainable development is defined as the right to satisfy the development aspirations of the present generations without restricting the rights of future generations to meet their development needs. This definition implies that, for the benefit of future generations, economic and civilization development should not occur at the expense of exhausting non-renewable resources and destroying the environment. The working definition of FAO defines as sustainable development, the management of natural resources, their protection, and such direction of technological and institutional changes to ensure that the needs of people are met now and in the future (Lutteken & Hagedorn, 1999).
In agriculture, sustainable development is characterized by protecting land, water, plant, and animal genetic resources, the absence of environmental degradation, technical correctness, economic sustainability, and social acceptance. Sustainable agriculture is the management of the agricultural ecosystem to ensure its biological diversity, productivity, regeneration capacity, viability, and functioning. Such control will ensure the fulfillment of current and future ecological, economic and social functions at the local, national and global levels, excluding negative impacts on other ecosystems (Lewandowski et al., 1999).
To evaluate the economic strategy, indicators have started to be used as measurable parameters or qualitative assessments (Lewandowski et al., 1999). In assessing the balance of agricultural development, it is proposed to use mainly quantitative indicators (Andreoli & Tellarini, 2000; Fotyma & Kuś, 2000; Rigby et al., 2000; Steiner et al., 2000; OECD, 2001).
The multifunctional nature of agriculture, emphasizing its non-market function, was indicted in the 1992 Rio Convention on environmental protection as part of the sustainable development concept. Formally, the term was used in Agenda 21 relating to environmental issues and has since been used in various programming documents related to agricultural policy.
In the agricultural legislation of the European Union, the genesis of multifunctional agriculture can be found in Council Directive 75/268/EEC of 28 April 1975 (Directive, 1975), relating to mountain and hill farming and farming in certain less-favored areas. The document indicates the need to transfer subsidies to regions where agriculture is uncompetitive but plays an essential role in maintaining the balance of regional development. A similar position was found in the European Commission document from 1988 on the future of rural areas. This document contains an analysis of the multifunctionality of rural areas and a diagnosis of development problems and emphasizes the need for economic and social changes in the countryside.

Attention is drawn to the multitude of functions performed by agriculture that go beyond the traditional functions of food production, including the role of agriculture in the protection and conservation of the natural environment and the special features of rural areas that enable the diversification of economic activities in the context of environmental responsibility.

The 1996 Cork Declaration, an important program laying the foundations for reforming the standard agricultural policy, used the term multifunctionality for the first time as an official position of the European Commission. Multifunctionality is related to various functions of individual forms of activity resulting from this activity (Duczkowska - Małysz, 2001; Wilkowski, 2004; Kłodziński, 2004). Thus, multiple forms of agricultural and non-agricultural activity can be the source of various functions that satisfy social needs. Multifunctionality can derive from goods produced as a result of various activities, subsistence farming activities, or the impacts of the agricultural sector. Multifunctionality must also be associated with the development of education, infrastructure, entrepreneurship, social capital, and various institutions.

The concept of smart villages (SV) has emerged to address the need to implement the EUROPE 2020 agenda in rural development policy. The idea's implementation should be in line with the objectives and recommendations of Cork 2.0 (2016). The declaration addresses the expectations and aspirations of rural areas and indicates policy directions to use their potential. As part of the SV concept, it is possible to distinguish areas of activity in three main areas of intelligent solutions (Intelligent Village, 2019):

- ✓ public services, i.e., e-health, e-care, remote education, transport (e.g., telebuses), energy (e.g., RES), as well as security (e.g., video surveillance);
- ✓ public management, i.e., e-administration, waste management (e.g., container filling sensors), spatial planning (e.g., digitization), as well as environmental monitoring (e.g., air quality sensors),
- ✓ entrepreneurship, i.e., precision farming, online trading (e.g., local products), rural tourism (based on intelligent solutions), as well as sharing (e.g., specialized equipment).

As part of an extensive literature review of the publications from 2010 to 2021, Gerli et al. (2022) identified five components characterizing SV, i.e., technology, human capital, physical resources, services, and governance. Examples of their use depend primarily on the local economic, social, and natural conditions.

Within technology, broadband (Dobrota et al., 2020; Doyle et al., 2021) and information and communication technologies (ICT) (Zhang & Zhang, 2020; Ram et al., 2021) are indicated as the primary condition for the development of SV, and at a more advanced level, the use of technology, e.g., for climate-friendly agriculture (Adesipo et al., 2020; Aggarwal et al., 2018).

The use and development of technologies largely depend on their users. The human capital, including education, knowledge transfer, activation of attitudes, and the role of local leaders, is the key to achieving the goals of the SV (Komorowski, 2022). A measurable effect of combining the technology and human capital component may be using public participation as a tool for socio-spatial rural planning projects (Ogryzek et al., 2021).

Smart Villages are based on physical resources such as land, including the spatial structure of rural areas (Bielska et al., 2021), water (Adamowicz & Zwolińska-Ligaj, 2020), and infrastructures (Torre et al., 2020).

The context of services is considered differently depending on the initiatives taken. The main trends are public services, e.g., e-healt (Taibah et al., 2022, Philip & Williams, 2019) and education - especially in developing countries (Dharane & Gururaj Malge, 2018; Aziiza & Susanto, 2020). In the private dimension, innovative services combine information technologies with social entrepreneurship, e.g., e-tourism and services in intelligent agricultural technologies (Ballina, 2020; Adesipo et al., 2020).
In terms of management, the role of international and national institutions in the context of agricultural policy (strategies guiding the implementation of the SV) and regional and local governments in taking up and supporting executive projects is emphasized (Wolski, 2019). Above all, however, the participation of society in initiated and coordinated grassroots initiatives is highlighted, which best recognize the needs of a given community and place (Davidenko et al., 2018).
Rural areas in Poland are highly diversified in terms of their spatial structure. The intensive social and economic changes in rural areas in recent years have underpinned the necessity of spatial restructuring to meet the challenges of the present.
The aim of the study is to diagnose the main problems which result in spatial conflicts and to offer the possibility of mitigating them with the use of innovative digital technologies and public participation, in line with the Smart Village concept. The research conducted in the Mazowieckie region has identified areas where dedicated measures are needed to adapt rural space to rural development. The study's underlying assumption is that the key barrier to multifunctional development of rural areas is the spatial structure of land plots and holdings that is not adapted to the present needs, technologies, and potential land use.

## 2. MATERIALS AND METHODS

The research objective is to assess the spatial structure of rural areas in terms of the need for comprehensive changes and transformation of land development. The spatial structure of the registration plots was considered, especially their area, width, extension, and number on the farm. It was found that these parameters significantly affect the development possibilities of the areas. Moreover, they should change (transform) in the event of a change in the function and manner of use.
The research was carried out based on the following methods:

- ✓ literature review - analysis of the possibilities of multifunctional, sustainable development of rural areas using modern technologies as part of the Smart Villages idea.
- ✓ spatial and multi-criteria analyzes - (i) spatial analyzes were performed in the ArcGiS program; the shape of the plots was assessed, and the elongation of plots was calculated; the Minimum Bounding Geometry (Data Management Tools-Features) tool was used to calculate the width and length of the cadastral plots - (ii) multi-criteria analyzes were used to determine the rank of individual criteria and to determine the scoring of areas requiring transformation and transformation.

A simplified approach was used in the research methodology, assessing the selected criteria with two levels (0-1). The adopted, simplified scoring was aimed at identifying the features having a positive or negative impact on the development opportunities of rural areas. When determining the size of parameters and points, expert knowledge, the results of literature

research, the analysis of the preliminary results of the General Agricultural Census of 2020, and the spatial features of the research area were used.
Used selected spatial parameters of farms and registration plots in the author's assessment of the transformation needs and complete changes in land development. On this basis, the transformation index "T" was calculated. Made the assessment based on the following simplified criteria:

1. Spatial structure of farms (F):
a. Average area of a farm above 1 ha in a commune (Fa)
b. Number of plots on the farm (Fn)
2. The shape of the small records (S):
a. Plot width (Sw)
b. Parcel extension (Se)

The criteria concerning the spatial structure of farms and the shape of plots were considered important from the point of view of comprehensive transformations (mainly spatial structure and ownership structure) due to land consolidation processes or real estate consolidation and division.
The F and S criteria were assigned ranks of 40% and 60%, respectively, considering the shape of the plot (S) as a factor of greater importance in determining the transformation needs. The ranks were adopted according to the formula:

$$T = (F * 40\%) + (S * 60\%) \quad (1)$$

where:

$$F = (Fa * 40\%) + (Fn * 60\%) \quad (2)$$
$$S = (Sw * 60\%) + (Se * 40\%) \quad (3)$$

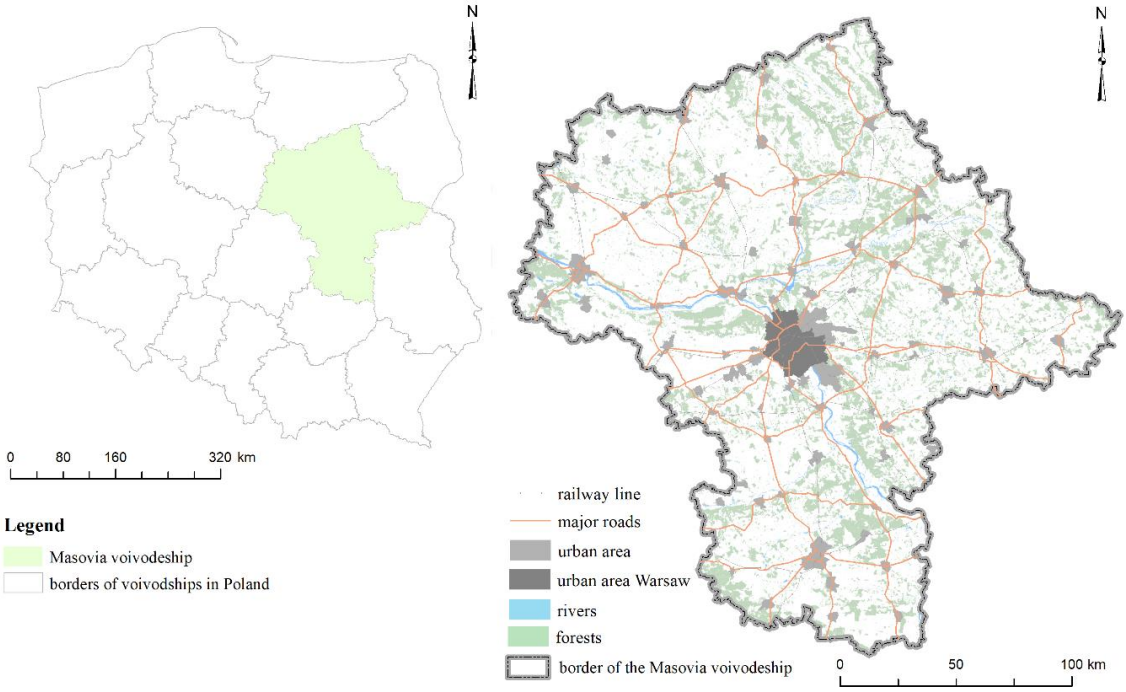
The following materials were used in the study:

a) Cadastre - data on the number of registration plots, the area of cadastral precincts in the voivodship (source: district collective statements from 2021);
b) Database of land and building records - vector layer of the plot (source: Poviat Geodetic and Cartographic Documentation Centers and https://www.geoportal.gov.pl/rejestry);
c) State Register of Borders (source: http://www.gugik.gov.pl/pzgik/dane-bez-oplat/dane-z-panstwowego-reresses-granic-i-powierzchni-jednostek-podzialow-terytorialnych-kraju-prg);
d) d) Statistical data from Central Statistical Office of Poland (2010; 2020) (source: Local Data Bank).

## 3. STUDY AREA

The research was carried out in the Mazowieckie Voivodeship, located in the central-eastern part of Poland. The analysis covers only rural communes that face problems other than urban areas. Rural areas are very diverse here. They are regions located near cities, including Warsaw, the capital of Poland, and peripheral areas, which differ significantly in terms of environmental, spatial, and economic conditions (Fig. 1).

Fig. 1. Location of the study area.




Source: Own study based on the Database of Topographic Objects and the State Register of Borders.

Mazowieckie voivodship is the largest voivodeship of Poland, both in terms of area (35.6 thousand km2), accounting for 11.4% of the country's area, and in terms of population (5.4 million inhabitants), accounting for 14.1% of the country's population. It is a region with the highest economic potential and gross domestic product. In 2018 it amounted to PLN 478 billion, i.e., 22.5% of its GDP (Central Statistical Office of Poland, 2020).
A characteristic feature of the Mazowieckie Voivodeship is the spatial differentiation of economic development between the metropolitan center of the region and its mainly agricultural periphery. According to the OECD classification, Mazovia was considered the most internally diversified region in Europe, second only to London. The voivodship has 105 out of 500 poorest communes in Poland. The region is, therefore, extremely diverse.
The Mazowieckie Voivodeship ranks first both in terms of the area of rural areas (94% of the voivodship's area) and the population living there (1.9 million people, constituting 35.5% of the total population of the region). The people living in the countryside in the Mazowieckie Voivodeship constitute 12.6% of the rural population in Poland.
Agricultural land constitutes 68.7% of the area of Mazowieckie voivodship. However, the area of agricultural land is decreasing, and the rate of decline is accelerating. This process is relatedto land allocation for non-agricultural purposes, including housing development (Sulmicka, 2013).

## 4. RESULTS

The adopted research methodology assumes taking into account the characteristics of the research area. Thus, the adopted parameters reflected the spatial conditions of the Mazowieckie Voivodeship.

Criterion I - Spatial structure of agricultural holdings (F):

The research included farms with an area of more than 1 ha. It was assumed that the greatest demand for the transformation of the spatial structure would be in areas with an average area of farms below 15 ha. For these areas, it will be advisable to apply the land consolidation procedure (for farms) or the consolidation and division of real estate (for land intended for development). Due to the small area, these farms do not achieve an adequate income. The most extreme changes in land development are likely to take place in these areas. Some farm owners will want to enlarge the area of their farms in order to stay on the market. Other owners will seek to diversify their income, which may result in new forms of development. Taking into account the number of registration plots on the farm, it was assumed that farms with more than 10 plots are less profitable. The number of plots has a negative impact on the possibility of their use and reduces the income (Decko et al., 2019).

Criterion II - The shape of the record books (S):

The second criterion was the shape of the registration plots. When analyzing the spatial parameters of plots in the Mazowieckie Voivodeship, it was assumed that plots with a width of fewer than 20 m and an elongation of more than 1: 10 have an unfavorable shape.

Table 1 presents the parameters of farms and registration plots along with their score on a 0-1 point scale.

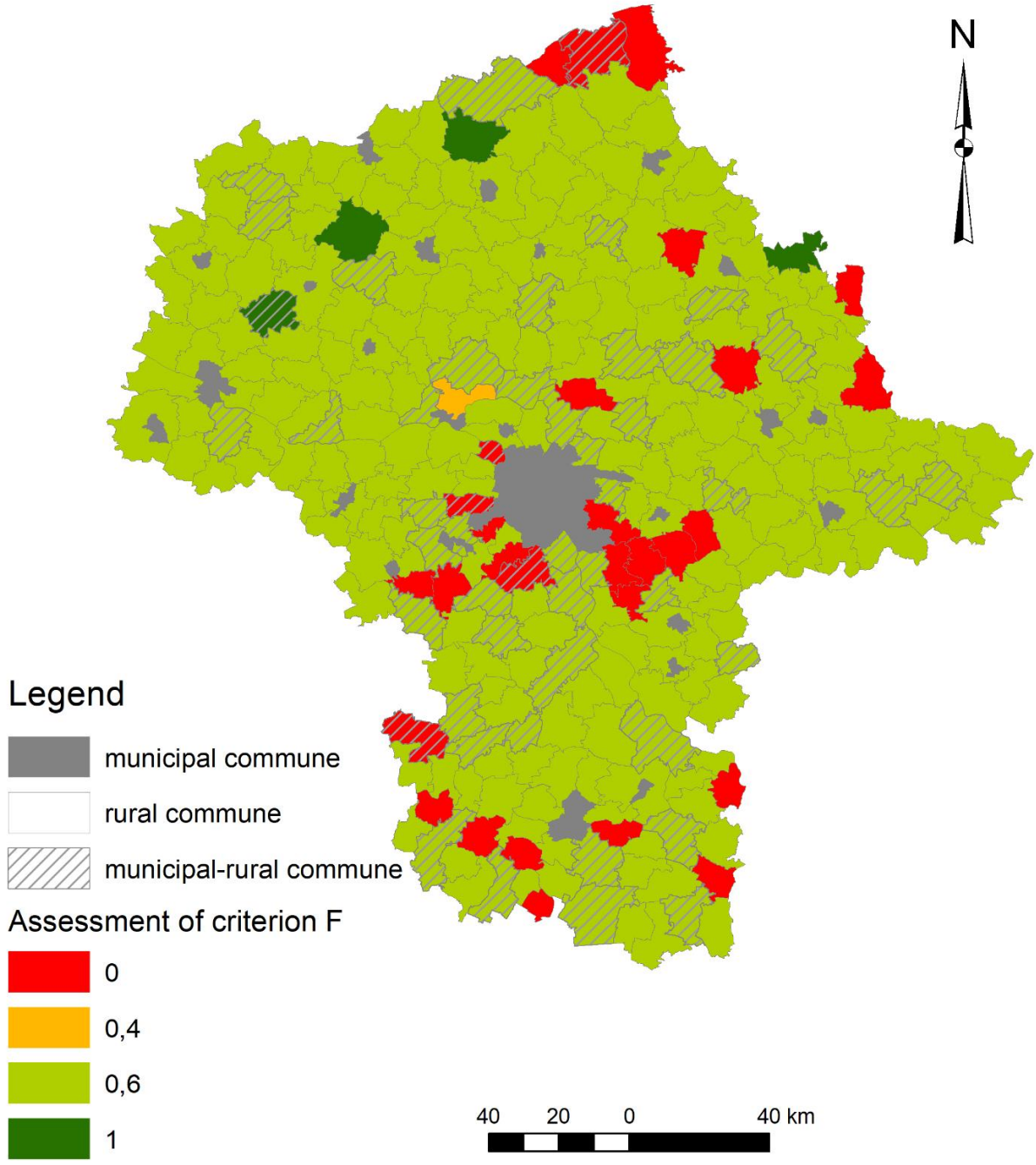
Table 1. List of parameters and points for the adopted criteria

| Criterion | Parameter | Points (0-1) |
|---|---|---|
| **F – 40%**<br>**The average area of a farm is over 1 ha** | **[ha]** | |
| Fa | ≤ 15,0000 | 0 |
| Fa | > 15,0000 | 1 |
| **Fn – 60%**<br>**Number of registration plots on the farm** | **[szt]** | |
| Fn | ≤ 10 | 1 |
| Fn | > 10 | 0 |
| **Sw – 60%**<br>**width of registration plots** | **[%]** | |
| Sw ≤ 20 m | ≤ 50 | 0 |
| Sw > 20 m | > 50 | 1 |
| **Se – 40%**<br>**length / width of registration plots** | **[%]** | |
| Se ≤ 1: 10 | ≤ 50 | 1 |
| Se > 1: 10 | > 50 | 0 |

Source: Own study.

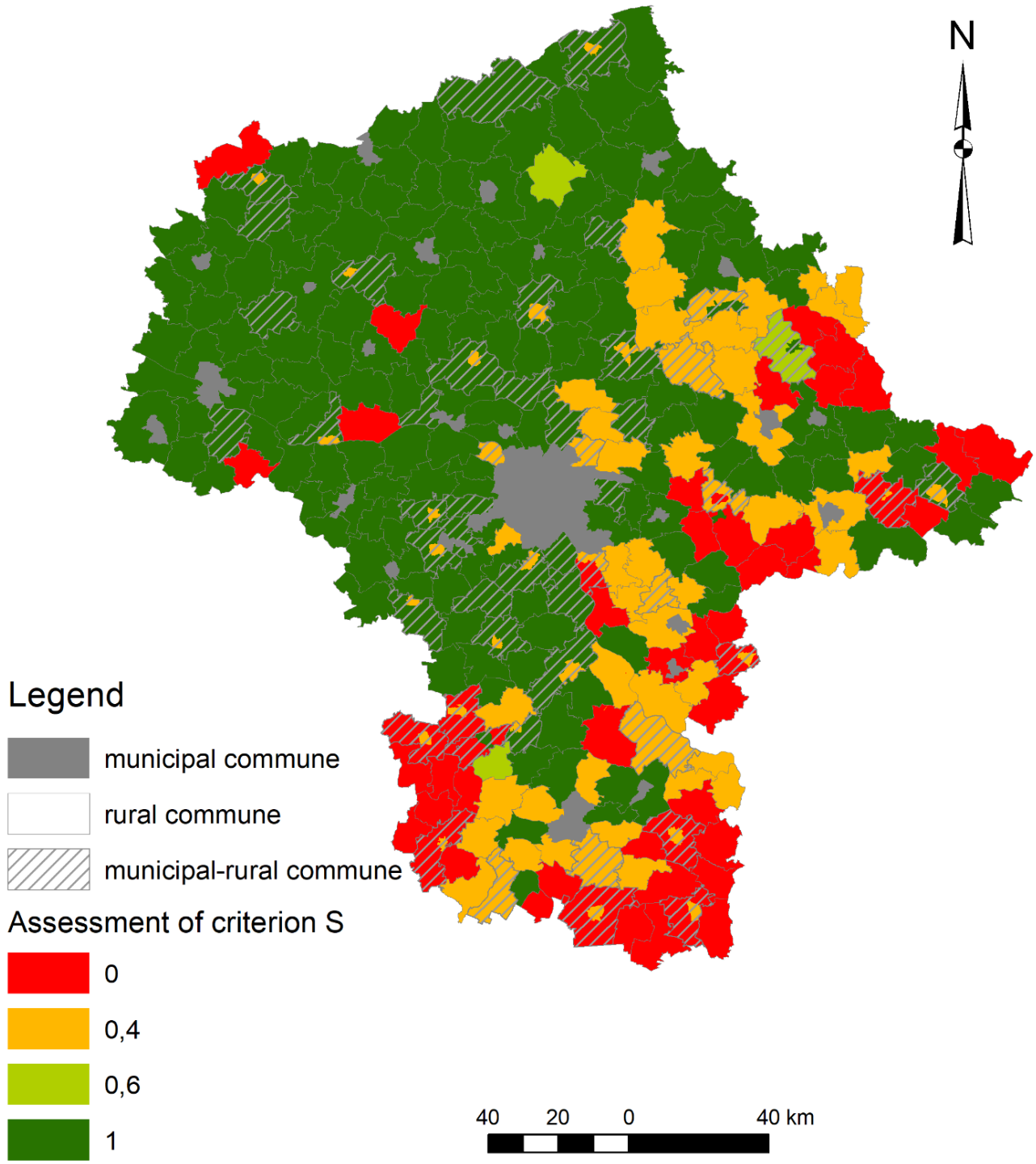
The simplified transformation index "T" was calculated following the formula (1) based on the adopted criteria.
The analysis results are presented on the maps shown in Fig. 2-4.

Fig. 2. Assessment of the spatial structure of farms



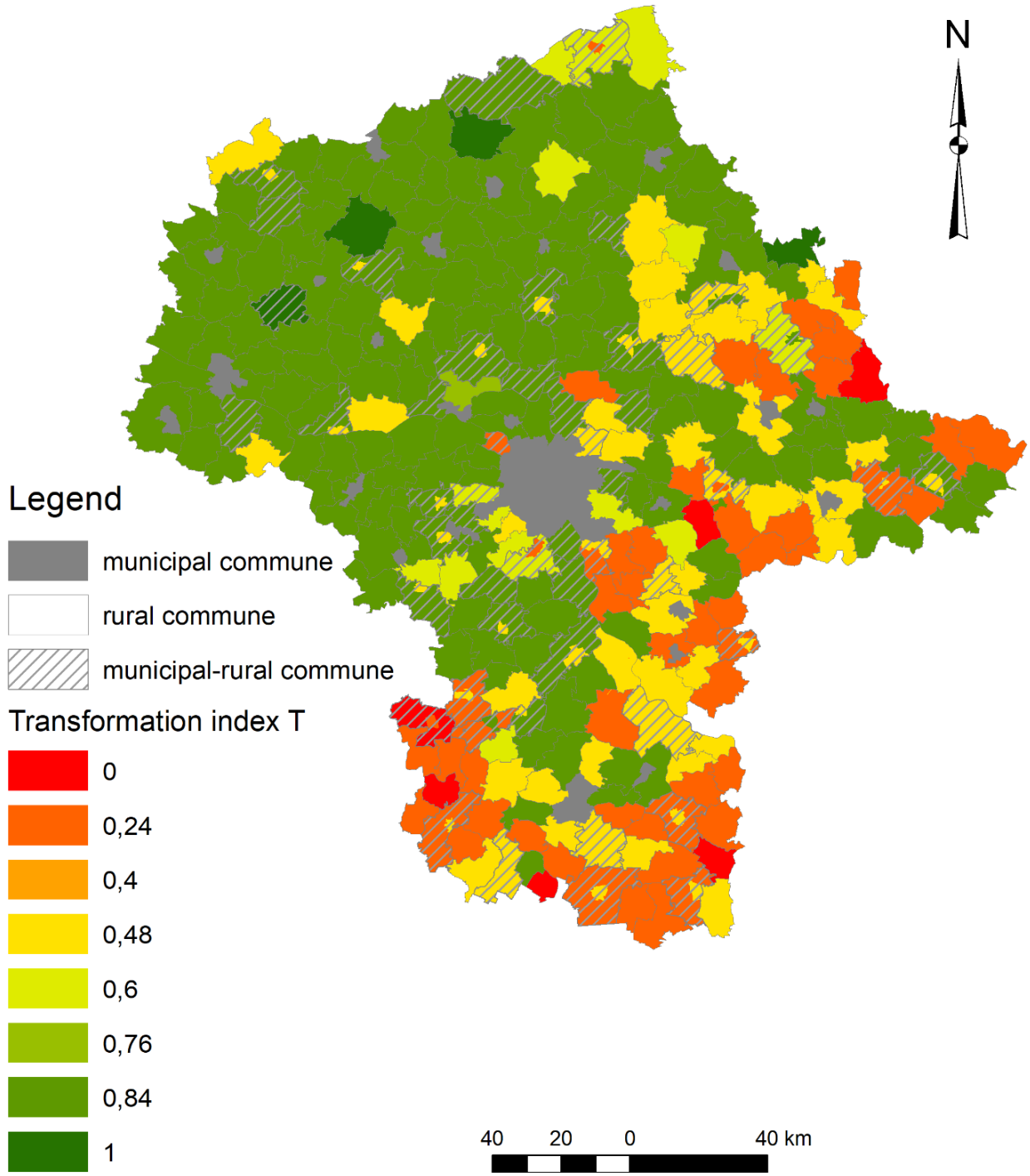

Source: Own study

Fig. 3. Assessment of the shape of registration plots




Source: Own study

Fig. 4. Assessment of the needs of comprehensive transformations in rural areas with the use of the transformation index (T)




Source: Own study

## 5. DISCUSSION AND CONCLUSIONS

Multifunctional, sustainable development of rural areas is an essential process. It requires a lot of support both at the regional and local levels. Support for multifunctional development requires considering the current land use and factors determining such a condition. The research results conclude that an essential factor slowing down the multifunctional development of rural areas in the Mazowieckie Voivodeship is the spatial structure of registration plots and farms.
The research aimed at identifying areas requiring changes towards multifunctional rural development has shown that communes located in the southern and south-eastern part of the Mazowieckie voivodship need the most urgent changes and transformation of land development (transformation index T ranging from 0 - 0.48).
According to the authors, the areas of agricultural production space located in these areas require land consolidation, primarily to increase the area of plots. A large number of plots (over 50% of the total number of plots in the commune) with a width of less than 20 m significantly limit the possibilities of intensive agriculture. In addition, the process of land consolidation carried out comprehensive land consolidation allows you to rebuild the space and adapt it to the needs of residents running various activities, including ecological production. In consolidation, it is possible to predict and adjust the infrastructure to conduct non-agricultural activities, e.g., agritourism. Carrying out the land consolidation process, taking into account social participation at every stage, allows for the multifunctional development of rural areas.
On the other hand, in the vicinity of cities, in well-connected areas, it is important to adjust the spatial structure of plots to the new residential or other function related to the development of land for non-agricultural purposes. The main activity in this respect is the real estate division procedure. However, in the case of narrow and long agricultural plots, it is necessary to consolidate and divide the real estate.
According to the authors, the use of intelligent technologies as part of the Smart Villages idea is crucial in strengthening the processes of transforming the spatial structure of plots and farms. The possibilities of multifunctional, sustainable development of rural areas largely depend on reconstructing their spatial structure. Intelligent digital technologies that technically support land consolidation and consolidating and dividing real estate will undoubtedly provide a reasonable basis for shaping non-agricultural economic activity. Adapting the shape of the plots and their area to new functions (e.g., former agricultural plots for residential buildings) will eliminate spatial conflicts resulting from the change in the way of development.
Considering the large spatial differentiation of the rural areas of the Mazowieckie Voivodeship, it can be concluded that the possibilities and directions for implementing the Smart Villages idea depend primarily on local conditions. Both in communes where farms will develop towards intensive agricultural production and where other management functions will enter, the ongoing changes require adaptation of the space structure to the current needs. Smart technologies and intelligent spatial planning, i.e., elements of the SV concept that fits into the main areas, can

significantly accelerate these processes and thus strengthen the development of rural areas towards their multi-functional development.

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