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# THE 2007–2013 AGRI-ENVIRONMENTAL PROGRAM AS AN INSTRUMENT FOR THE RETARDATION OF NATURAL RESOURCES IN POLAND

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**Abstract.** This paper describes regional differences in agricultural management methods, and attempts to present the implementation scale of the 2007–2013 agri-environmental program as an instrument slowing down the depletion of natural resources in Poland. Two indicators were used as the basis for the regional analysis of this Program: the number of applications (as a percentage of the total number of farms) and the amount of funds received per hectare of agricultural land. The geographic scope of the analysis covered the whole country and its different voivodeships, with districts being used as basic units. A synthetic indicator of payment absorption levels under the agri-environmental program and spatial autocorrelation methods were employed. The financial support had a positive impact on the concentration of agricultural land covered by additional agri-environmental payments, which was noticeable in north and north-east Poland. The research shows that the instruments slowing down the depletion of natural resources – such as the agri-environmental program – provide encouragement, above all, for the development of multifunctional agriculture. The multifunctionality of agriculture is more accentuated in Pomorskie, Zachodniopomorskie, Lubuskie, Dolnośląskie and Podkarpackie voivodeships, and less so in the south-central part of the country, i.e. in Opolskie, Śląskie, Małopolskie and Łódzkie voivodeships.

**Keywords:** 2007–2013 agri-environmental program, multifunctionality of agriculture, spatial autocorrelation

## INTRODUCTION

While Poland demonstrates specific landscape assets and a wide biodiversity, there is a risk of damaging the natural environment due to road investments, industrial activity and the intensification of agriculture. A high use of chemicals in production, stubble burning and poor management of animal waste and household wastewater are some of the factors behind the degradation of ecosystems and biodiversity in rural areas. Field trees, small ponds, peat bogs as well as wild birds and other animal species disappear from the landscape as a consequence of agricultural production processes. As an incentive for the farmers to change their land-use patterns, the European Union has introduced the agri-environmental program. Its main objective is to promote environmentally-friendly methods of agricultural management. It is the first program that attaches great importance to the establishment of relationships between farming and the environment while considering farmers not only as food producers but also as protectors of natural resources. Farmers influence the preservation of the country's natural resources with their agricultural activity which is also carried out in areas of significant natural value. As regards land management, it is important to consider possible threats to these areas which may result from a change in the existing land-use patterns. Despite slowing down the use of the natural

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environment, the existing function of an area is allowed to be changed in order to meet specific needs or provide expected benefits. This objective may be pursued with research tools and instruments which enable slowing down or restricting the environmental transformation processes (Raszka, 2010).

In order to emphasize the significance of biodiversity protection in agricultural areas, use was made of economic instruments conducive to slowing down the depletion of natural resources under the 2007–2013 agri-environmental program. These instruments enable the continued use of the extensive management method in some parts of the country where it helps preserving landscape biodiversity. Therefore, this paper seeks to present the implementation scale of the 2007–2013 agri-environmental program as an instrument slowing down the depletion of natural resources in Poland. Two indicators were used as the basis for the regional analysis of the program: the number of applications submitted (as a percentage of the total number of farms) and the amount of funds received per hectare of agricultural land. The geographic scope of the analysis covered the whole country, with voivodeships and districts used as basic units (314 district offices of the Agency for Restructuring and Modernization of Agriculture). The calculations were based on average figures from 2007–2013, in accordance with the list of agricultural producers delivered by the Agency for Restructuring and Modernization of Agriculture (ARMA). The research covered the activity period of the 2007–2013 agri-environmental program.

## THE 2007–2013 AGRI-ENVIRONMENTAL PROGRAM

The objective of measures taken under the agri-environmental program is to promote agricultural production systems compliant with requirements for environmental protection (preventing water pollution, soil erosion), landscape protection and development, protection of endangered flora and fauna species together with their habitats, and protection of genetic resources of farm animals. Agri-environmental activities affect the multifunctional development of agriculture, especially including the non-market (green and blue) functions. Green functions are related to land resource management focused on protecting its valuable features, creating living conditions for wild animals and plants, protecting animal welfare, maintaining biodiversity, and streamlining the circulation of chemical substances in agricultural production systems. In turn, blue functions are intended to manage water resources, improve water quality, prevent floods, and generate water and wind energy (van Huylenbroeck et al., 2007).

Pursuant to the Council Regulation (EC) No. 16/98/2005 of September 20, 2005 for the Development of Rural Areas and Appendix II to the Regulation of the Commission (CE) No. 1974/2006 of December 15, 2006 laying down detailed rules for the application of the above Regulation, the agri-environmental program provided for environmental payment rates for the farmers participating in the implementation of packages. The payments compensated for the loss of income, and for additional and transaction costs related to the implementation of packages. Payments were calculated on a per hectare or per animal basis, and differed depending on the package and species (breed, variety) of animals. Nine packages, which included 41 variants, were implemented under the 2007–2013 agri-environmental program. Compared to the previous period (2004–2006), the 2007–2013 program was extended to restore natural assets or to conserve valuable habitats in agricultural use; to preserve rural biodiversity; to promote sustainable management and proper land use and water protection; to protect endangered local farm animals and local varieties of cultivated plants. Also, the rural community's greater environmental awareness was manifested by the protection of genetic resources of farm animals and the promotion of agricultural production systems compliant with requirements for environmental protection, landscape protection and development and protection of endangered species of flora and fauna together with their habitats. The requirements to be fulfilled by program beneficiaries also changed: in 2004–2006, good agricultural use was enough. Now, the farmers have to meet compulsory standards, defined in both the national and EU legislation concerning farming and natural environment protection. In the 2007–2013 agri-environmental program, some packages were continued: "Sustainable agriculture," "Organic farming," "Land and water protection," "Buffer strips," and "Protection of local farm animals." In turn, some packages were modified: organic farming was extended with a variant for herb cultivation and orchard and berry cultivation. In dedicated variants, buffer strips are treated separately from field baulks. The payment was adjusted so as to compensate farmers

for not receiving both the area payments and LFA payments. The package for the protection of local farm animals was extended with an additional variant, namely the protection of local pig breeds. Emphasis was mainly put on environmental issues, and therefore packages for the maintenance of extensive meadows and grazing areas were implemented under the "Extensive permanent grassland" package. New environmental packages were introduced, such as "Protection of endangered bird species and natural habitats outside NATURA 2000 areas" and "Protection of endangered bird species and natural habitats within NATURA 2000 areas." A new solution was the support for farmers implementing active measures for the protection of local varieties of crop plants, including traditional orchards. Such an extension of the program and its focus on the protection of endangered habitats and bird species – both within and outside NATURA 2000 areas – may help to preserve biodiversity in Poland, which is an issue to be addressed in agricultural spatial planning. Compared to the previous period, the implementation area also changed: all agri-environmental program packages under the 2007–2013 Rural Development Program were implemented on a countrywide basis (Zegar, 2009).

## RESEARCH METHODS

The main research objective, which is to evaluate regional differences in the 2007–2013 agri-environmental program, was achieved using a synthetic indicator and the spatial autocorrelation method (LISA). The determination of the absorption level of EU funds provided an answer to many research questions:

- the amount of financial resources used by farmers,
- regional differences in the agri-environmental program's impact on environmental enhancement,
- the farmers' interest in accessing the payments,
- the development of extensive farming.

This is important in the context of the research conducted in the EU states on the impact of Common Agricultural Policy instruments on sustainable agricultural development which plays an essential role for the preservation or restoration of environmental assets in rural areas. The Pearson's correlation coefficient was used to analyze the linear correlation between diagnostic variables. At the significance level $\alpha = 0.05$, there was high correlation between the number of projects implemented as per the application and the number of farms ($r = 0.72$), and between the area of agricultural land covered by environmental payments and the average area of farmland in good agricultural use ($r = 0.81$). This data enabled the creation of the following indices:

- the proportion of farms covered by environmental payments in the average number of agricultural households,
- the amount of payments per application granted,
- the proportion of farmland covered by environmental payments for farmland in good agricultural use,
- the amount of payments per ha of agricultural land covered by the program.

The above indices were necessary to define the absorption level using a synthetic index. The synthetic index refers to the actual value of features rather than to their rank (Runge, 2007). If the data matrix is composed of features expressed in different units, the values are standardized before the calculation, with zero corresponding to the country average level. The next step is the calculation of the arithmetic means of standardized values which – once arranged in ascending or descending order – are interpreted in terms of the synthetic index (Racine and Reymond, 1977). The following formula is used:

$$W_s = \frac{\sum_{j=1}^{p} y_{ij}}{p}$$

where:

$W$s – synthetic index,
$j$ – 1, 2, ..., $n$,
$p$ – number of features taken into account,
$y_{ij}$ – standardized value of variable $j$ for object $i$.

The results were divided into five groups:

I – very low level of absorption of funds: below –0.499;
II – low level of absorption: from –0.500 to –0.001;
III – medium level of absorption: from 0 to 0.500;
IV – high level of absorption: from 0.501 to 1.000;
V – very high level of absorption: above 1.001.

The spatial autocorrelation method (LISA) was used to analyze the agri-environmental program's impact on environmental enhancement. The search for local relationships between the variables analyzed was based on the correlation coefficient which allows to locate the units in space (i.e. spatial autocorrelation). Spatial correlation is related to spatial dependence (Anselin, 1995).

It is defined as the impact of a process or phenomenon taking place at one or several points in space on a process or phenomenon taking place elsewhere. According to Tobler's First Law of Geography (1970), near things are more related than distant things. The consequence of spatial dependence is a correlation between the observed values of one variable at different points in space. According to Bivand (1980), autocorrelation takes place when one phenomenon in one spatial unit causes an increase or decrease in the probability for the phenomenon to occur in neighboring units. Spatial autocorrelation specifies the strength of the relation between the value of a variable in one spatial unit and the value of the same variable in a different unit (location). The global Moran's *I* and local Moran's *Ii* statistics, described and applied by many researchers, including Cliff and Ord (1973), Anselin (1995), Kossowski and Perdał (2014), are employed to specify the local spatial relationships of a given phenomenon. The research on local spatial relationships was conducted at district level and covered the period 2007–2013. A more detailed examination of structures and spatial dependencies was based on LISA analysis for the five closest neighbors. The environmental payments per area of agricultural land were measured as the ratio of the amount of funds obtained to the farming area covered by the agri-environmental program. The calculations were performed using GeoDa software.

## RESEARCH RESULTS

The 2007–2013 environmental payments, intended as an incentive for the farmers to undertake environmental protection measures, amounted to PLN 6,936.9 million (the highest ratio of 12.6% was recorded in Zachodniopomorskie; see Table 1).

The average amount disbursed per hectare of agricultural land over the period 2007–2013 was PLN 488.40, ranging from PLN 311.31 in Opolskie voivodeship and PLN 367.84 in Kujawsko-Pomorskie voivodeship to PLN 603.24 in Lubuskie voivodeship, PLN 603.41 in Podkarpackie voivodeship and PLN 665.49 in Małopolskie voivodeship. According to district offices of the Agency for Restructuring and Modernization of Agriculture, the amounts disbursed ranged from below PLN 300 in Golub-Dobrzyń district (PLN 297.09; Kujawsko-Pomorskie voivodeship), Lubań district (PLN 295.25; Dolnośląskie voivodeship), Świdnica district (PLN 287.05; Dolnośląskie voivodeship), Brzeg district (PLN 275.08; Opolskie voivodeship), Nysa district (PLN 269.10; Opolskie voivodeship) and Strzelin district (PLN 233.61; Dolnośląskie voivodeship) to above PLN 1,000 per hectare of agricultural land in Zakopane district (PLN 2,161.29; Małopolskie voivodeship), Nowy Targ district (PLN 1700.71; Małopolskie voivodeship) and Sucha Beskidzka district (PLN 1434.66; Małopolskie voivodeship). A single farm was allowed to implement up to three agri-environmental projects which resulted in an unprecedentedly high number of applications submitted (138.4 thousand), ranging from 1.9 thousand in Śląskie voivodeship to 17.2 thousand in Lubelskie voivodeship. As regards the farms' activity in applying for funds to implement agri-environmental projects, the number of applications accepted exceeded the number of farms in 14 districts located in Lubelskie voivodeship (Włodawa district), Lubuskie voivodeship (Krosno district), Podkarpackie voivodeship (Bieszczady district; 179%, the highest rate across the country), Pomorskie voivodeship (Bytów, Lębork and Słupsk districts), Wielkopolskie voivodeship (Chodzież and Września districts) and Zachodniopomorskie voivodeship (Drawsko, Łobez, Goleniów, Gryfice, Szczecinek and Wałcz districts). Farmers from the Zachodniopomorskie voivodeship (25.5%), Warmińsko-Mazurskie voivodeship (23.4%) and Pomorskie voivodeship (62.8%) accounted for the greatest proportion of applications, whereas those from Śląskie voivodeship (3.2%), Małopolskie voivodeship (4.3%) and Łódzkie voivodeship (4.4%) accounted for the smallest share.

When analyzed by voivodeship, the synthetic index of activity level in the agri-environmental program ranged from –0.904 in Śląskie voivodeship and –0.477 in Podkarpackie voivodeship to 0.927 in Lubuskie voivodeship and 1.052 in Zachodniopomorskie voivodeship. The average area of farmland in good agricultural use was taken into account. This average allows for both favourable environmental conditions and the size structure of farms. Based on the value of the synthetic index, five groups of districts with different levels of absorption of financial resources under the agri-environmental program were identified (I: very low; II: low; III: medium, IV: high; V: very high). The absorption of payments differed from one region to another (Fig. 1).

A very high level of payments disbursed (group V) was reported in 36 districts located in Zachodniopomorskie, Pomorskie, Warmińsko-Mazurskie, Lubelskie,

**Table 1.** Selected aspects used to assess the participation of farms in the 2007–2013 agri-environmental program in Poland

| Voivodeship | Payment received | | | Projects implemented as per the application | | | Synthetic index of support |
|---|---|---|---|---|---|---|---|
| | PLN million | % of total | PLN per ha of agricultural land | thousand | % of total number of apps | % of farms | |
| Dolnośląskie | 378.80 | 5.5 | 479.18 | 5.2 | 3.8 | 8.8 | 0.060 |
| Kujawsko-Pomorskie | 551.42 | 7.9 | 367.84 | 11.0 | 7.9 | 16.4 | –0.025 |
| Lubelskie | 606.16 | 8.7 | 497.87 | 17.2 | 12.3 | 9.1 | –0.119 |
| Lubuskie | 439.73 | 6.3 | 603.24 | 4.2 | 3.0 | 19.3 | 1.22 |
| Łódzkie | 149.34 | 2.2 | 455.40 | 5.6 | 4.1 | 4.4 | –0.400 |
| Małopolskie | 189.24 | 2.7 | 665.49 | 6.5 | 4.6 | 4.3 | –0.473 |
| Mazowieckie | 536.53 | 7.7 | 527.06 | 13.7 | 9.8 | 6.1 | –0.137 |
| Opolskie | 164.19 | 2.4 | 311.31 | 2.9 | 2.1 | 10.4 | –0.272 |
| Podkarpackie | 353.22 | 5.1 | 603.41 | 10.4 | 7.5 | 7.5 | –0.477 |
| Podlaskie | 522.74 | 7.5 | 592.48 | 12.5 | 9.0 | 14.8 | 0.438 |
| Pomorskie | 529.30 | 7.6 | 443.96 | 8.2 | 5.9 | 20.7 | 0.205 |
| Śląskie | 81.72 | 1.2 | 497.85 | 1.9 | 1.4 | 3.2 | –0.904 |
| Świętokrzyskie | 188.75 | 2.7 | 469.93 | 8.7 | 6.2 | 8.9 | –0.458 |
| Warmińsko-Mazurskie | 744.06 | 10.7 | 498.71 | 10.4 | 7.5 | 23.4 | 0.634 |
| Wielkopolskie | 641.30 | 9.2 | 428.82 | 13.1 | 9.4 | 10.7 | –0.048 |
| Zachodniopomorskie | 860.38 | 12.4 | 569.84 | 7.6 | 5.5 | 25.5 | 1.052 |
| Poland | 6,936.90 | 100.0 | 488.40 | 138.4 | 100.0 | 9.3 | x |

Source: own study based on data delivered by the Agency for Restructuring and Modernization of Agriculture.

Mazowieckie, Wielkopolskie, Lubuskie, Dolnośląskie, Świętokrzyskie and Małopolskie voivodeships. In these districts, the average area of farmland in good agricultural use ranged from 6.72 ha (Pruszków) to 37.14 ha (Łobez). The financial support encourages medium-sized farms (5 to 15 ha) to opt for and continue extensive management methods. In large agricultural holdings, located in districts of Lubuskie, Zachodniopomorskie and Warmińsko-Mazurskie voivodeships, the payments compensate for additional costs involved in restrictions to farming and for the lost opportunity to intensify their agricultural production.

Group IV, with a high level of fund absorption, consisted of 48 districts located mostly in the western and northern part of the country. Like group V, it included large and medium-sized farms who keep farmland in good agricultural use.

Group III, with a medium level of fund absorption, consisted of 88 districts located in Warmińsko-Mazurskie, Zachodniopomorskie, Lubuskie, Wielkopolskie, Dolnośląskie and Podkarpackie voivodeships.

Group II, demonstrating a low level of farming funds absorption, was the largest group composed of farms of various sizes. Larger ones were concentrated in districts of Warmińsko-Mazurskie, Pomorskie, Kujawsko-Pomorskie, Wielkopolskie and Dolnośląskie voivodeships, whereas smaller ones were located along the eastern border of the country, i.e. in districts of Podlaskie, Lubelskie and Podkarpackie voivodeships. A very low level of fund absorption (group I) was noted in 3 districts situated mostly in the central (Wieruszów, Bełchatów) and south-central (Oświęcim) part of the country. In both groups, there was a predominance of small farmers. For them, the environmental payments provided an

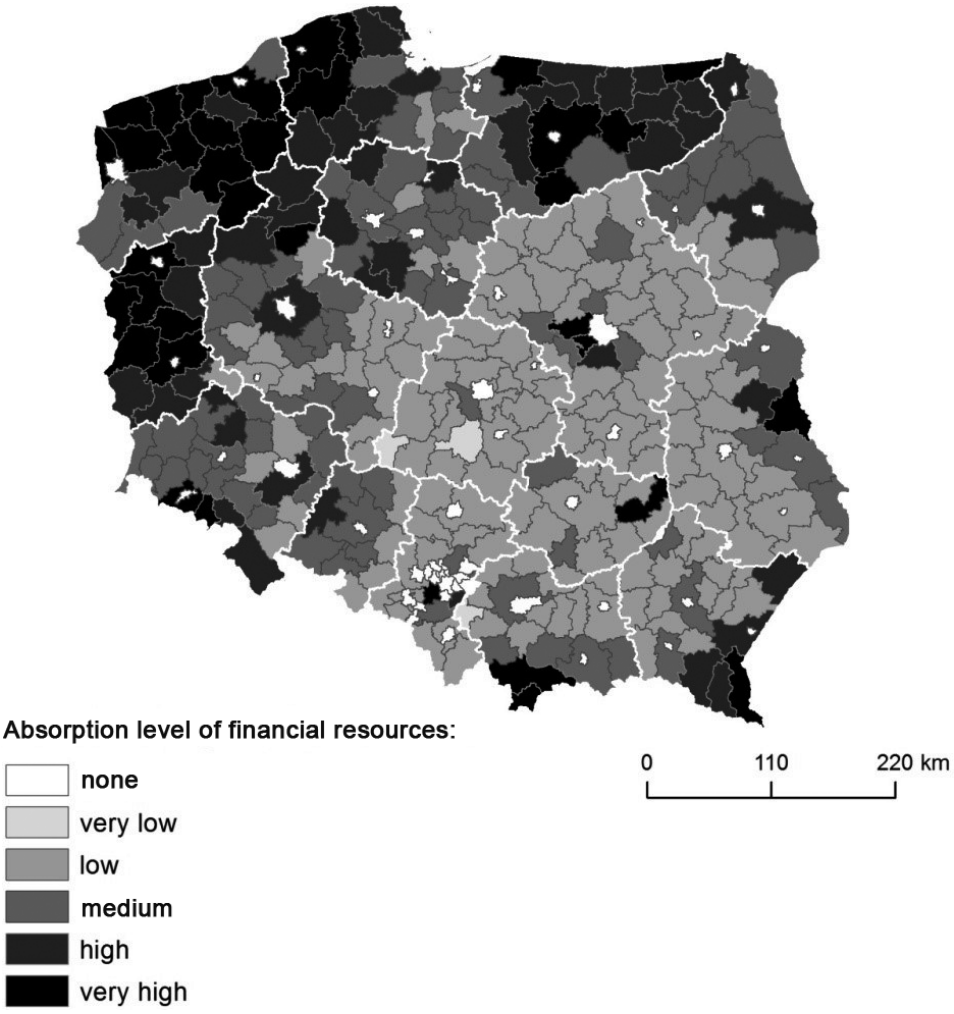


**Fig. 1.** Absorption of payments under the 2007–2013 agri-environmental program in Poland
Source: own elaboration.

incentive to continue extensive cultivation and animal husbandry and to engage in environmental activities by delivering desirable agro-technical services.

The spatial autocorrelation coefficient for the value of farmland covered by environmental payments was statistically significant at $\alpha = 0.05$ and amounted to 0.2915. Farmland eligible for payments under the 2007–2013 agri-environmental program is arranged in dense distinct clusters. The largest one, an HH cluster, is located in northern Poland, at the boundary of Zachodniopomorskie, Pomorskie and Wielkopolskie voivodeships. Smaller clusters were found in Warmińsko-Mazurskie and Lubelskie voivodeships (Fig. 2).

The clusters are characterized by medium levels of spatial cohesion. LL clusters were more clearly marked in the country and were much more spatially coherent than HH clusters. The largest LL cluster is located in central Poland. Despite poor spatial cohesion, LL clusters may also be found in Mazowieckie voivodeship; smaller ones are located in Małopolskie and Śląskie voivodeships. Additionally, the structure of clusters is affected by the presence of outliers. This is the case in Małopolska where the share of farmland covered by payments was much higher than in the neighboring units, resulting in the formation of outlying HL clusters. It was the opposite in Mazowsze and Wielkopolska where LH outliers were reported.

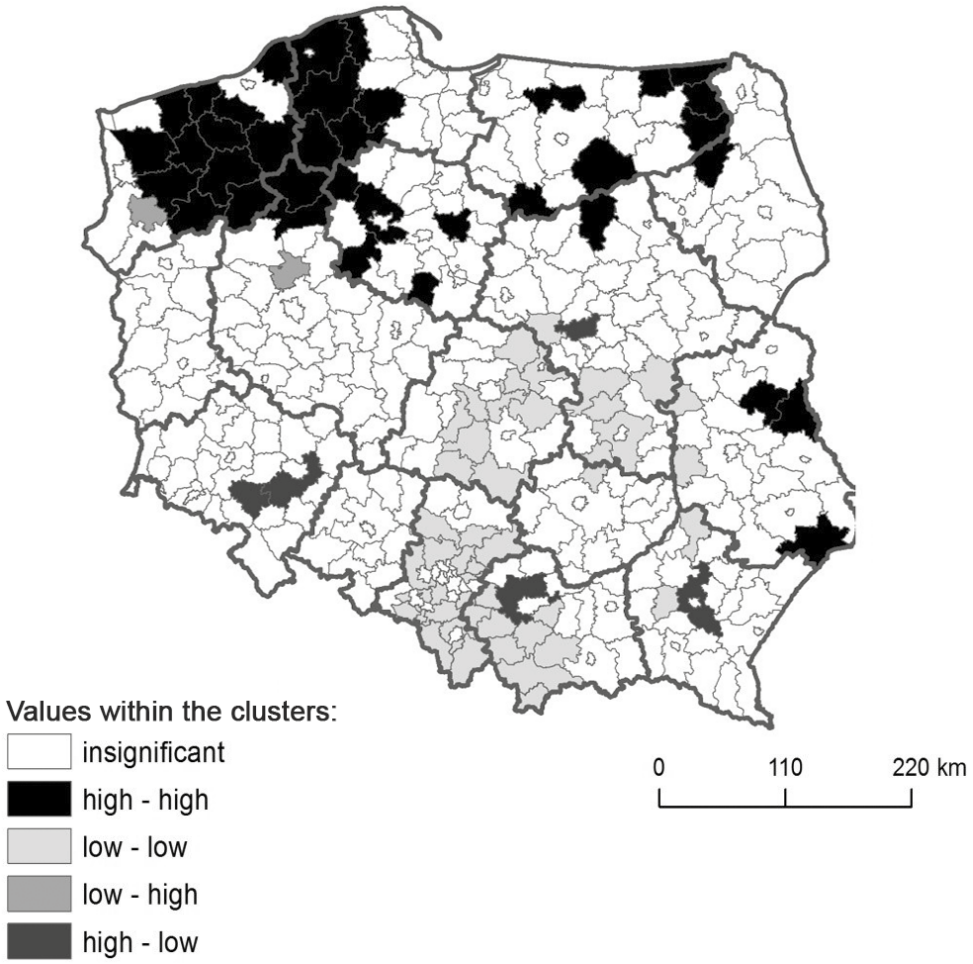


**Fig. 2.** Spatial dependencies (LISA) between the shares of farmland covered by 2007–2013 environmental payments in Poland.
Source: own elaboration.

As regards spatial distribution of farmland area covered by financial support under the 2007–2013 agri-environmental program, the allocation of funds may be considered reasonable. The resources were targeted at areas whose location and natural conditions are conducive to slowing down the environmental transformation. The spatial autocorrelation coefficient for the value of amounts disbursed under the 2007–2013 agri-environmental program was statistically significant at $\alpha = 0.05$ and amounted to 0.2759. The concentration of environmental payments was manifested by the formation of two large HH clusters in the north (Zachodniopomorskie, Pomorskie) and north-west (Warmińsko-Mazurskie, Podlaskie). Note also that areas with a high proportion of environmental payments reflect the ratio of farmland covered by payments. A concentration of areas demonstrating low shares of environmental payments was clearly visible at the boundary of Śląskie and Łódzkie voivodeships (Fig. 3).

Some smaller LL clusters were observed in Mazowieckie and Podkarpackie voivodeships. There were few HL outliers (in Małopolskie and Dolnośląskie voivodeships) and no LH clusters. The financial support had a positive effect on the concentration of farmland covered by agri-environmental payments, as could be observed in north and north-east Poland.

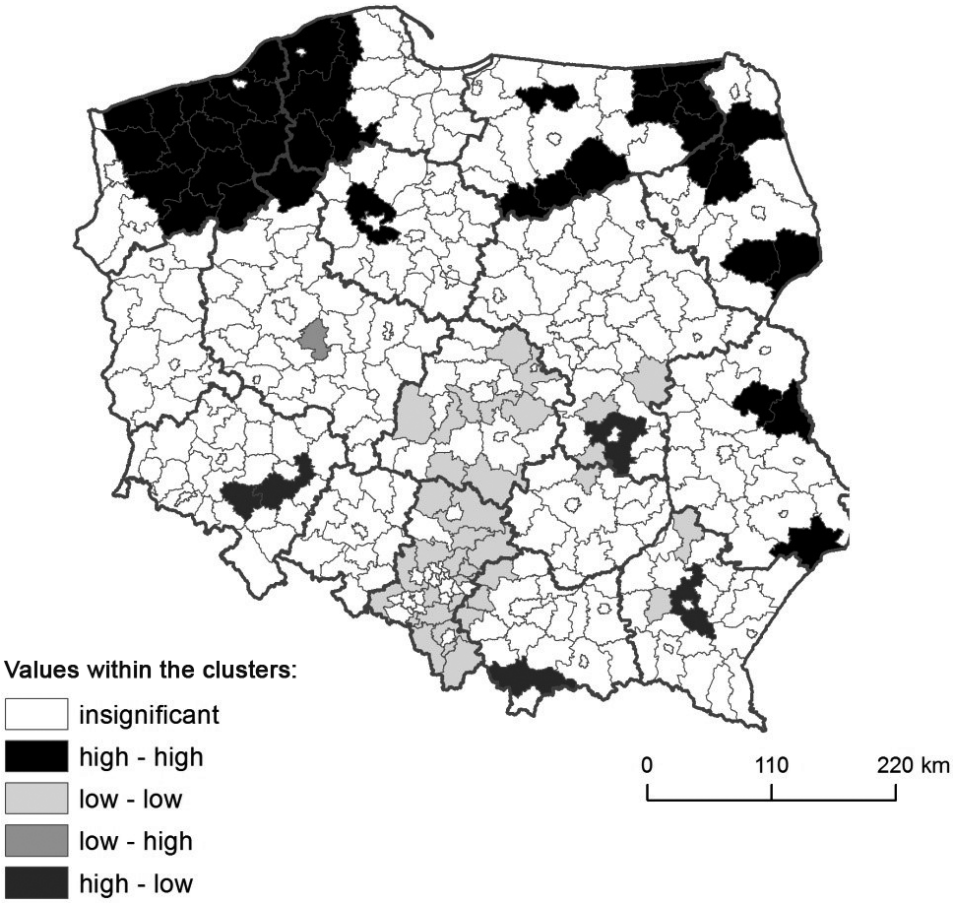


**Fig. 3.** Spatial dependencies (LISA) between the amounts disbursed under the 2007–2013 agri-environmental program in Poland
Source: own elaboration.

As an instrument slowing down the depletion of natural resources, the agri-environmental program has provided encouragement, above all, for the development of multifunctional agriculture. Based on the outcomes of support for activities related to productive and environmental (green) functions, it may be concluded that the degree of the farms' multifunctionality differed from one region to another (Kołodziejczak, 2010). Green functions of agriculture are provided with greater support in Pomorskie, Zachodniopomorskie, Lubuskie, Dolnośląskie and Podkarpackie voivodeships. In turn, smaller amounts are allocated to that purpose in the south-central part of the country, i.e. in Opolskie, Śląskie, Małopolskie and Łódzkie voivodeships. In these regions, the continued development of multifunctional agriculture requires the stabilization of ownership relations and an improvement in the area structure of farms.

## SUMMARY

The implementation of agri-environmental program instruments reduces the environmental impact of agriculture. It is mainly focused on extensive farming practices respecting biological co-dependencies (which intervene in environmental processes only to a small extent), and helps maintaining an environmental balance and preserving the traditional agricultural landscape. The measures deployed also contributed to the rise in importance of areas affected by unfavorable environmental conditions, often legally protected. Previously not addressed

in the government's preferential agricultural policy, they were characterized by a number of undesirable processes, such as depopulation, declining biodiversity and erosion of the agricultural nature of rural areas. The key effects of measures implemented were as follows: slowing down the trend towards discontinuing extensive agricultural practices in marginal areas which are an important aspect of environmental protection; accelerating the de-intensification of agriculture, especially including the discontinuation of extremely intensive production forms; and the initiation of deliberate efforts to preserve the landscape and natural assets of rural areas.

The degradation of natural assets of rural areas in Poland continues even though the European Union has launched an effective financial tool – the agri-environmental program – to slow down the depletion of natural resources. This is because the program lacks mechanisms for the protection of unproductive elements of agricultural landscape, i.e. field weeds, field ponds, field and near-water trees, wetlands and meadows located near/along ditches and rivers. It results in the destruction of plant habitats which are the feeding base for animals. As a consequence, farmers turned the refuges of biodiversity into production areas because they lacked motivation to preserve such assets until 2017 when the redefined principles for receiving area payments took effect.

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## REFERENCES

Anselin, L. (1995). Local Indicators of Spatial Association – LISA. Geogr. Anal., 27, 93–115.

Bivand, R. (1980). Autokorelacja przestrzenna a metody analizy statystycznej w geografii [Spatial autocorrelation and methods of statistical analysis in geography]. In: Z. Chojnicki (Ed.), Analiza regresji w geografii (p. 23–38). Warszawa-Poznań, PWN [in Polish].

Cliff, A. D., Ord, J. K. (1973). Spatial Autocorrelation. London: Pion.

Kołodziejczak, A. (2010). Modele rolnictwa a zróżnicowanie przestrzenne sposobów gospodarowania w rolnictwie polskim [Models of agriculture and spatial differences in Polish agricultural management]. Poznań: Wyd. Nauk. UAM [in Polish].

Kossowski, T., Perdał, R. (2014). Wykorzystanie metod ekonometrii przestrzennej do analizy procesów koncentracji w rolnictwie polskim [Employment of spatial econometric methods for the analysis of concentration processes in Polish agriculture]. In: B. Głębocki (Ed.), Zróżnicowanie przestrzenne rolnictwa (p. 466–487). Warszawa: GUS [in Polish].

Program Rozwoju Obszarów Wiejskich 2007–2013 [Rural Development Programme 2007–2013] (2007). Warszawa: MRiRW [in Polish].

Racine, J. B., Reymond, H. (1977). Analiza ilościowa w geografii [Quantitative analysis in geography]. Warszawa: PWN [in Polish].

Raszka, B. (2010). Narzędzia retardacji przekształceń środowiska w gospodarce przestrzennej [Retardation tools for the environment transformation in spatial management]. In: J. Kostecka (Ed.). Retardacja materialnego przekształcania zasobów przyrodniczych. Osiągnięcia, Problemy, Perspektywy. Biul. KPZK PAN, 242, 109–120 [in Polish].

Runge, J. (2007). Metody badań w geografii społeczno-ekonomicznej – elementy metodologii, wybrane narzędzia badawcze [Research methods in socio-economic geography – methodological elements, selected research tools]. Katowice: Wyd. Uniwersytetu Śląskiego [in Polish].

Tobler, W. (1970). A computer movie simulating urban growth in the Detroit region. Econ. Geogr., 46(2), 234–240.

van Huylenbroeck, G., Vandermeulen, V., Mettepenningen, E., Verspecht, A. (2007). Multifunctionality of agriculture: a review of definitions, evidence and instruments. Living reviews in landscape research: 3. Retrieved July 17th 2017 from: http://www.livingreviews.org/lrlr-2007-3

Zegar, J. (2009). Z badań nad rolnictwem zrównoważonym (10). Raport końcowy, synteza i rekomendacje [Research on sustainable agriculture (10). Final report, synthesis and recommendations]. In: Ekonomiczne i społeczne uwarunkowania rozwoju gospodarki żywnościowej po wstąpieniu Polski do Unii Europejskiej. Warszawa: IERiGŻ-PIB [in Polish].