http://dx.doi.org/10.15576/GLL/2013.1.19

GLL

Geomatics, Landmanagement and Landscape No. 1 • 2013, 19–29

ANALYSIS OF LAND CONFIGURATION OF ARABLE LANDS CASE STUDY OF MŚCIWOJÓW

Jacek Gniadek, Stanisław Harasimowicz, Jarosław Janus,
Jacek M. Pijanowski

Summary

The article contains the results of research on arable land configuration in Mściwojów. To determine the basic qualities of land configuration the following software was employed: MKTopo GUTR, Plikpol, Pole. The basic surface elements assumed for research were plots, defined as continuous parts of cadastral plots utilized only in one way. The analysis covered spatial parameters of the plots, estimated land configuration related cultivation costs, location of the land in the village and farm and basic features of the farm. The obtained results allowed to define the degree of influence of land configuration on the costs connected with cultivation and to determine if correction of land layout is necessary.

Keywords

land configuration • spatial land structure

1. Introduction

Excessive fragmentation and ackward and incorrectly shape of agricultural lands are the reason for lower agricultural production efficiency, as compared to lands properly shaped. These have an optimal harvesting area. The existing rural management solutions meant to correct the land layout are usually preceded with evaluation of the current state, which analyzes the basic spatial parameters of the plots and land configuration related cultivation costs (land configuration costs). The traditional methods of researching land configuration are laborious, because they are associated with determining many spatial parameters for a large number of surface elements. In order to improve this process, it is necessary to introduce new IT solutions which automate this procedure and give full information about the area under research.

2. The purpose and methodology of the study

The aim of the article is to analyze the existing land layout in Mściwojów (Jaworski District in Lower Silesian Voivodeship) which was not the object of land consoli-

dation, for future redevelopment. The activities were run in the framework of the VITAL LANDSCAPE project (CENTRAL EUROPE EU program). The study used an automated method for assessing the distribution of farmlands. That allowed the analysis of all the plots that make up the existing farms in the area. The basic surface elements assumed for research were continuous parts of cadastral plots utilized only as arable land. The analysis was conducted using the following software: MKTopo GUTR, Plikpol, Pole [Gniadek 2001]. This software uses the data from a digital cadastral map and from the descriptive part of digital land and buildings cadastre to produce results. MKTopo GUTR software enables gainig information concerning plots from digital cadastre map. The next software PlikPol helps in processing of gained source files, and the last software Pole enables determination of plots spatial parameters and cultivation costs which are a function of plots layout. For every plot were established: area, length, width, elongation and distance from the farmer's habitat. The study of land configuration of arable plots mainly consisted in evaluating particular features of land configuration with the values considered to be proper or optimal, and in analyzing the arrangement of the plots in the village. This was accomplished by determining their location with respect to habitats and the center of the village.

A complete evaluation of land configuration of the plots covered by the study was made using the so called land configuration costs which are the sum of the related cultivation costs and production losses. These costs were estimated under two assumptions: 5 tons per hectare (ha) production and full mechanization.

3. Area and shape of arable lands

The average area of an agricultural land belonging to the residents of Mściwojów is 2.36 ha and varies from 0.02 to 7.51 ha (Table 1).

Figure 1 presents the distribution of the number of arable lands depending on their area in hectares. The graph shows, that the minority of the plots in Mściwojów (about 21%) are no larger than 0.75 ha, and their average length ranges from 80 to 280 m. Utilization of plots that are too small is inconvenient and in case of using tractors leads to high land configuration related costs, which exceed 20 cereal units per hectare. For properly shaped plots for optimal use, these costs should not exceed 5 cereal units per hectare.

About 9% of the plots covered by the study have areas from 0.75 to 1 ha, which do not differ much from the area considered proper for mechanical farming. It is assumed that in case of mechanical farming the minimal area should be 1–2 ha [Cymerman et al. 1982, Pruszczyk and Żurawski 1991, Woch 2001]. The average length of these plots is approximately 300 m, which can be considered proper for mechanical farming. The land configuration costs for these plots are much lower than in the case of the previous group of plots and are about 7 cereal units per hectare. The remaining plots make up 70% of the plots under study and are bigger than 1 ha. Their larger area is caused by the increase to their lengths which range from 300 ha

Table 1. Basic descriptive statistics of considered features of arable plots land configuration in Mściwojów

Variable name	Statistic								
	Mean	Median	Minimum	Maximum	Interval	Standard deviation	Mean standard error	Skewness	Curtosis
Plot area [ha]	2,36	2,06	0,02	7,51	7,5	1,86	0,14	0,88	–0,01
Plot length [hm]	3,37	3,34	0,44	8,76	8,32	1,63	0,12	0,66	0,89
Plot width [hm]	0,68	0,57	0,02	3,07	3,05	0,5	0,04	1,61	3,32
Plot perimeter [hm]	8,34	8,71	1,41	18,98	17,57	3,53	0,26	0,26	0,23
Number of vertexes	5,78	5	4	24	20	2,63	0,19	3,07	14,26
Plot elongation	7,32	6,21	0,65	33,5	32,85	5,63	0,41	1,8	4,56
Number of plughing strips	0,75	1	0	2	2	0,71	0,05	0,39	–0,94
Length of ploughing strips [hm]	0,95	0,64	0,06	5,2	5,14	0,87	0,08	2,35	7
Land configuration costs without driving to the plot [cereal units per ha]	3,77	2,31	1,14	79,7	78,56	6,31	0,46	9,77	114,65
Land configuration costs with driving to the plot (bad roads)[cereal units per ha]	11,69	10,69	4,02	82,95	78,93	7,03	0,52	5,87	56,63
Land configuration costs with driving to the plot (good roads)[cereal units per ha]	6,94	6,05	2,64	81	78,36	6,25	0,46	9,27	107,35
Distance from the nearest vertex of the plot to the farmers' habitat	8,54	8,02	0,31	27,78	27,47	5,6	0,41	0,83	0,85
Distance of the plot from the farmers' habitat	10,56	9,54	1,17	29,35	28,18	5,81	0,43	0,71	0,4
Distance of the plot from the village center	9,72	8,99	1,73	23,01	21,28	4,61	0,34	0,63	0,27
Number of plots at the farm	23,92	15	2	62	60	19,4	1,42	1,25	0,03
Number of arable plots	13,35	10	1	38	37	12,29	0,9	1,37	0,25
Number of grassland plots	1,4	1	0	7	7	1,53	0,11	1,63	3,2
Area of the farm [ha]	32,99	18,02	0,47	113,47	113	39,3	2,88	1,52	0,46
Area of the arable land [ha]	31,87	17,5	0,41	110,86	110,45	38,57	2,83	1,52	0,47
Distance of the farmers habitat from the centre of the village [hm]	7,06	3,96	0,23	22,48	22,25	7,74	0,57	1,36	0,15

to more than 500 m. This is the reason why the cultivation costs are relatively low. The cost do not significantly exceed the allowable level of 5 cereal units per hectare.

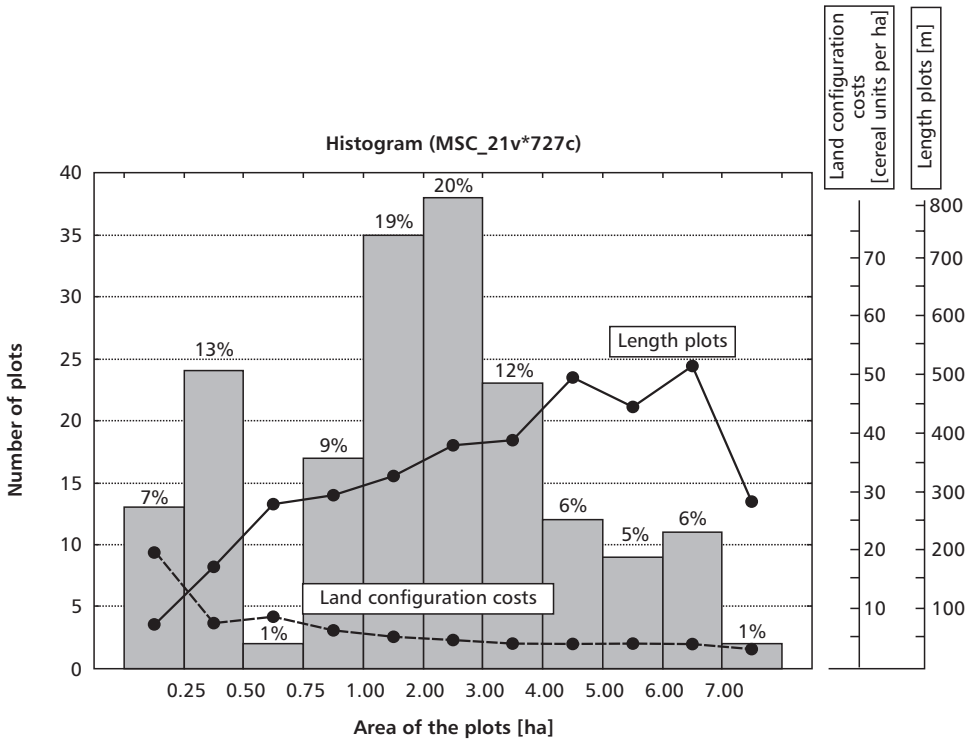

Fig. 1. Number distribution of arable plots depending on their area

The average plot length is 337 m (Table 1) and is definitely proper for the mechanical cultivation which requires plots longer than 100–150 m. The lengths of considered plots range from 44 m to more than 800 m.

About 9% of plots have short lengths, not exceeding 100 m (Figure 2). The length of these plots is more than three times their width, which is 30 m on average. In case of these plots, cultivation may be troublesome and is indicated by the big land configuration costs. These costs are about 20 cereal units per hectare. Fewer plots (6%) have the length of 100–150 m. The widths of these plots are usually twice as long as in the previous case, about 70 m. Both make lower costs. The length and width of these plots are not a significant difficulty in their agricultural utilization and the cultivation costs are slightly decreased to around 7 cereal units per hectare.

About 85% of plots are longer than 150 m. The increase of the length of the plots is accompanied by a slight fluctuations of their widths and slight fluctuations of cultivation costs. The graph under discussion shows a dominating influence of the length of grasslands and the cost of their cultivation. The shorter the plot lengths are, from the optimal length (100–150 m), the higher the costs.

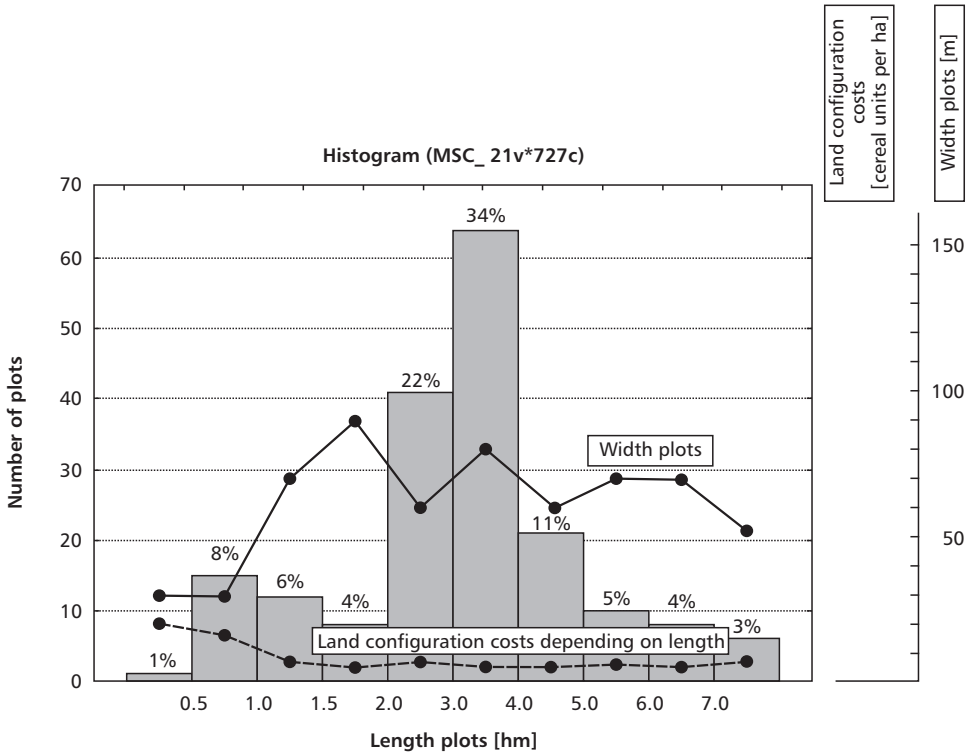

Fig. 2. Number distribution of arable plots depending on their length

The average plot width is 68 m. The number distribution shown on Figure 3 shows, that 13% of plots are less than 25 m wide. This results in considerable losses in harvest on the borders of these plots, during cultivation. These are small plots, 0.4 ha, narrow and relatively long. They average at the length approximately 210 m. Therefore, the land configuration costs for these areas are the highest and usually exceed 12 cereal units per hectare. A significant group (33%) of plots are between 25 m and 50 m wide. These plots have the proper length (average about 300 m), which is beneficial for cultivation and keeps the land configuration costs low. On the average, the cost is 7.4 cereal units per hectare. A similar group, in terms of size (32%) are plots whose widths range from 50 m to 100 m. They can be considered sufficiently large for mechanical cultivation [Harasimowicz 2002]. However, the larger widths of these plots, in the range of 360–440 m, are accompanied by increased cultivation costs in the range of 4.9 to 6.0 cereal units per hectare. The remaining group of plots, comprise 21% of the total number of plots covered by the study. In this scope, there is a significant decrease of plot length (from approximately 400 m to 250 m), which corresponds to the increase of cultivated area from 4.4 to 5.9 ha.

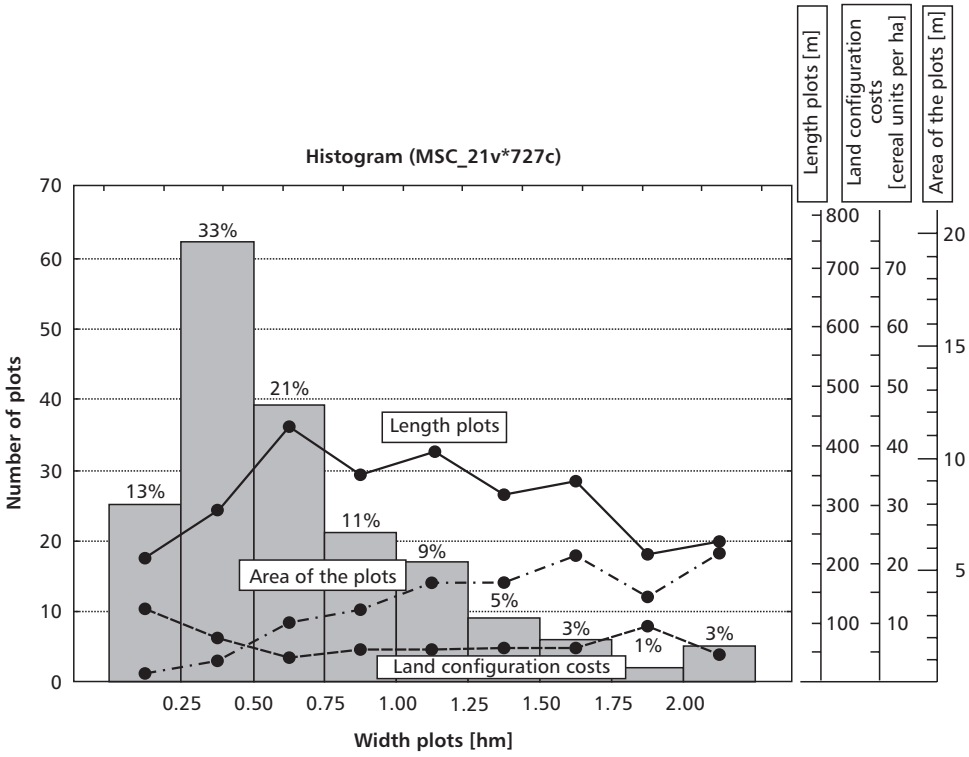

Fig. 3. Number distribution of arable plots depending on their width

The average elongation of plots is around 1:7 (Table 1). This elongation, is the consequence of adequate plot lengths, which is close to the proper value, for the plots bigger than 1–2 ha, as it should be 1:5 [Stelmach 1971].

The number distribution of plots in Figure 4, shows that around 11% of analyzed plots have small elongation, not exceeding 1:2. Considered plots of elongation smaller than 1:2 have the average areas of approximately 3.2 ha and lengths of around 190 m. The faulty elongation of these plots leads to significant increase in cultivation costs which are about 7–8 cereal units per hectare. A large group of plots, covering 21% of their total number, has elongation ranging from 1:2 to 1:4. These plots of area, similar to those whose elongation is the smallest are much longer. They reach on average about 270 m. The land configuration costs of this group of plots is, about 8 cereal units per hectare which exceeds the allowable level of 5 cereal units per hectare. In the area of study, 17% of plots have the proper elongation of between 1:4 and 1:6. They have the optimal areas and their related land configuration related cultivation costs are proper [Harasimowicz 2002]. The rest of the plots have too large elongations for their area.

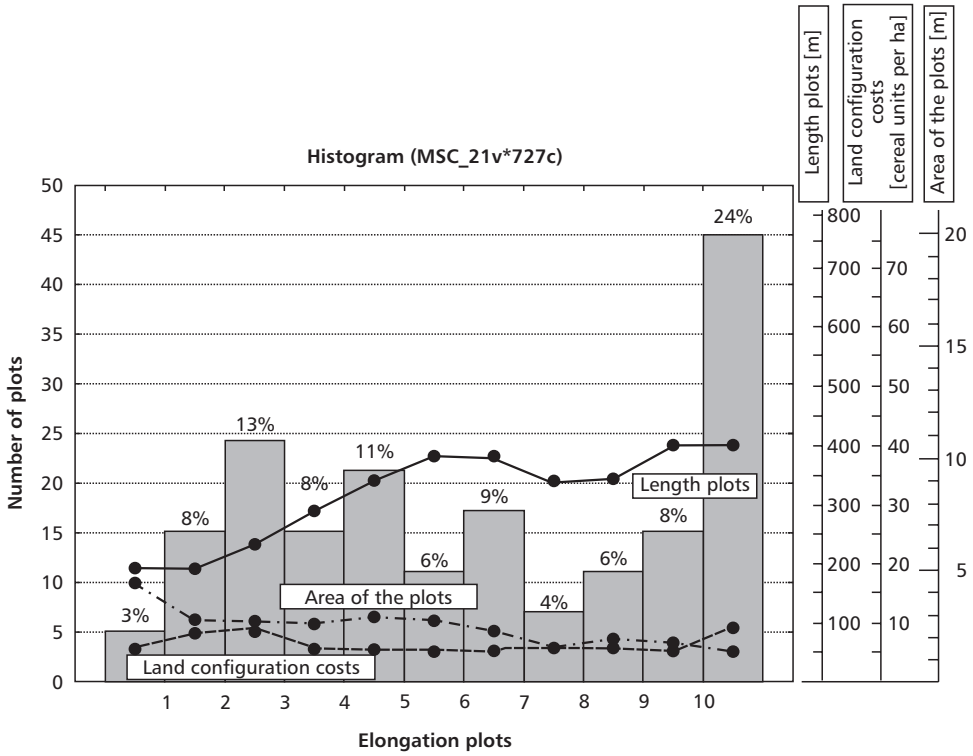

Fig. 4. Number distribution of arable plots depending on their elongation

4. Location of arable lands on farms and in the village

The location characteristics of arable lands on farms were determined by the distance from the closest corner of the plot from the habitat and on the average distance of the middle of the plot from the habitats. In order to establish the location of the plot in the village, the distance of the closest corner from the center of the village was used.

The average distance of arable lands from habitats in Mściwojów is 1056 m. This is approximately 200 m longer from the distance of the nearest corners of plots from the habitats. The distance of arable lands from habitats is very similar to the distance from the center of the village. This is confirmed by the density of buildings in the southern part of Mściwojów. Figure 5, shows the number distribution of plots dependant on their distance from habitats. The first group consists of 22% of the plots. These plots according to Dembowska and Lachert [1974a, b] are properly located with respect to the habitats, which is no further than 500 m. About 77% of plots are located within 1500 m which is the proper distance according to Przybyłowski [1998]. In this interval, the plots have the suitable area of around 1.5 to 2.5 ha and the proper lengths from 230 m to 270 m. The propriety of these parameters is confirmed by the low land configuration related cultivation costs which is no more than 5 cereal units per hectare.

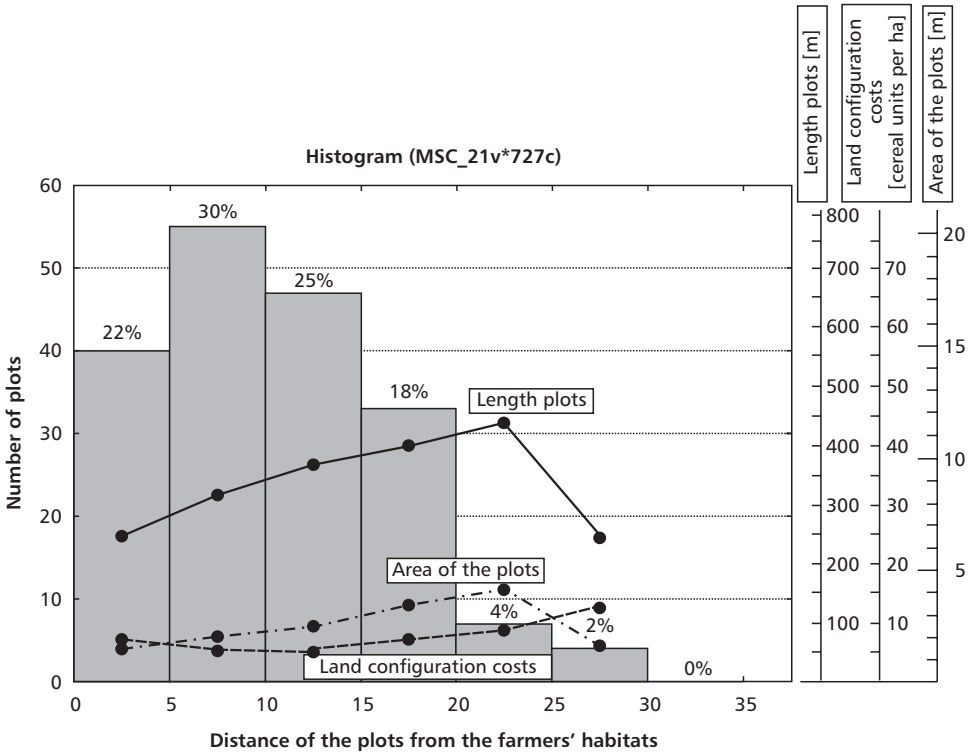

Fig. 5. Number distribution of arable plots depending on their distance from the farmers' habitats

According to Manteuffel [1971], Dembowska and Lachert [1974a, b], Przybyłowski [1991], one kilometer more of distance of lands from habitats leads to an increase in labor from 10% to 25%. This in turn results in lower income from 4% to 25% per one kilometer [Stelmach et al. 1975]. Plots located further than 1500 m from habitats have bigger areas and lengths. However, gradual increase of these parameters is associated with increasing cultivation costs which exceed 10 cereal units per hectare. This group is 23% of all the plots.

5. Land configuration related cultivation costs

The majority of arable lands have cultivation costs which may indicate unsatisfactory land configuration for the object under study, which was not taken into consideration during land consolidation. Average costs incurred on the arable lands are around 7 cereal units per hectare and range from 2.6 to over 30 cereal units per hectare.

The number distribution of arable lands depending on the cultivation costs is shown on Figure 6. The first group of arable lands, 32% of their total number, has cultivation costs below 5 cereal units per hectare. It consists of plots located on average

600 m from habitats, ergo the closest to the buildings. They have relatively large areas 1.9 ha and lengths close to 400 m. These plots have the largest areas and lengths from all the covered plots. The largest group consists of the plots on which the cultivation costs range from 5 to 10 cereal units per hectare. This group covers about 60% of agricultural lands, whose land configuration is close to average. Their average lengths are 340 m, areas 2.3 ha, and their average distance from habitats is about 1250 m.

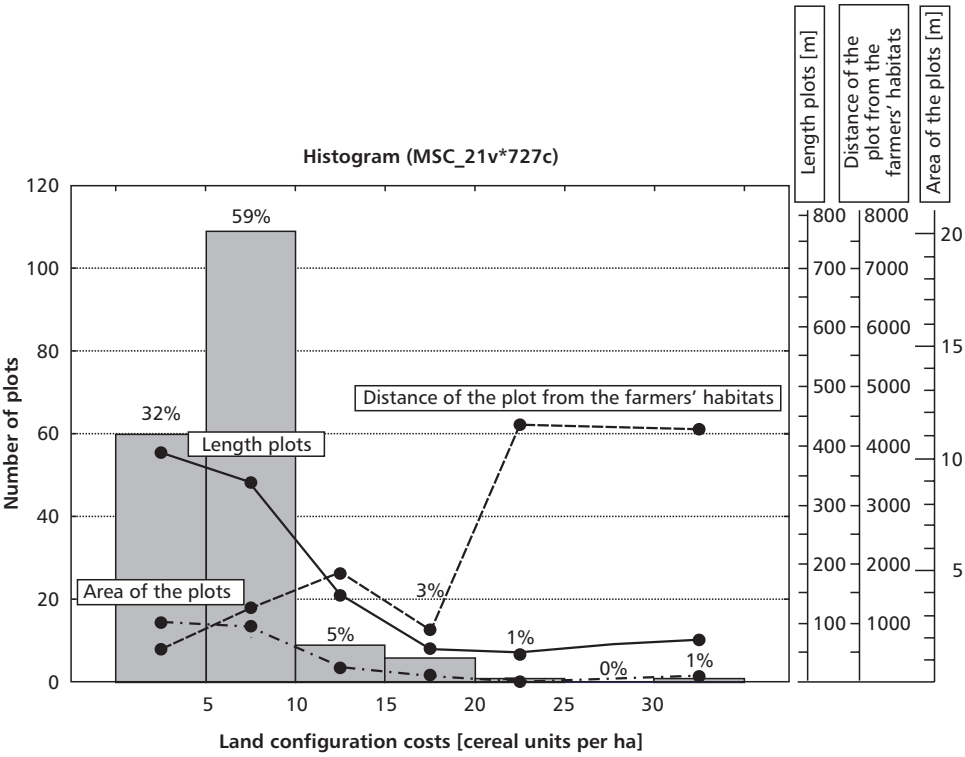

Fig. 6. Number distribution of arable plots depending on their exploitation costs connected with land configuration

Around 5% of all the plots covered by this study, have the cultivation costs between 10 and 15 cereal units per hectare. Plots in this group have areas under 0.2 ha, lengths about 150 m and are located in distances under 1800 m from the habitats. The high cultivation costs for this group is associated both with disadvantageous land configuration and too long distance from habitat.

Very few of these plots (around 4%) have land configuration related cultivation costs over 15 cereal units per hectare. Such high cultivation costs occur on plots with the poorest land configuration, whose average distance from habitats ranges from 800 m to 4400 m. The lengths of these plots do not exceed 70 m and their areas are not bigger than 0.2 ha.

6. Summary

Based on the analysis of land configuration of arable lands in Mściwojów, it can be concluded that the majority (around 70%) of plots have area considered to be suitable for mechanical cultivation. The lengths of plots are also acceptable. Nine percent of the plots have lengths which generate high land configuration related cultivation costs, reaching 20 cereal units per hectare. Incorrect widths occur in approximately 46% of plots. A majority of analyzed elements have too large an elongation for their area. In most cases analyzed plots are properly located with respect to habitats, 23% do not. Based on the land configuration related cultivation costs (which are a synthetic measure for evaluating land configuration) it can be concluded that only 32% of plots are within the correct limit of 5 cereal units per hectare in this study. The rest significantly exceeds this value. The results indicate a need for reconfiguration of land which was not the object of land consolidation and exchange. This will contribute to creating much more beneficial economic conditions for their agricultural use.

Bibliography

Cymerman R., Hopfer A., Nowak A. 1982. Ocena i waloryzacja gruntów wiejskich PWRiL, Warszawa.

Dembowska Z., Lachert Z. 1974a. Zagospodarowanie przestrzenne wsi a warunki hodowli bydła w gospodarstwach chłopskich. PWN, Warszawa.

Dembowska Z., Lachert Z. 1974b. Zagospodarowanie przestrzenne wsi a warunki produkcji roślinnej w gospodarstwach chłopskich. PWN, Warszawa.

Gniadek J., Harasimowicz S., Janus J. 2001. Automatyzacja analizy rozłogu działek z wykorzystaniem programu komputerowego. Materiały Międzynarodowej Konferancji „Rural management and kadastre". Politechnika Warszawska, Warszawa, 139–147.

Harasimowicz S. 1986. Optymalizacja podziału wsi na gospodarstwa ze względu na odległość gruntów od siedlisk. Zesz. Nauk. AR w Krakowie, ser. Rozpr. Habil. 110.

Harasimowicz S. 2002. Ocena i organizacja terytorium gospodarstwa rolnego. Akademia Rolnicza, Kraków.

Manteuffel R. 1971. Ekonomika i organizacja pracy wykonawczej. PWRiL, Warszawa.

Pruszczyk W., Żurawski Z. 1991. Metodyka określania spodziewanego wzrostu wydajności pracy w wykonywaniu prac polowych do oceny potrzeb i efektów scaleń gruntów. Zesz. Nauk. AR w Krakowie, ser. Sesja Naukowa, 31, 55–62.

Przybyłowski K. 1991. Wpływ czynnika odległości na pracochłonność produkcji roślinnej na gruntach uprawowych terenów nizinnych. Zesz. Nauk. AR w Krakowie, ser. Sesja Naukowa, 30, 69–78.

Przybyłowski K. 1998. Optymalizacja wielkości areałów gruntów gospodarstw rolnych. Biuletyn PAN-Komitet Przestrzennego Zagospodarowania Kraju. Prawne i przestrzenne problemy gospodarowania nieruchomościami, 183, 101–110.

Stelmach M. 1971. Metoda ustalania optymalnych kształtów działek ornych w gospodarstwach indywidualnych. Prz. Geodez., 1, 17–20.

Stelmach M. Lasota T. Malina R., Sugalski A., 1975. Wpływ oddalenia pól od zabudowy na produkcję i dochody gospodarstw indywidualnych. [In:] Nowe tendencje w teorii i praktyce urządzenia terenów wiejskich. AR we Wrocławiu, 126–135.

Woch F. 2001. Optymalne parametry rozłogu gruntów gospodarstw rodzinnych dla wyżynnych terenów Polski. Rozpr. Habil. Pamiętnik Puławski, Instytut Uprawy Nawożenia i Gleboznawstwa, z. 127. Puławy.

Prof. dr hab. inż. Stanisław Harasimowicz
Uniwersytet Rolniczy w Krakowie
Katedra Zastosowań Matematyki
30-198 Kraków, ul. Balicka 253A
e-mail: rmharasi@cyf-kr.edu.pl

Dr hab. inż. Jarosław Janus
Uniwersytet Rolniczy w Krakowie
Katedra Geodezji Rolnej, Katastru i Fotogrametrii
30-198 Kraków, ul. Balicka 253A
e-mail: j.janus@ur.krakow.pl

Dr inż. Jacek Gniadek
Uniwersytet Rolniczy w Krakowie
Katedra Geodezji Rolnej, Katastru i Fotogrametrii
30–198 Kraków, ul. Balicka 253A
e-mail: rmgniade@cyf-kr.edu.pl

Dr. inż. Jacek M. Pijanowski
Uniwersytet Rolniczy w Krakowie
Katedra Geodezji Rolnej, Katastru i Fotogrametrii
30-198 Kraków, ul. Balicka 253A
e-mail: j.pijanowski@ur.krakow.pl