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ASSESSMENT OF THE AGRICULTURAL ROAD NETWORK IN THE WOLA IDZIKOWSKA VILLAGE RESULTING FROM LAND CONSOLIDATION

Roman Rybicki
University of Life Sciences in Lublin

Abstract

Parameters of agricultural transport network are an important element that affects the operating costs of farms. The proper shape of the road network, suitable density and the quality (in particular the width of the roads and the type of their surface) should provide an opportune and efficient transport between home farm and some of the parcels. The article presents an evaluation of the agricultural road network in the village of Wola Idzikowska in the Fajsławice commune, which underwent land consolidation from 2004 to 2006. An inventory of the study area was conducted, and the following were determined: the distances between agricultural land and home farm, the road density index, the road extension index, and requiring different grades of the urgency of hardening roads' surface due to degradation of erosion were indicated. Eexisting agricultural transport network in quantitative terms has rated positively, whereas urgent and very urgent of hardening requires at least 4.45 km of ground roads.

Key words: road of agricultural transport, rural areas, land consolidation

INTRODUCTION

One of the factors that affect the economy of the agriculture business is the agricultural expanse of farms, which fundamentally influences the costs associated with the cultivation of individual plots (Woch 2001). Features also include: the number of farms, the shape, size of the farms, the spatial distribution of plots, the length of the borders and locations of the buildings. The length, layout and quality of the road used for agricultural transport are very important when evaluating the shape of the land configuration (Akińcza and Malina 2007).

A tool used for organizing expanses optimal for agriculture in which the ground is closest to the largest habitats in order to obtain the optimal shape of plots is ground consolidation. Although these treatments are very complex, costly, and require responsible agricultural hardware work, there are also measureable benefits in the rural development over a longer period of time (Przegon 2007). According to Woch (2006) unit work should include hardening roads, melioration of the drainage system, anti-erosion measures, agro-border regulations between the forests and meadows, as well as other arising projects from local needs apart from just improving the structure of farms, the rational formation of the expanse of land as well as adjusting the boundaries of land property to the water facilities. This applies to areas with surface features and high-intensity water soil erosions where the merging process is conducted without taking into consideration the principles of anti-erosion protection, which triggers the erosion of soil degradation and devastation of land (Józefaciuk et al. 1992). The first priority is the reconstruction of the road involved in agricultural production (Hopfer et al. 1980, Sobolewska-Mikulska and Pułecka 2007). The conducted work during the consolidation and development of post reparcelling should result in: adjusting the density of the transport network to the new spatial structure of the ground after the process of merging, the development of roads with an adequate width and surface, not be endangered by erosions, provide access to every plot. The ground surface occupied by roads should be as small as possible. The decisions made during the consolidation process should flawless. Therefore, the roads used for agriculture transport should be assessed before and after the consolidation process in terms of their suitability for agricultural transport, especially (Radziszewska and Jaroszewicz 2012):

- when taking into perspective quantitative terms: degree of compaction of roads (Gd), the rate of elongation of roads (Ud), transportation-intensiveness (T),
- when taking into perspective the quality: width, surface type, minimum radius of curves,
- from the point of view of individual farms (easy access to all agriculturally used lands with habitat farms, the shortest distance from the buildings to the farms.

PURPOSE AND METHODOLOGY

The aim of the study is to assess the agricultural road network in the village of Wola Idzikowska in the municipality of Fajsławice, subjected to land consolidation. As agricultural road was considered the road used exclusively or predominantly for the purposes of agricultural production including transport of persons, animals and cargoes and the movement of agricultural vehicles and machinery. These roads provide direct service of complexes and agricultural fields. Materials on the basis of which the study was conducted were: a digital consolidation map with a scale of 1:5000 (base plots, contour classification, land use, layers), a register of the ground before and after the merging process as well as the project management post reparcelling, developed by the Regional Office of Geodesy in Lublin (used under license No. GG.6642.683.2015_0606_LC0). The following needed to be specified for the study: the degree of compaction of roads (G_d), the rate of elongation of roads for randomly selected farms in various surface ranges, as well as the index of compactness of farms (U_z). While assessing the agricultural roads, especially in areas with erosion threats it is important to evaluate the surface, and the ratio analysis. Therefore, on the basis of the inventory of the road conditions, and the methodology proposed in Nowocień and Wawer's (2007) work, an evaluation of the roads has been performed in terms of urgency of hardening the roads, due to the soil erosion and degradation. EWMapa was used to analyze the distance and to present the results. For this purpose layer of the road network was done.

CHARACTERISTICS OF THE FACILITY

The village Wola Idzikowska is located in the municipality of Fajsławice in the center of the Lublin Upland on "Giełczewska Lofty", about 20km from Krasnystaw and about 40km southeast from Lublin. The area of the village is un-even. There are differences in levels up to 50 meters. The highest elevation (230m above sea level) is in the central area, known as "Kamienna Góra", which has unexploited quarries. The slope on the north-western part of the "mountain" is characterized with declines that exceed 15%, which is the reason behind soil erosions from degree 3 to 4 (average erosion to strong erosion). On the opposite side of the hills there is a vast undulating plateau. About 37% of the ground is threatened by water erosion. 70% is endangered by wind erosion because of the lack of anti-wind obstacles. In the structure of use, the arable land occupies 86% of the area (473 ha). The majority is good quality soil. About 87% of the acreage are class IIIa and IIIb soils – brown soils made from loess and rendzina, included in complex 2 (good wheat – located outside the slope) and complex 3 (defective wheat – located on the slope). In terms of suitability of the ground for the foundation of pavement roads, soils should be classified as low expansive soils. The arable soils in the arrangement system, extend from the buildings to the border of the village, which is about 2,5km. Before the merging process, along the plots about every 2-4 strips of soil (figure 1), were narrow roads with a width of 2 to 3 meters and a total length of 98,7km. Despite such a developed network of roads, about 70% of the plots didn't have access to the roads. Additionally, areas with bigger denivelation had roads carved by water erosions. The maximum depth reached up to 2 meters. The north-eastern and south-western parts of the area (strips of land) had plots located on terraces, where the soil borders – balks had a height of 0,5m to 1,5m (Economic and spatial assumptions for the project of consolidation 2005).

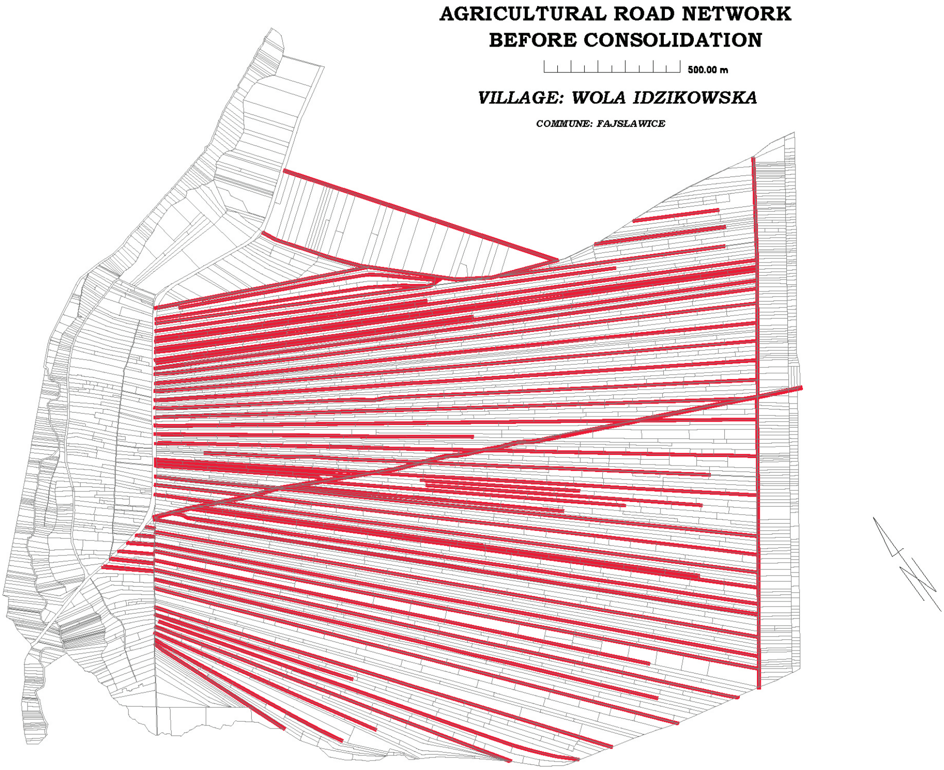

Figure 1. Agricultural road network before consolidation (source: Provincial Bureau of Surveying in Lublin)

The land of the farms before consolidation (there are only individual farms in the village of Wola Idzikowska), were fragmented (Table 1) and the plots located in a mutual chessboard pattern. Out of 602 registered units with an average area of 0,92 ha there were 2757 plots with an average area of 0,20ha. The smallest surface area of a unit was 0,02 ha, the largest surface area for a unit was 10,50ha. 10 record parcels with a surface area of 0,22ha correspond to one farm with a surface area larger than 1 ha (177 farms, average surface area 2,28 ha).

In 2004-2006, the village of Wola Idzikowska conducted land consolidation. Land management assumptions included:

- a new road system necessary for the service of fields,
- reducing the board by reducing the amount of land plots,
- eliminating unnecessary roads,
- adjustment of habitat parcels,
- allocate the area with a considerable height difference of land – slope >15% for afforestation or woodlots, eventually for sodding (about 10 ha),
- roadside foliage with a length of 1,25km along the local road going through the hilltop (Economic and spatial assumptions for the project of consolidation 2005).

Table 1. Surface structure of farms before land consolidation

Area group	Area (ha)	Number of farms	Participation (%)	Number of plots	Average number of plots in a farm	Average area of plots (ha)
< 1 ha	147,54	425	27	958	2	0,15
1 – 2 ha	132,79	95	24	655	7	0,20
2 – 5 ha	212,01	73	38	895	12	0,24
5 – 10 ha	48,02	8	9	214	27	0,22
> 10 ha	10,50	1	2	35	35	0,30
Total	550,86	602	100	2757	5	0,20

Source: Assumptions for the project of consolidation 2005

As a result of consolidation, 84km (16,8 hectares) of old agricultural roads have been eliminated (including 0,54 ha of gorges roads). The new system of rural roads is 28km, of which 14,7km are preexisting roads (intended to even the roads with a graded, which include 1,5km of asphalt to be consolidated), as well as 13,3km of new roads (including 2km planned for consolidation with aggregate). Additionally, 103km (12,4 ha) of redundant bounds had been eliminated, including the eradication of 945 m^2 of high bounds by a bulldozer. There was a decrease in the number of plots – to 1435 (48% reduction), by which the average plot area increased by 90% – up to 0,38 ha. Taking into account only the farms with a surface area larger than 1 ha (163 farms, average area 2,80 ha), there were 6 record parcels with an area of 0,44 ha per one farm (Economic and spatial assumptions for the project of consolidation 2005).

A new system of roads and plots provided all the plots access to the road. The assumptions in terms of phytomelioration, for various reasons (Przegon et al. 2016) have not been realized.

Table 2. Arrangement parameters of selected farms

Area group and number of farm	Before consolidation						After consolidation					
	Number of plots	P (ha)	Lp (m)	Lrz (m)	Ud	Uz	Number of plots	P (ha)	Lp (m)	Lrz (m)	Ud	Uz
1 – 2 ha												
G 59	9	1,24	599	643	1,07	14,07	5	1,17	412	466	1,13	9,94
G 107	12	1,14	1380	1586	1,14	29,55	6	1,65	1216	1493	1,23	24,68
G 472	4	1,49	1688	1839	1,08	41,33	3	1,12	2058	2530	1,22	22,7
2 – 5 ha												
G 33	14	4,58	1465	1730	1,18	17,89	9	4,82	1320	1706	1,29	15,70
G 54	18	2,17	1139	1480	1,30	20,22	8	2,77	1513	1920	1,16	16,16
G 61	23	2,76	962	1073	1,11	15,14	5	3,40	1210	1405	1,16	17,15
G 86	16	4,11	1677	1973	1,17	21,63	9	4,05	1305	1747	1,33	14,83
5 – 10 ha												
G 4	28	5,15	1045	1220	1,16	12,65	14	9,35	1242	1625	1,30	10,62
G 16	21	5,27	1390	1855	1,33	18,71	10	5,19	1178	1535	1,30	7,32
G 73	26	5,46	1498	1627	1,08	16,75	11	8,30	1432	1600	1,12	12,99
G 174	17	6,29	988	1023	1,03	10,85	11	6,50	922	1114	1,21	9,45
> 10 ha												
G 43	35	10,50	1053	1124	1,06	8,96	13	11,45	1266	1438	1,13	7,32

Source: own elaboration

EVALUATION OF SPATIAL AGRICULTURAL ROAD TRANSPORT

The basic indicator describing the road network used for agricultural transport in figures and used to evaluate the status of land fragmentation is a degree of road compaction (Gd). It is defined as the ratio of road length in meters (*ld*) to a supported area in hectares (*P*) (Akińcza and Malina 2007). According to Janus and Taszakowski (2014), the low value of the road network density index proves that there is an insufficient amount of roads per 1 ha. However, the high values can be interpreted in two ways. First of all, it indicates that the road network is well developed and offers easy access to the fields. However, in the context of rural management works it may indicate that there are too many roads with unfavorable land structure. Large losses in agricultural areas and difficulty in separating large well-shaped fields are disadvantages of the state mentioned above. For the village of Wola Idzikowska the road density ratio is 208 $m \cdot ha^{-1}$ when taking into consideration the length of the roads before the consolidation process, which is 98,7km (supports 473 ha of arable soil). As a result of consolidation, the length of the road was reduced 3,5 times, which caused the road density ratio to decrease to 59 $m \cdot ha^{-1}$. According to Jasiński and Nowak (1986), the most advantageous road density is 35 $m \cdot ha^{-1}$. Wherein the minimum road maintenance costs and parcels as well as their distance from the habitat are obtained in the range of 30 to 44 $m \cdot ha^{-1}$ (Akińcza and Malina 2007).

In order to properly interpret the rate of road density in terms of consolidation, its value must be weighed with an indicator defining the phenomenon of plots without access to the public road (Janus and Taszakowski 2014). The analysis conducted by the authors in the Dąbrowski district (Małopolskie province) shows that the low value of the road density ratio and high value of the plots without access to roads indicator, indicate that there are high needs for a remodel of the agricultural hardware in the village. A high density ratio and low indicator for plots without access to roads, were noticed within Żdary, which pointed out a correctly shaped road network that provides access to almost all of the plots. In the case of Wola Idzikiowska, the situation is somewhat different. The need to carry out the consolidation process (excluding large fragmentation of farms) is indicated by a high road density ratio (6 times larger than the optimum), along with a high rate for plots without access to the public road (70%). The road network after consolidation, despite being higher than the optimum value Ud (1,6 times higher), should be considered correct. This is because the indicator for plots without access to roads is equaled 0, as well as the varied terrain for which the value of Ud should be higher (Akińcza and Malina 2007). Another indicator for evaluating the roads used for agricultural transport is the extension of roads indicator Ud. It is calculated for the average farm as the ratio of the average actual distance between plots and farm center (*Lrz*), which is measured from the existing roads and field entrance to the average straight line distance between the plots and farm centers (*Lp*) (Harasimowicz 2002). It recognizes the problem in the length of agricultural transport in a more comprehensive manner, taking into consideration not only the roads, but also the field entrance and the shape of the field. If the approaches to the fields are held on winding roads and when the fields are long and narrow the ratio will be high. The closer the ratio is to one, the course of the road is more favorable and the distance used for transportation is shorter. The results from measuring the straightforward distance (*Lp*), the actual road distance (*Lrz*) for selected farms as well as the obtained road extension ratio (Ud), and the farm compactness indicator are summarized in table 2 before and after consolidation. Analyzing the data summarized in table 2, it is clear that there was an improvement in the expanse of the presented farms manifested by a decrease in the number of plots. In half of the cases (G16, G33, G59, G73, G86, G107) there was a decrease in the average distance between the farm centers and the plots (straightforward distance and road distance). In 10 cases there was a slight increase in the road elongation ratio (about 0,04 in units G61 and G73 and 0,18 in unit G174). Only in two cases, the ratio decreased. In the G16 register unit, the ratio Ug decreased from 1,33 to 1,30, while reducing the distance between the lands. In the G54 unit, the Ud ratio increased from 1,30 to 1,16, while the distance between soils increased 1,3 times. This indicates that the comparison of the road elongation ratio before and after the consolidation without comparing other ratios, can give misleading results about consolidation effects. These ratios should be evaluated individually, while paying special attention to the values or variables including the compactness of the farms Uz, in which 11 out of 12 cases showed an improvement after consolidation. The evaluated road elongation ratio in all of the cases was close to 1 (not exceeding the value of 1,33), which indicates that there is a correct increase in the road transport in relation to the distance measured in a straight line.

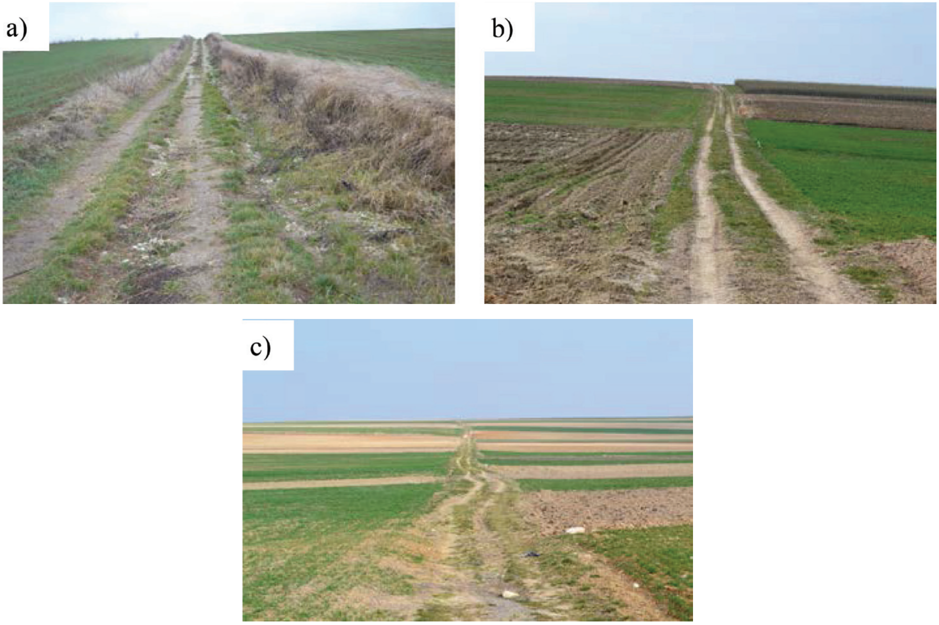

Figure 2. Ground roads with different grades of the urgency of hardening: a) very urgent; b) urgent; c) advisable locally

EVALUATION OF THE ROAD SURFACE AFTER CONSOLIDATION IN TERMS OF WATER EROSION THREATS

A significant element of the anti-erosion drainage system and the correct distribution of land in eroded areas is the adaptation of agricultural roads to the terrain, by hardening the surface and building equipment used for draining the surface (Józefaciuk et al. 2000; Nowocień and Wawer 2007, Ziemnicki 1967). Properly marked and paved roads, apart from playing an important role in the farm industry, also provide protection from erosions by draining the excess rain-water. The roads don’t undergo any damage to the erosion and they don’t sink into the terrain, which is the cause for an unchanged erosion base (Ziemnicki 1967). While evaluating the surfaces of existing roads in the researched village, special attention was paid to the protection against the softening process and their longitudinal declines (figure 3). Considering the facts mentioned above and the soil heave, the index UHRR was specified (Urgency of Hardening Rural Roads), which distinguishes classes of urgent surface treatments and implements road surface drainage hardware (Nowocień and Wawer 2007). The soil found in Wola Idzikowska, is classified as low heaving (rendzina soils and loess). In such conditions, the roads require very urgent hardening – the first stage (figure 2a) is a road with slope more than 8%. The total length of these sections is 0,54km. The length of the roads with an urgent need to harden – second stage (figure 2b) is 4,45km (slope 4-8%). The remaining 23km of roads have slopes up to 4%, where the hardening process is indicated only local – stage 4 (figure 2c). Currently the length of the paved roads – figure 3, on sections with a slope larger than 4% (urgent and very urgent surface hardening) is about 0,50km. Therefore, improving the road surface requires roads with a minimum length of 4,45km, especially if 0,60km of the roads are gorges roads with surfaces that undergo erosions (figure 2a).

SUMMARY

The study showed that designed during consolidation the road network in Wola Idzikowska should be viewed positively. The length of the roads was reduced from 98,7km to 28km, thereby recovering 16,8 hectares of agricultural land. The degree of compaction reduced 3,5 times, from 208 $m \cdot ha^{-1}$ to 59 $m \cdot ha^{-1}$. The new road system has enabled the process of designing plots with access to the road (mostly bilateral). Comparing the road elongation ratio before and after the consolidation can give a misleading picture of the consolidation results. Out of 12 researched farms, 10 cases showed a slight (maximum 17%) increase in the ratio after consolidation. Compared to the achieved reduction of the road length, the increase should be considered negligible. It is worth noticing that the assessed road elongation ratio in almost all of the cases was close to 1, indicating a slight extension of road transportation in relation to the distance measured in a straight line. These ratios must be assessed individually in terms of their value, or in conjunction with other ratios for example, farm compactness indicator (Uz) or with translation distance (Hopfer and others (1980) proposition) – actual distance with an additional emphasis on the rolling resistance depending on the quality of the roads. Taking into consideration the quality of the road surface and the risk of degradation as well as erosion, the transport network should be assessed as unsatisfactory. 0,60km of dirt roads are gorges roads subjected to continuous erosion and 4,45km of roads require urgent hardening of the surface.

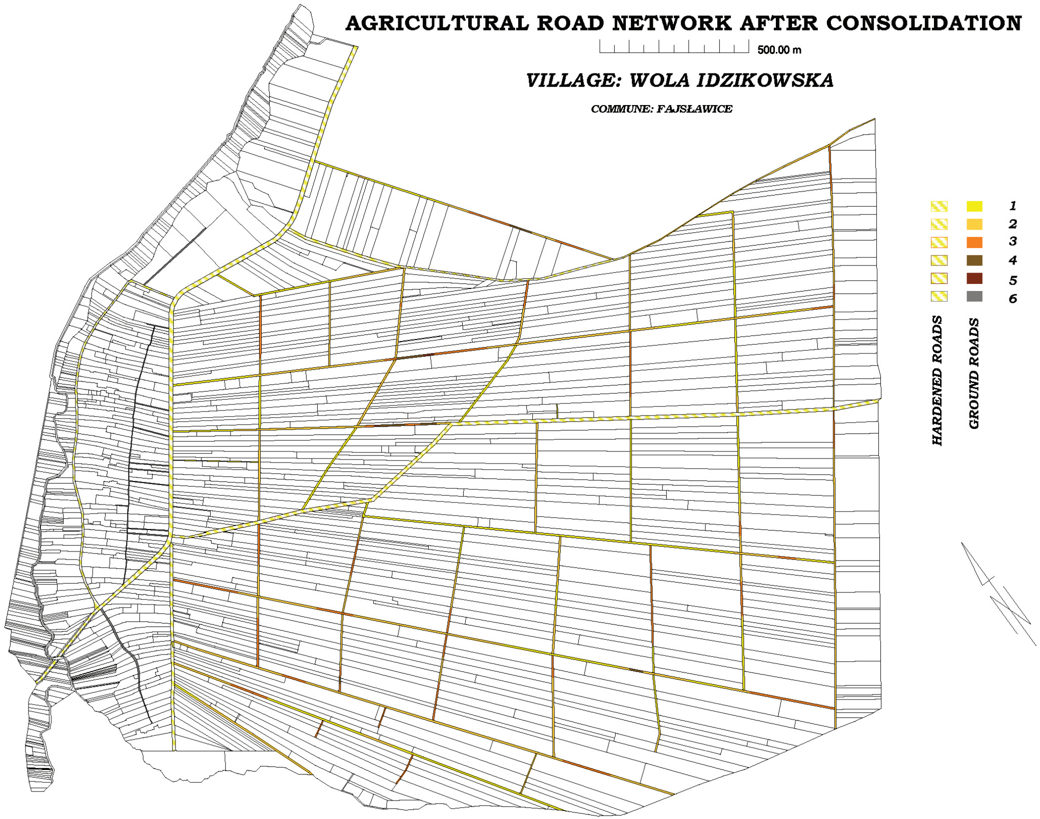

Figure 3. Agricultural road network after consolidation with inclination of road's surface: 1) inclination 0 – 1%; 2) inclination 1 – 4%; 3) inclination 4 – 8%; 4) inclination 8 – 12%; 5) inclination >12%; 6) other roads, (own elaboration on map made by the Provincial Bureau of Surveying in Lublin)

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Dr Roman Rybicki
University of Life Sciences in Lublin
Department of Environmental Engineering and Geodesy
Leszczyńskiego Str. 7, 20-069 Lublin
Tel. 81 5248128
E-mail: roman.rybicki@up.lublin.pl

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