

## SUPPORT OF INTERNAL TRANSPORT OPTIMIZATION IN FARMS WITH THE USE OF SPATIAL INFORMATION SYSTEMS

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### ABSTRACT

Excessive distribution of holdings is one of the most important barriers which causes that in a great part of Poland rational use of farms is impossible. This problem particularly concerns the south and east region of the country. Correct spatial distribution of lands belonging to holdings is one of the most crucial factors that enable an economically profitable activity of these farms. The aim of the paper was verification of the applicability of the prepared spatial data base, farm-land configuration of agricultural plots of the selected agricultural farms to indicate the areas of optimization of the internal transport. As a result, based on the developed spatial data base, an impact of the land configuration of agricultural plots in the investigated group of agricultural producers on organization of the field transport between the holding and agricultural plots was determined. The scope of the paper covered a vegetable producer group, which associates 5 farms that have in total 620 ha of agricultural land.

## Introduction

There are many problems that the Polish agriculture must deal with. An unfavourable agrarian structure is a basic weakness which influences, inter alia, a high level of employment, low level of mechanization and low marketability of individual farms. In Poland, small farms prevail in number; they are up to 5 ha of surface area and they constitute 53.2% of the total number of farms. Moreover, farms from 5 to 10 ha, which constitute 22% have a considerable share and it has decreased in the recent years. Farms, which have the biggest area, i.e., above 20 ha of agricultural land, which have the biggest perspectives of development

constitute only 9.4%. The average area of an individual farm decreased slightly in recent years and in 2018 it was 10.81 ha ([www.arimr.gov.pl](http://www.arimr.gov.pl)). However, it seems that still this area is too small for effective use of the machinery park, for increase of the work performance and for obtaining higher incomes. Combining small individual farms in groups i.e., producer groups seems to be an alternative, which allows, inter alia, common acquisition and use of machines and thus affect the improvement of work performance (Rorat and Szeląg-Sikora, 2013). The agricultural producer groups – is an activity that aims at support of team actions of agricultural producers so that through a stronger position in discussions with clients they could take over a part of a profit margin and thus increase their incomes (Szeląg-Sikora, 2010). Excessive distribution of lands together with a small area of plots and big distances from a seat very often cause resignation from using the land (Janus, 2011).

The team activity of farmers enables obtaining many advantages related to building a competitive dominance of a farm not only during the sale of their products on an agricultural market but also in purchase and processing within a group of a common activity (Boguta, 2006). Single farms, regardless their size, are too small units to be a partner for big entities which deal with intermediation and trade with agri-food articles and to meet the requirements of competitive, agricultural producers that are associated in corporations. Small agricultural producers often have only one purchaser. It causes great uncertainty with regard to the sale of their products and meeting the quality requirements. Combination of common efforts in one representing entity acting as an “agricultural producer group” reduces this uncertainty to a great extent, raises a competitive force and ensures more favourable position towards big trade companies and food producers. Moreover, it ensures access to cheaper production means, indispensable services and limits the risk and uncertainty, maintaining at the same time a family character of agriculture (Domagalska-Grędys, 2010; Grzywińska-Rapca, 2003).

Groups are founded by agricultural producers to carry out a business activity. They adjust the production to the market needs through creation of effective marketing structures that enables acquisition of sale markets for products both in the country and abroad (Kowalski et al., 2011). Farmers may organize in agricultural producer groups to adjust the agricultural production to market condition, improvement of farming effectiveness, planning of production including in particular its amount and quality, focusing of supply and organization of sale of agricultural products and protection of a natural environment (Czapiewska, 2013).

The aim of the paper was verification of the applicability of the prepared spatial data base, farmland configuration of agricultural plots of the selected agricultural farms to indicate the areas of optimization of the internal transport and possibilities of using the base.

## Methodology

To realize the aim of the paper, a spatial data base of a farmland configuration of agricultural plots for a particular facility i.e., an agricultural producer group was developed. This base was made with the Spatial Information Systems technique in ArcView environment which includes thematic layers related to the shape and size of agricultural plots and road network of the investigated area. For the purpose of the analysis, particular farms from the investigated agricultural producer group were coded with letter: A, B, C, D and E – they will

Support of internal...

be presented as such in the paper. Due to a varied labour consumption of particular crops, also analysis of particular farms with regard to the structure of crops was carried out.

## Results of research

The paper covered a producer group which unites 5 individual farms. The investigated group of producers in total farms on 620 ha of agricultural land, its specialization is cultivation of root vegetables, grains, root, and oil plants are cultivated in crop rotation. The mentioned groups of plants in the structure of sowing constituted respectively 41%, 37%, 19% and 3% (table 1).

Table 1.

*Surface area and structure of crops for entire group and particular farms*

Specification of crops	Group	A (ha)	B (ha)	C (ha)	D (ha)	E (ha)	Structure (%)
Beetroot	15	15					2.4
Parsley	20				20		3.2
Spring barley	9					9	1.5
Maize	24	24					3.9
Carrot	198	108	53.5	10		26.5	31.9
Grain mixture	8	3	4	1			1.3
Spring wheat	33.5	0	0		17	16.5	5.4
Winter wheat	164	47	95		19	3	26.5
Potato	118.5	51	21.5		30	16	19.1
Winter rapeseed	19	0	19				3.1
Oat	9	0	0	9			1.5
Perennial grasslands	2	1	1				0.3
Total	620	249	194	20	86	71	100

*Source: author's own research*

The group fields are located in 15 towns on the territory of three provinces of Śląskie Voivodeship. The group and associated producers have each one field in 10 towns, these fields are within respectively: 37, 12, 12, 14, 12, 13, 14, 12, 43, 7 kilometers from the registered seat. Next two fields of two associated producers are located in 1 town 13 km from the seat. While, in 4 towns there are 3 fields in each belonging to 3 associated producers located respectively 38, 3, 5, 20 km from the registered seat (Table 2).

Table 2.  
*The surface area of half of the group and farms A, B, C, D and E in particular towns*

Town	Distance of fields from the seat (km)	Surface area of fields of the group (ha)	Surface area of fields of particular farms (ha)				
			A	B	C	D	E
Bełk	38	190.5		120		30	40.5
Czechowice-Dziedzice	37	37				37	
Ćwiklice	12	14					14
Goczałkowice-Zdrój	3	64	36	18	10		
Kobielice	12	10	10				
Kryry	14	9			9		
Ligota	12	24	24				
Łąka	5	65.5	48		1		16.5
Miedzna	13	19.5		19.5			
Międzyrzecze	14	65	65				
Poręba	12	6	6				
Stanowice	43	2		2			
Stara Wieś	7	18	18				
Studzionka	20	61.5	21	21.5		19	
Wiśła Wielka	13	34	21	13			
Total		620	249	194	20	86	71

*Source: author's own research*

The studies covered agricultural farms associated in the agricultural producer group that produce vegetables located in the southern Poland in Pszczyna province. This producer group that associates five agricultural holdings with their registered seat in Goczałkowice (Fig. 1).

Figure 2 with displayed attributes of agricultural plots presents a fragment of the scope of spatial distribution of agricultural plots. In this example, a name of the agricultural plot which is unique in a given production year was displayed as a label. In the performed spatial base, this number is an identification code (the object name) based on which other attributes that describe a particular spatial object (an agricultural plot) may be combined. In this case, the image is not editable and presents the surface area of the municipality range in the geographical system. On the other hand, traverses as a thematic layer of agricultural plots are fully editable within written in attributes as well as the outline and shape.

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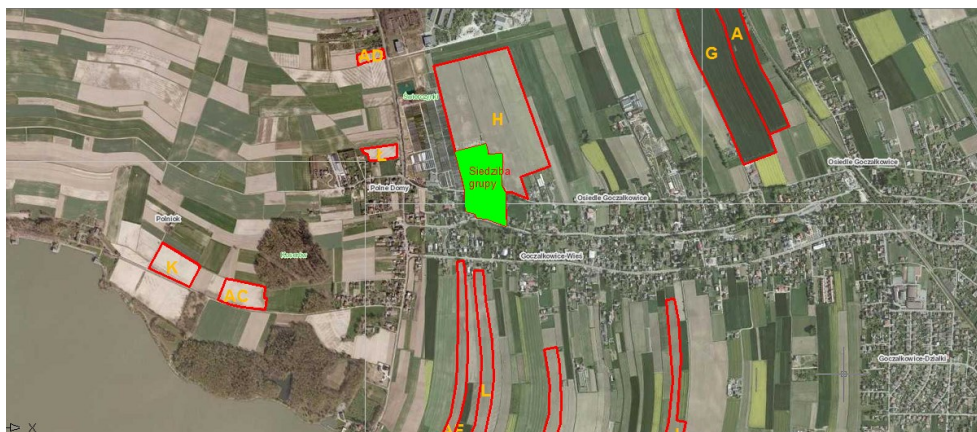


Figure 1. The registered seat of agricultural producer group where studies were performed

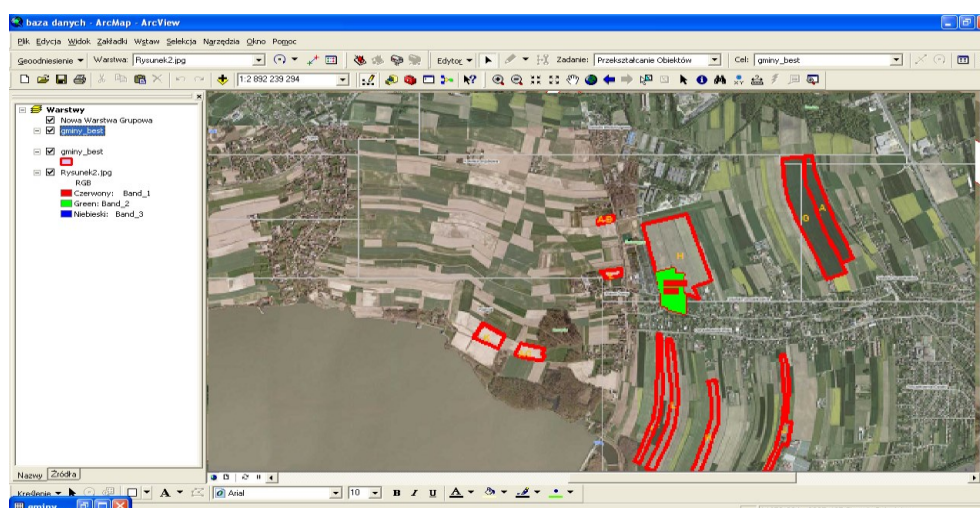


Figure 2. Farm land configuration of cadastral district of the investigated group of agricultural producers introduced to the environment of ArcView

Background bitmap of the range of the producer group was prepared in the scale of 1:10000 which covers with its range the area of the runner of spatial objects of the investigated farms. This area in the assumed scale covers 760 x 320 mm and using such format in the analogue form would be difficult. Using the non-scale feature of GIS analysis of such area is performed on the screen on a traditional computer. Farm plots are located in this area. The image that describes characteristics of the area was introduced in the coordinate system. The system to which background bitmap was adjusted is a commonly used WG84 system.

Orthophotomaps which farmers obtain from the Agency for Restructuring and Modernisation of Agriculture are in the 1992 system (it is the most popular reference system for Poland). A shift between those two systems is automatic in the ArcView environment. A prepared traverse thematic layer that presents distribution of plots can write in and modify attributes in \*.dbf files.

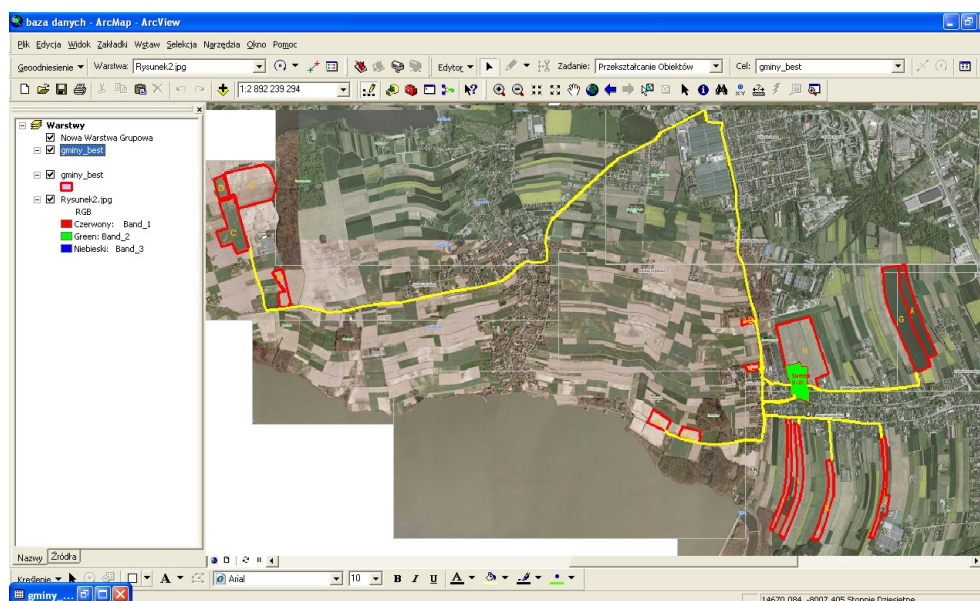


Figure 3. Farmland configuration of agricultural plots of the investigated agricultural producer group with drawn routes from the registered seat of the group to the boundary of plots

A prepared spatial data base enables an automatic exploration of the geographical image of plots with a vector layer that presents an access road to the plot. It was presented in figure 3. The prepared spatial data base enables obtaining automatic responses about distances between the registered seat and the agricultural plot. The longest distance of the agricultural plot from the seat of the producer group is 6.44 km. Whereas, the average distance of the plot from the producer group seat is 1.61 km.

The performed spatial data base in the environment of the Spatial Information Systems may be a valuable element of management of agricultural production. Based on this, there is a possibility of performing graphical enclosures. The base may be successfully used for archiving and stocktaking of agricultural production parameters. Agricultural production has a specific spatial character which gives possibilities of using the Spatial Information Systems to facilitate/optimize the course of the production process including support operation such as, inter alia, transport.

## Summary and conclusions

Formation of the agricultural producer group caused a considerable improvement of the spatial distribution of agricultural plots. The group farms in total 620 ha of agricultural land. The surface area of agricultural land is over 77 times bigger than the average in Śląskie Voivodeship which in 2019 was 8.02 ha ([www.arimr.gov.pl](http://www.arimr.gov.pl)). The producer group by associating gained big agricultural plots in 15 towns and distribution of cultivated vegetable cultivars reduced.

The studies that were performed in the entire group of agricultural producers and in particular farms associated in the group A, B, C, D and E enables to conclude as follows:

1. The prepared data base enables automatic determination of the distance from the producer group registered seat
2. In the agricultural producer group selected for tests, associating 5 producers, farms A and B brought into the group the highest percentage resource of agricultural land, i.e., respectively 40% and 31% remaining farms C, D and E brought in respectively 3%, 14% and 12%.
3. The GIS environment satisfactorily can be used for planning archiving, storing, and visualization of data of the agricultural production performed on the plots belonging to the holding.
4. The producer group cultivates 12 cultivars of plants in 15 towns. The foundation of the agricultural producer group caused unification of agricultural plots thus increasing the surface area of particular fields and reducing by half the number of cultivated plants species reducing distances with regard to internal transport.
5. A practical aspect of the performed work results from the fact that based on the archived attribute data, one may carry out analysis related to fertilization, yield, crop protection on particular agricultural plots. It may be automatically taken to a tabular form and on this basis agri-environmental plans and reports which require knowledge on crop rotation and fertilization can be made. It enables, as early as on the stage of planning, to make optimization concerning internal transport through planning, inter alia, of the order of agrotechnical treatments including optimal routes.

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## **WSPOMAGANIE OPTIMALIZACJI TRANSPORTU WEWNĘTRZNEGO W GOSPODARSTWACH ROLNYCH Z WYKORZYSTANIEM SYSTEMÓW INFORMACJI PRZESTRZENNEJ**

**Streszczenie.** Nadmierne rozdrobnienie gospodarstw jest jedną z najważniejszych barier, która uniemożliwia racjonalne użytkowanie gruntów w dużej części obszaru Polski. Problem ten szczególnie mocno dotyczy południowo-wschodnich regionów kraju. Prawidłowe przestrzenne rozmieszczenie gruntów gospodarstw jest jednym z najważniejszych czynników umożliwiających prowadzenie przez te gospodarstwa opłacalnej ekonomicznie działalności. Celem pracy było zweryfikowanie aplikacyjności wykonanej przestrzennej bazy danych, rozłogu działek rolnych wybranej grupy producentów rolnych, w celu wskazania obszarów optymalizacji transportu wewnętrznego. W efekcie na podstawie wykonanej przestrzennej bazy danych określono wpływ rozłogu działek rolnych w badanej grupie producentów rolnych na organizację transportu polowego pomiędzy siedzibą gospodarstwa a działkami rolnymi. Zakresem pracy objęto grupę producentów warzyw, która zrzesza 5 gospodarstw rolnych, posiadających łącznie 620 ha użytków rolnych.

**Słowa kluczowe:** warzywnicza produkcja rolnicza, transport wewnętrzny, baza danych, struktura agrarna