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ANALYSIS OF CHANGES IN THE TECHNICAL PRODUCTION MEANS POTENTIAL OF FARMS IN THE PROVINCES OF LUBELSKIE VOIVODESHIP

Summary

The aim of the study was to determine the spatial distribution of farm equipment with technical means of production in a given period of time (the period of the agricultural census in 1996, 2002 and 2010) of 20 counties of Lubelskie Voivodeship. The scope of work included the spatial database of the examined region at the level of counties. The data were taken from the European Statistical Office and related inter alia to variables such as: agricultural tractors, self-propelled machinery or residential areas per unit area of the farm. Then the analysis of the spatial distribution in 1996, 2002 and 2010 was conducted, and spatial changes were determined. Based on the accepted diagnostic variables a synthetic indicator was determined and the multi-scale phenomenon was described with one feature.
***Key words**: equipment with technical means, synthetic indicator, spatial econometrics, spatial autocorrelation*

ANALIZA ZMIAN POTENCJAŁU TECHNICZNYCH ŚRODKÓW PRODUKCJI GOSPODARSTW ROLNYCH W POWIATACH WOJEWÓDZTWA LUBELSKIEGO

Streszczenie

Celem pracy było wyznaczenie rozkładu przestrzennego wyposażenia gospodarstw rolnych w techniczne środki produkcji w wybranych latach (1996, 2002 i 2010) na poziomie 20 powiatów województwa lubelskiego. Zakres pracy obejmował wykonanie przestrzennej bazy danych badanego województwa na poziomie powiatów. Dane atrybutowe zostały pozyskane z opracowań Europejskiego Urzędu Statystycznego i odnosiły się min. do takich zmiennych jak: ciągniki rolnicze, maszyny samobieżne czy powierzchnie użytkowe w przeliczeniu na jednostkę powierzchni gospodarstwa. Następnie została przeprowadzona analiza rozkładu przestrzennego w 1996, 2002 i 2010 roku oraz wyznaczone zostały zmiany przestrzenne. Na podstawie przyjętych zmiennych diagnostycznych został wyznaczony wskaźnik syntetyczny a zjawisko wieloskalowe zostało opisane jedną cechą.
***Słowa kluczowe**: wyposażenie w środki techniczne, wskaźnik syntetyczny, ekonometria przestrzenna, autokorelacja przestrzenna*

1. Introduction

Technical progress is influenced by broadly defined technical infrastructure namely "a group of basic facilities, devices and installations such as: roads, bridges, power and telecommunication grids which have a provide services and which are indispensable for the proper functioning of the society and production branches of economy" [1]. The so-called internal infrastructure, which consists of buildings, machines, agricultural equipment and transport means was analysed. In 2005 in Poland in agricultural farms, there were 1 437.2 thousand tractors, 147.3 thousand combine harvesters, 89.2 potato harvesters and 36.8 thousand of beetroot harvesters. However, per one unit of agricultural land area or crop area, the values of the equipment ratio considerably differ from analogous ratios of the European Union (old 15). The number of tractors per 100 farms in Germany, France, United Kingdom is from 2 to 3 times higher than in Poland. Tractors used in the Polish agriculture are greatly worn and their period of use is very long (the average age of a tractor is 23 years and a combine harvester 21 years) [9]. Since Poland's accession to the European Union, one may notice many changes which have taken place in the Polish agriculture. Inter alia, criteria of accessibility of the selected structural funds affect the potential of agricultural farms and thus indirectly influence the changes which take place in our country. The agrarian structure changes systematically, the number of farms decreases with the simultaneous increase of their profitability. Farms with a specific production single out. Moreover, technical infrastructure is modernized through the obtained funding for purchase of e.g. agricultural machines or equipment of livestock buildings. Consequently the farmers' incomes increase and work conditions in rural farms improve. Replacement of the used and worn technical equipment in Poland is still considerably impeded, inter alia, on account of a small scale of farms' production and low commodity nature. As a result, machines and devices, whose exploitation time is longer than the one recommended by catalogue standards, are used. High prices of modern machines obstruct new investments. The research carried out by Szeląg- Sikora and Kowalski in 2010 shows that investing in the machinery park is the most frequent form of EU funding used by farmers. The obtained funds are designated for the purchase of tractors, sprayers, combine harvesters as well as cultivation and sowing units. Besides the investment in the technical infrastructure, farmers decided, inter alia, to modernize inventory facilities. They built or modernized cowsheds and cowshed floors or manure containers the most often [8]. A rationally selected and used machinery park facilitates the performance of production treatments according to the agrotechnical requirements and

enhances the quality of treatments [5]. The equipment of the Polish agriculture with machines and agricultural devices is varied in relation to the area which results, inter alia, from the past and present investment possibilities which originate in the available European funds [3]. The results of research by Lorencowicz show that on the territory of Lubelskie Voivodeship the level of equipment with technical means of farms increased. It resulted from the possibilities of obtaining EU subsidies. However, financial restrictions related to the farm size, and production results obtained by farms caused that farmers decided to purchase mainly the used machines [2, 4].

Irregular intensity and spatial variation of rural areas in respect of development of technical infrastructure of farms causes difficulties in planning the agriculture development in the regional aspect. Introduction of uniform development strategies for entire regions or macro-regions may cause growing diversification in the sustainable development of rural areas. Evaluation of the level of equipment of farms with technical infrastructure may be helpful in taking the decision on the relevant developmental strategy for each region. However, difficulty of classification of the investigated territorial unit is a problem in the multi-dimensional comparative analysis on account of many indices and properties which may be used to define the level of density of infrastructure. Multi-dimensional statistics, which allow determination of the synthetic measure are helpful in comparative analyses. Such measure replaces a numerous collection of the properties of the particle area (variables which describe the equipment in particular elements of the internal infrastructure) with one aggregated variable. Due to such activity, evaluation of the facility (province) with one value, and the analysis of the investigated facility with others with regard to the considered phenomenon is possible [6, 7].

Taking into consideration the above discussion, determination of the spatial distribution of the equipment of farms with technical production means in 1996-2002 and 2010 on the level of Lubelskie Voivodeship provinces was assumed.

2. Material and methods

Data for the analysis were accepted from the query of the European Statistical Office (Eurostat). Diagnostic variables described the equipment of farms with technical infrastructure (movables and real property) and concerned such data as: real property: total area of cowsheds, total area of piggeries, total chicken houses area, total area of sheds; movables: number of trucks, number of farm tractors, number of combine harvesters, number of potato harvesters, number of beetroot harvesters and the number of other machines and agricultural devices. All provinces of Lubelskie Voivodeship were analysed within (1996, 2002, 2010). Data were saved in the spreadsheet which has the GUD code of a municipality based on which the lines from the spreadsheet were automatically allotted to the records of the geographical data base. The geographical data base includes dbf files. In order to determine similarities between the objects and to calculate the distance between them, diagnostic variables were brought to comparativeness, obtaining thus standardization of variables. This treatment allowed removing of original feature names and brought the scope of variability to similar dimensions [6]. The course of standardization of diagnostic properties was according to the formula [6]:

$$z_{ij} = \frac{x_{ij} - \bar{x}_{ij}}{S_j} \quad (1)$$

where:
i - facility number; j – diagnostic feature number S_j – standard deviation of the feature j; x_{ij} – realization of the feature j in facility i.

The paper presents a synthetic measure of development based on the generalized concept of distance which may be defined as: "the distance of two points ηl and ηk in the dimensional m-space in the determined system of positive weights" [10]. During calculations it was assumed that weights of all properties are the same, as a result, each diagnostic variable has the same meaning [6]. In the calculations which were carried out, the formula for the synthetic measure of development was assumed after Hellwig as the following square function:

$$q_i = 1 - \frac{d_{i(1)}}{d_{(0),(1)}} = -\frac{\left[\sum_{j=1}^{m} \alpha_j (z_{ij} - z_{(0),j})^2\right]^{\frac{1}{2}}}{\left[\sum_{j=1}^{m} \alpha_j (z_{(0),j} - z_{(1),j})^2\right]^{\frac{1}{2}}} \quad (2)$$

where:
$d_{i(1)} = d(\eta i \; i \; \eta(1))$ – distance between the disaggregated development level of the i-facility ηi and disaggregated model of the development level $\eta(1)$,
$d_{(0)\,(1)} = d(\eta(0) \; \eta(1))$ – distance between the disaggregated zero development level $\eta(0)$ and the disaggregated model development level $\eta(1)$,
αj –weight coefficient of property xj.

The synthetic measure of development is an aggregate of diagnostic variables accepted for analysis. In the investigations it was assumed that $\alpha_j=1$, which means that each diagnostic variable obtained the same weight. Thus, finally the synthetic measure of development was determined from the following formula:

$$\sum_{j=1}^{m} [(z_{ij} - z_{(1),j})]^2]^{\frac{1}{2}} \quad (3)$$

The accepted model of synthetization of features meet demands of measure standardized to <0.1> and linearly orders facilities from the worst to the best with regard to the accepted criteria [6]. For each object i subjected to analysis the measure of development was determined q_i, with which the vector of aggregates in the form of a single-columns matrix was formed:

$$P_{[1xn]} = \begin{bmatrix} q_1 \\ q_2 \\ \cdots \\ q_n \end{bmatrix} \quad (4)$$

The obtained vector $P_{[1xn]}$ is a synthetic measure of development, which allowed classification with the use of only one number, multi-characteristic phenomenon, in the form of technical production means potential in the provinces of Lubelskie Voivodeship.

In the analysis which was carried out, provinces, which were divided into five groups with the area of similar values of the index which describes the technical production means potential were classified [10]. This classification was presented in table 1.

Table 1. Division of counties in respect of development synthetic measure value
Tab. 1. Podział powiatów ze względu na wartość syntetycznej miary rozwoju

Group	Description of the group	The scope of the group variability
I	Areas with very low development measure values	$0 \leq q_i \leq min\{q_i\} + 0,2R$
II	Areas with low development measure values	$min\{q_i\} + 0,2R \leq q_i \leq min\{q_i\} + 0,4R$
III	Areas with average development measure values	$min\{q_i\} + 0,4R \leq q_i \leq min\{q_i\} + 0,6R$
IV	Areas with average development measure values	$min\{q_i\} + 0,6R \leq q_i \leq min\{q_i\} + 0,8R$
V	Area with very high development measure values	$min\{q_i\} + 0,8R \leq q_i \leq min\{q_i\}$

q_i- value of the synthetic measure determined for i-facility; R - range of the development measure range

Source: Author's own study based on [10] / Źródło: opracowanie własne na podstawie [10]

3. Results

According to table 2 in 1996 Lublin County ($d_{i\ 1996}$ = max) was the best facility with reference to the analysed real property. This county obtained the highest value of the synthetic indicator value which was 0.794. In comparison to Hrubieszów County, which was on the second position this value was higher by 0.258. The province which took the first position in the group of analysed 23 provinces may be recognised as a model for this group in the ownership space for the real property in 1996.

In the research it was assumed that the optimal mathematical model aims to unity. According to this assumption, it may be stated that the county which takes the first position in the global view is not far from the ideal. In this county, equipment of farms with technical production means allows obtaining a high value of the development measure which achieves almost the value of 0.8.

In the paper, in order to observe the change of the development measure value in space and time also the collection (Ω) was analysed in 2002 (Φ_{2002}) and 2010 (Φ_{2010}). The development measure value was within $d_{i2002} \in \langle 0,02 - 0,877 \rangle$ and in 2010 $d_{i2010} \in \langle 0,027 - 0,783 \rangle$.

Through a comparative analysis trends of changes on the level of equipping farms with real properties in 1996-2010 were indicated. In the table set one may notice changes in the position of particular counties in rankings. It was affected by the level of farm equipment with technical production means which was changing throughout fourteen years.

In 1996 and 2002 the same counties were on the first three positions. These were the counties of Lublin, Hrubieszów and Zamość. However, only for the first position taken by Lublin county the value of the development measure in 2002 was higher than in 1996 ($d_{i\ 1996}$=0.794 ,$d_{i\ 2002}$ = 0.877). For the next two counties, this value decreased (Hrubieszów County $d_{i\ 1996}$ = 0.536, $d_{i\ 2002}$= 0.497, Zamość County $d_{i\ 1996}$ = 0.480, $d_{i\ 2002}$ = 0.475).

Table 2. Lublin counties arranged according to the obtained value of the synthetic indicator for movables and real properties in 1996, 2002, 2010
Tab. 2. Powiaty woj. lubelskiego uporządkowane ze względu na uzyskaną wielkość wskaźnika syntetycznego dla ruchomości i nieruchomości w latach 1996, 2002, 2010

Item	Farm name	Movables			Real properties		
		$d_{i\ 1996}$	$d_{i\ 1996}$	$d_{i\ 2002}$	nd_{i2010}	$nd_{i\ 2002}$	nd_{i2010}
1	Lublin County	0,7944	0,7944	0,8774	0,8721	0,9383	0,4888
2	Hrubieszów County	0,5364	0,5364	0,4966	0,1894	0,3321	0,2538
3	Zamość County	0.4804	0,4804	0,4747	0,8481	0,7898	0,6164
4	Biala Podlaska County	0,4794	0,4794	0,4248	0,3791	0,7987	0,8083
5	Tomaszów Lubelski County	0,4338	0,4338	0,3963	0,2211	0,3828	0,2906
6	Biłgoraj County	0,3545	0,3545	0,3351	0,3913	0,4985	0,4005
7	Łuków County	0,3458	0,3458	0,3850	0,3519	0,5743	0,5148
8	Krasnystaw County	0,3055	0,3055	0,3238	0,256	0,4132	0,315
9	Kraśnik County	0,2969	0,2969	0,3314	0,3407	0,5373	0,5086
10	Radzyń County	0,2658	0,2658	0,2672	0,2129	0,4529	0,546
11	Chełm County	0,2356	0,2356	0,2157	0,2194	0,3889	0,3049
12	Puławy County	0,1972	0,1972	0,1945	0,3086	0,3636	0,1894
13	Świdnica County	0,1965	0,1965	0,1851	0,1462	0,2218	0,1497
14	Opole County	0,1825	0,1825	0,2692	0,3477	0,3636	0,2397
15	Lubartów County	0,1783	0,1783	0,1701	0,3089	0,4601	0,6905
16	Janów Lubelski County	0,1693	0,1693	0,1939	0,1527	0,2774	0,3704
17	Parczewo County	0,1618	0,1618	0,1664	0,1494	0,2533	0,2859
18	Łęczna County	0,1335	0,1335	0,1376	0,2183	0,2014	0,1749
19	Ryki County	0,1129	0,1129	0,1018	0,1656	0,278	0,2666
20	Włodawa County	0,1115	0,1115	0,0863	0,139	0,2062	0,1603
21	County of the city of Lublin	0,0485	0,0485	0,0742	0,0403	0,1953	0,1839
22	County of the city of Biała Podlaska	0,0269	0,0269	0,0200	0,0716	0,0577	0,0436
23	County of the city of Zamość	0,0253	0,0253	0,0295	0,06	0,0533	0,2403

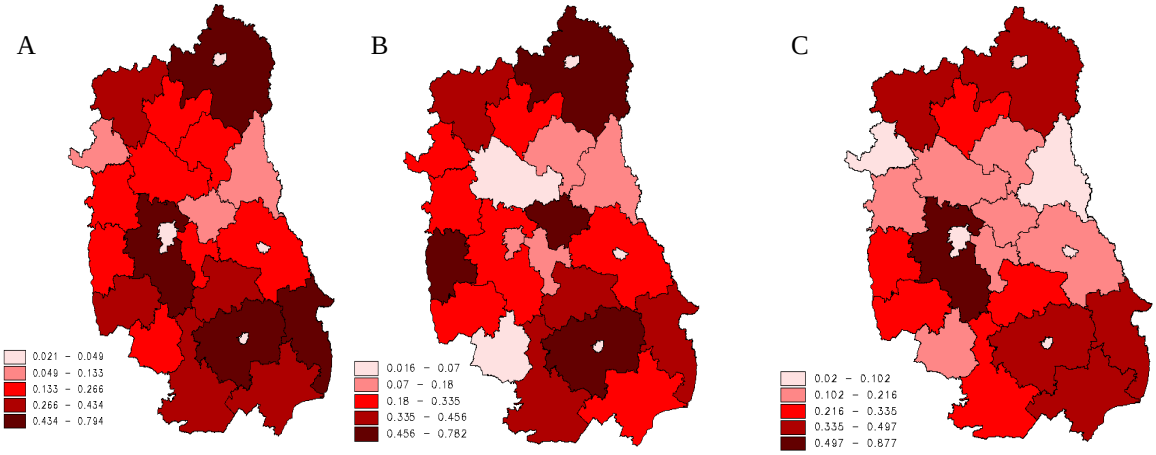
Source: own work / Źródło: opracowanie własne

In 2010, the first position was also taken by Lublin County however, the measure of development was lower than in 1996 and 2002 and it was $d_{i\ 2010}$ = 0.783. Biała Podlaska County, whose development measure value in comparison to 1996 ($d_{i\ 1996}$ =0.479) increased almost by 0.2 and it was $d_{i\ 2010}$ = 0.674 was promoted to the second position. Łuków County was on the third position ($d_{i\ 2010}$ = 0.559), its development measure value increased by average of 0.2 in comparison to the previous years ($d_{i\ 1996}$= 0.346, $d_{i\ 2002}$= 0.385). The biggest decrease in the ranking is in case of Tomaszów Lubelski County for which the development measure value in 2010 was $d_{i\ 2010}$ = 0.310 ($d_{i\ 1996}$ = 0.434, $d_{i\ 2002}$ = 0.396) which resulted in only the 11th position. City counties (Lublin, Biała Podlaska and Zamość counties), which always take the last three positions due to non-agricultural activities which develop mainly in cities have the lowest level of equipment with movable technical production means.

Based on the table 2, it was reported that in 1996 Lublin County had the highest value of the synthetic indicator with reference to real properties ($nd_{i\ 1996}$ = max). It has a development measure of the value of 0.872 which causes that it is almost ideal. Zamość County was on the second position. Its development measure was lower only by 0.02 and it was $nd_{i\ 1996}$ = 0.848. The next position is taken by Biłgoraj County whose equipment of farms with real properties did not allow obtaining even half of the value of the development measure and it was by half lower than in the outstripping regions ($nd_{i\ 1996}$ = 0.391). In 2002 once again Lublin County took the first place with the Hellwig measure value higher than in 1996 which was $nd_{i\ 2002}$ = 0.938. Biała Podlaska County was on the second position among diagnostic variables (Φ_{2002}). Its development measure value increased almost by twofold (1996 $nd_{i\ 1996}$ =0.379; 2002 $nd_{i\ 2002}$ = 0.799). The next increase of the development measure value in 2010 caused that Biała Podlaska County was on the first position, with the highest level of equipment of farms with real properties ($nd_{i\ 2010}$ = 0.808). In 2010 we also observe 'promotion' of two other counties; throughout the years the Hellwig measure value increased almost by twofold. It is Lubartów County $nd_{i\ 2010}$ = 0.691 (1996 $nd_{i\ 1996}$ =0.309; 2002 $nd_{i\ 2002}$ = 0.460) and Radzyń Province $nd_{i\ 2010}$ = 0.546 (1996 $nd_{i\ 1996}$ =0.213; 2002 $nd_{i\ 2002}$ = 0.453). The current leader namely Lublin County took only the seventh position with the Hellwig measure value almost two times lower than in 2002 ($nd_{i\ 2010}$ = 0.489). The last positions with regard to the equipment of farms with real properties similarly as in case of movables were taken by the city counties. The county of the city of Lublin is an exception. This region as the only one from this group was promoted by four places in comparison to the last place in 1996. It means that in farms which are located within this county the index of equipment with real properties increased almost four times.

In order to reflect the spatial distribution figure 1 presents the administrative division of the investigated voivodeship according to the borders of counties. In order to show regional diversifications in relation to the value of the index of Hellwig development measure five groups were accepted after Sikora and Woźniak [6]. These groups reflect the best the distribution of intensification of the investigated counties with the selected technical means which are in farms. They were calculated based on the saved formulas (table 2).

According to the spatial analysis for movables the group III was the most numerous group in 1996 which has an average technical infrastructure development of farms and aggregated development measure within d_i 0.133-0.266. There were 8 counties in this group i.e. 34.8% of the entire group. Majority of facilities from this group are provinces located in the northern and western part of the voivodeship (Radzyń, Parczew, Lubartów, Puławy and Opole counties). There were only 4 counties which constitute only 17.4% of the entire group in the last range of counties with the highest potential of technical infrastructure of farms. For comparison in the I group there were 3 facilities (cities) which means that Lubelskie Voivodeship in 1996 did not have a very high level of equipment of farms in the internal infrastructure but it also was not the area with the extremely low level of the investigated phenomenon.



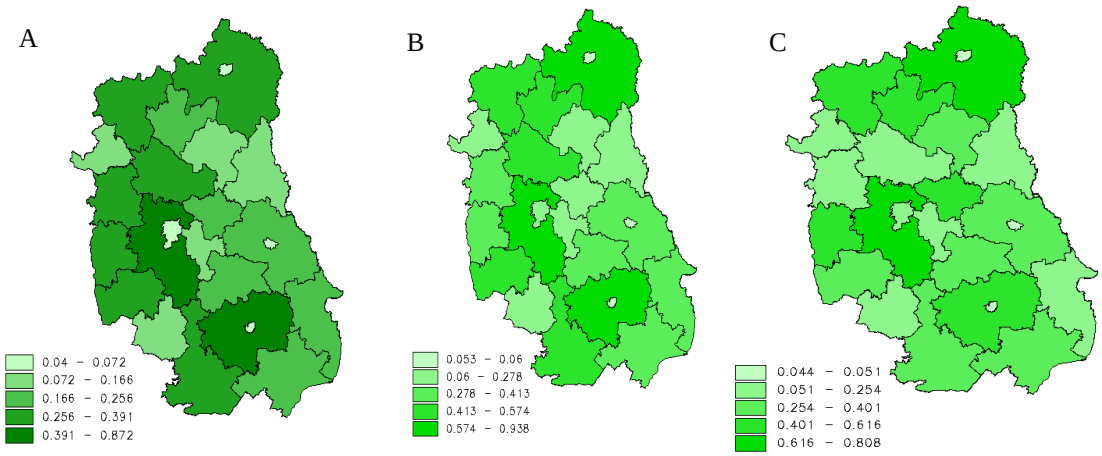
Source: own work / Źródło: opracowanie własne

Fig. 1. Intensification and spatial variability of equipment with movable technical means of production on the level of Lubelskie Voivodeship counties: A – 1996, B – 2002, C – 2010

Figure 1 presents the spatial distribution of the aggregated development measure in 1996 (Φ_{1996}), 2002 (Φ_{2002}) and 2010 (Φ_{2010}) for movables.

Rys. 1. Nasycenie i przestrzenne zróżnicowanie wyposażenia w ruchome techniczne środki produkcji na poziomie powiatów woj. lubelskiego: A – w 1996, B – w 2002, C – w 2010 roku

Na rys. 1 przedstawiono przestrzenny rozkład występowania agregatowej miary rozwoju w roku 1996 (Φ_{1996}), 2002 (Φ_{2002}) oraz 2010 (Φ_{2010}) dla ruchomości.



Source: own work / Źródło: opracowanie własne

Fig. 2. Intensification and spatial variability of real properties of farms according to the development measure on the level of Lubelskie Voivodeship counties A – 1996, B – 2002, C – 2010
Rys. 2. Nasycenie i przestrzenne zróżnicowanie nieruchomości gospodarstw wiejskich według miary rozwoju na poziomie powiatów woj. lubelskiego A – w 1996, B – w 2002, C – w 2010 roku

Based on the research it was found out that the number of particular groups in 2002 changed. It concerns, inter alia, the range which characterizes the most developed facilities on account of the potential of technical production means of farms. This group reduced its number to only one county (Lublin County) and constituted only 4.3% of the entire researched group. While, in 2010 the structure of all groups returned to the similar state as in 1996. Once again, the III range with an average level of farm equipment with technical production means with 8 counties i.e. 33.3% of the entire group constituted the most numerous group. Each remaining group included 4 counties. It means that in the group with highly developed potential of technical production means in farms there were by 3 counties more than in 2002. Moreover, these were counties which were in this range in the analysis in 2002. They comprise such provinces as: Biała Podlaska, Opole and Zamość. Such results may prove that after the crisis in the equipment of farms with movables since 1996 to 2002 the intensification of the modernization process took place which caused an increase in technical infrastructure in the following years. However, this level stayed lower than in 1996.

The figure 2 presents the spatial distribution of the aggregated development measure in 1996 (Φ_{1996}), 2002 (Φ_{2002}) and 2010 (Φ_{2010}) for real properties.

According to the spatial analysis for real properties the group IV was the most numerous group in 1996. It had a high development of the technical infrastructure of farms and aggregated development measure within nd_i 0.133-0.266. This group included 7 counties i.e. 30.4% of the entire group. Majority of counties in this group had also an average or high level of equipment with movables which may prove the intensity of the agricultural activity in this area. The III range proved to be the second one with regard to the number (it characterised the facilities with an average degree of equipment of farms with real properties), which comprised only one county less than in the group IV. It provided over 26% participation of this group in the entire group of the analysed facilities. There were only 2 counties which constituted only 17.4 % of the entire group in the last range of counties with the highest potential of technical infrastructure of farms. The first range included, similarly as in the analysis concerning movables, 3 facilities (cities). It means that Lubelskie Voivodeship in 1996 had mainly high and average level of equipment of farms with internal infrastructure.

4. Conclusions

Based on the research which was carried out in this paper it was found out that in Lubelskie Voivodeship the potential of technical production means considerably decreased for real properties in 1996, 2002 and 2010 and in particular for inventory buildings. It may result from shifting the production in majority of Lublin farms to plant production. The level of equipment of farms in Lubelskie Voivodeship with real properties deteriorated slightly in comparison to 1996. In the group which characterizes the farms with high development measure there were two provinces less; additionally in the group of facilities with low value of Hellwig measure, there were more provinces than in 1996.

On the other hand, the technical production means potential in the analysed years with reference to movables changed considerably. In 2002 a great decrease in the number took place in comparison to 1996 and in 2010 it increased to the level similar as in 1996. One may suppose that the reported increase resulted from the obtained investment funds for the purchase of machines. In 2002 in comparison to 1996 in the counties of Lubelskie Voivodeship the potential of farm movables decreased. In 2002 only one facility was in the group of facilities of the highest potential of technical production means, where in 1996 there were four of them. Moreover, the number of counties which comprised the areas with very low and low values of development measure, increased. In 2010 in the group with a high number of movables in farms, there were by 3 provinces more than in 2002.

Based on the determined spatial distribution of farm equipment with technical production means in the assumed years 1996, 2002, 2010 on the level of Lubelskie Voivodeship counties one may notice that the lowest potential both of movables and real properties took place in the city counties.

5. References

[1] Borcz Z.: Infrastruktura terenów wiejskich. Wydawnictwo Akademii Rolniczej we Wrocławiu, 2000.

[2] Golinowska M.: Rodzaje produkcji ekologicznej na Dolnym Śląsku. Journal of Research and Applications in Agricultural Engineering, 2011, Vol. 56(3), 108-116.

[3] Kukuła K., Luty L.: Dynamika wyposażenia polskiego rolnictwa w ciągniki. Stowarzyszenie Ekonomistów Rolnictwa i Agrobiznesu. Roczniki Naukowe SERiA, t. XVI (6), 296-301.

[4] Lorencowicz E.: Okresy użytkowania ciągników i maszyn w wybranych gospodarstwach rodzinnych województwa lubelskiego. Inżynieria Rolnicza, 2010, 2(120), 27-32.

[5] Muzalewski A.: Koszty eksploatacji maszyn. Falenty– Warszawa: Wydaw. ITP, 2010.

[6] Sikora J., Woźniak A.: Zróżnicowanie obszarów wiejskich woj. małopolskiego pod względem wyposażenia w środki techniczne gospodarstw rolnych. Infrastruktura i Ekologia Obszarów Wiejskich. PAN, 2005, 3, 135-149.

[7] Sikora J.: Modelling production space in the producer groups and comparative individual farms. Polish Society of Agricultural Engineering, 2014. ISBN 978-83-64377-12-9.

[8] Szeląg-Sikora A., Kowalski J.: Subwencje unijne a modernizacja parku maszynowego w aspekcie typu gospodarstw rolnych. Inżynieria Rolnicza, 2010, 3(121), 199-207.

[9] Waszg Z.: Wpływ dofinansowania unijnego na modernizację techniczną gospodarstw rolnych w Polsce. Inżynieria Rolnicza, 2009, 8(117), 267-273.

[10] Woźniak A.: Relacje przestrzenne w infrastrukturze i technicznym wyposażeniu rolnictwa w województwie małopolskim. Inżynieria Rolnicza, 2001, Seria - Rozprawy habilitacyjne nr 7.