Impact Assessment of Motorway on the Agricultural Land, Example from Motorway A4 Section Wolica Piaskowa - Czarna Sędziszowska with Application of the Author's Simplified Method

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Abstract. The method of estimating the impact of the motorway on agricultural land presented in this study allows to determine all losses related to the directions of this impact. The simplified method of assessing the motorway's impact on agricultural land is presented on the example of the A4 motorway section running through the villages of Wolica Piaskowa and Czarna Sędziszowska with a length of about 6.364 km. These are areas located in the Podkarpackie Voivodeship. The construction of one kilometer of the motorway section under consideration will result in a reduction in the value of agricultural land amounting to 867 cereal units. Taking over the land for the motorway construction and its negative impact covers about 76% of the total loss of value of agricultural land. The remaining 24% of the loss in value of land is related to the increase in transport and the deterioration of the plots layout.

1. Introduction
This study presents a simplified method developed by the author to assess the impact of the motorway on the agricultural land. Carrying out the test using this method enables the assessment of the effects of the motorway negative impact during the initial design of its route [1, 2].

For the proper analysis, it is necessary to specify following parameters:
• variability in the quality of soils located on the motorway route,
• location of the agricultural transport roads and the motorway viaducts,
• the area of agricultural land to which commuting requires crossing the motorway lane,
• parameters of the layout of plots crossed by the motorway,
• placement of protective green belts.

These data are the basis for the estimation of the variability caused by the construction of the highway for these land features, which have an impact on their production usefulness and are used to the full estimation of the impact of the motorway construction on agricultural land.

The simplified method of assessing the motorway impact on the agricultural land presented in this article allows to determine the most important directions of losses related to the construction of the motorway. [1, 3] These are:
• the loss of agricultural land for the construction of the motorway,
• decrease in the quality of land in the immediate vicinity of the road lane,
• increase of the expenditures on agricultural transport and deterioration of land plots layout.
The result of the analysis is the presentation of the change in the value of land, at which determination the diversity of its suitability for agricultural production was taken into account. This value is a determinant of the suitability of land for agricultural production.

The presented innovative method of assessing the motorway impact on agricultural land has a simplified character, thanks to that, its labour intensity is limited to a large extent, thus allowing for consideration of various variants of the route of the motorway still at the stage of designing its course and selection of the most favourable option. All processes related to calculations necessary to estimate the impact of the motorway have been automated using a developed computer program operating in the Visual Basic environment and using Microsoft Excel spreadsheets. Thanks to this approach, the use of this method is even less time-consuming. [4].

2. Characteristics of the test section of the A4 motorway

The simplified method of assessing the motorway impact on agricultural land was applied on the section of the A4 motorway between Wola Piaskowa and Czarna Sędziszowska. The section under investigation runs through the Podkarpackie Voivodeship and the Ropczyce-Sędziszów District, and its length is 6.364 km.

![Figure 1. The A4 motorway with the marked section between Wolica Piaskowa and Czarna Sędziszowska](image)

A properly designed motorway route should run along the borders of the village and as far as possible from the larger building concentrations. Thanks to this location of the motorway it is possible to limit the growth of agricultural transport on roads caused by cutting off land from the settlements. Negative effects for local residents resulting in increased car traffic are also limited. The section of the motorway between Wola Piaskowa and Czarna Tarnowska, analyzed in this study, meets the above assumptions to a very large extent. The whole section of the motorway under investigation virtually runs near the borders of the villages. The motorway also avoids the areas of intense development.

The section of the A4 motorway under examination crosses 10 local roads, of which only 4 are equipped with motorway viaducts, while 6 of them were cut without the ability to travel to the other side, however, these are mostly roads that secure transport only to the plots where they are located. The distance between neighbouring viaducts is on average 1.591 km. The distance between the motorway viaducts is one of the initial parameters, which are used to assess the impact of the motorway on increasing agricultural transport.
During estimation of the impact of the motorway section subjected to analysis on agricultural land, it was assumed that its width is close to the maximum and is equal 70 meters without taking into account the strips of protective greenery. The total width of the motorway lane will vary from 70 to 130 m depending on the presence of protective belts on one or both sides. It was assumed that the width of the protective green belt on one side of the motorway is 30 meters. Thanks to the adoption of such assumptions, it is possible to estimate the relatively high costs of buying out a wide motorway lane. They can, however, be reduced correspondingly to the actual width of the belt. There are no protective green stripes on the test section, and the width of the motorway is 70 meters.

2.1. The area of land taken over for construction and remaining in the motorway impact zone

The area of land taken over for the construction of the motorway on the examined section is 40.22 ha. It is a relatively small area. This value is mainly due to the fact that no protective green belt has been designed over the entire length of the motorway section under examination.

The areas used for the construction of the motorway and those in the zone of its negative impact include various types of land. The vast majority of these areas are occupied by agricultural land. They take in the case of the tested section as much as 90.3%. The area of agricultural land located in the area of toxic impact of the motorway is equal 103.41 ha.

The area of land located in the area of the harmful impact of the motorway is definitely larger than the area taken over for its construction. This area is directly dependent on the presence of protective green belts. If there are no protective green belts, the harmful impact of the motorway reaches 90 m from its border and reduces the quality of agricultural land by an average of 40% [5, 6]. The width of the motorway impact zone is then 180 m, and the motorway has a width of 70 m.

The creation of green protective belts on both sides of the motorway causes the increase of its width to 130 m, and the total width of the toxic highway impact zone is reduced to approximately 100 m. Often in such case, the area taken over for the motorway construction is larger than the area of its negative impact on agricultural land.

Accepted parameters regarding the area taken over for construction and affected by the harmful motorway impact on agricultural land refer to the assumptions related to the transverse profile of the motorway and the extent of its impact on agricultural land. They were set in such a way as to highlight the impact of the motorway, so that the obtained parameters of this impact can be slightly inflated. For example, the width of the motorway will be 70 m, although the minimum width of the motorway with three lanes can be 50 m. The developed computer program enables a simple change of the main parameters defining the motorway parameters and the range of its impact, such as: the width of the motorway, or the width of the protective green belt.

2.2. Cutting off land from settlements by a motorway lane

In the case of the section under test, the motorway axis crosses 10 roads, of which only 4 are equipped with a viaduct, therefore, a large part of the land requires detour commute through motorway viaducts.

The area of land to which the length of commuting will increase after the motorway has been built is 58.24 ha. However, after converting per kilometre of its course through agricultural land, this value amounts to 10.00 ha. Thanks to this conversion, the influence of the given section of the motorway on these surfaces and the intensity of occurrence of agricultural land along its route are eliminated.

On the basis of the conducted research, it is possible that the increase in the distance to the land caused by the construction of the motorway is directly dependent on distances between neighbouring viaducts and the number of roads crossed by the section under examination.

The increases in distances to land determined by the distances between viaducts will increase the amount of outlays for agricultural transport at that time, when they will be accompanied by a large area of land that requires commuting through roads that do not have overpasses. The correctness of the motorway route can be assessed on the basis of the size of the area of plots cut off from the settlements by it, [1].
2.3. Changes of the layout of plots divided by the motorway
The examined motorway section runs through 282 agricultural plots. The motorway most often intersects plots across their length, dividing them into two parts. The average area of plots crossed by the section of the motorway under investigation is about 0.28 ha. The sum of the areas of plots for which the land layout has deteriorated after being crossed by the motorway amounts to 158.37 ha. This area usually depends on the dimensions of the plots cut, the length of the motorway section under consideration and the size of the share of agricultural land in the land use structure in the area covered by the study. In the case under consideration, the area of plots with deteriorated layout referring to one kilometre of the motorway running through agricultural land is 27.20 ha.

2.4. Decrease in the value of agricultural land as a result of the motorway construction
On the basis of the conducted study, the decrease in the value of agricultural land was estimated due to the construction of the analyzed section of the motorway divided into four main directions of its impact. These reductions take into account both the changes in the unit value of land as well as the corresponding areas of land covered by the specific direction of the motorway's influence.

The total losses in the value of agricultural land on the test section of the motorway, approximately 63.64 km in length, amount to 5518.9 cereal units. For the construction of the motorway, the land worth 2062.5 of cereal units was taken over and only this land was bought by the investor. The purchase of land occupied by a road lane covers about 37.4% of losses related to agricultural land, which are caused by the construction of the motorway. The real losses of farms caused by the construction of the motorway can be estimated as twice as large as the reduction in the value of agricultural land. It happens very often that the purchase of land for the motorway construction covers about 25% of the part of the losses incurred by agricultural farms in connection with the construction of the motorway. In practice, however, the purchase price for land for motorways is 3 to 4 times higher than the average price of agricultural land [7].

The reduction of the quality of lands located near the motorway in the examined case covers on average 38.4% of the total reduction in the value of agricultural lands connected with the construction of the road.

Such high share is mainly due to the fact that no protective green stripes have been designed on the tested section. As in the case of land acquired for the construction of a motorway, this share depends on the existence of green protective belts. The lack of these protective belts means that less land is taken over for the construction of the motorway, and consequently the losses associated with this direction of the motorway are smaller. On the other hand, the reduction in the value of land caused by the toxic influence of the motorway is greater in such a situation [8]. The total impact of taking over the land for the motorway construction and its harmful impact on the land located in its vicinity is about 76% of the total motorway impact on agricultural land. On the basis of the above data, it can be concluded that the losses related to the creation of protective green belts are equivalent to reduction of the harmful impact of the motorway on agricultural land. However, it often happens that investors try to avoid designing these belts, because they cause an increase in the area of land that has to be bought. Such situation occurs precisely in the examined case.

Deterioration of the spatial structure of villages and farms caused by the construction of the motorway including unfavourable changes in the layout of plots and the increase of their distance from the settlements leads to the loss of value of agricultural land, which in the case study amount to about 24% of its total impact on arable land. The reduction in the value of agricultural land caused by the change of the layout of plots divided by the motorway on the examined section amounts to 16.2% of the total impact of the motorway on agricultural land. On the other hand, the increase in the distance caused by the plots being cut off from the settlements by the motorway lane causes the decrease in the value by 8.0%.
Table 1. The reduction in the value of land caused by the construction of the motorway for the existing section (own elaboration)

| No | The reason for the decrease in the value of land | Value of 1 ha of land [cereal units/ha] | Area covered by the change [ha] | Decrease of the income value | In the village [cereal units] | Per km of the motorway [cereal units/ha] | Per km of motorway section running through UR [cereal units/ha] | Struct [%] | Struct [%] |
|----|------------------------------------------------|----------------------------------------|--------------------------------|-----------------------------|-----------------------------|---------------------------------|---------------------------------|----------|----------|
| 1  | Taking over the land for the construction of the motorway | 51.29 - 40.22 | 2062.5 | 100.0 | 324.1 | 354.2 | 37.4 |
| 2  | Decrease of the quality of land lying near the motorway | 51.29 30.77 | 103.41 | 102.9 | 333.4 | 364.3 | 38.4 |
| 3  | Increase in the distance of land from settlements due to changes in the communication system | 51.29 43.75 | 58.24 | 21.3 | 69.0 | 85.4 | 8.0 |
| 4  | Deterioration of the layout of the plots cut by the motorway lane | 51.29 45.63 | 158.37 | 43.4 | 140.8 | 153.9 | 16.2 |
| Total | - - | 360.23 | 5518.9 | 267.6 | 867.2 | 947.8 | 100.0 |

3. Summary
The author's method of assessing the motorway impact on agricultural land presented in this study takes into account all the most important directions of the motorway's impact on agricultural land and shows this impact measurably and in comparable units. A very important feature of the used method is its very low labour intensity compared to other methods estimating the impact of the motorway on agricultural land. This is the effect of introduced simplifications in the assessment of the motorway's impact limiting the scope of obtaining initial data to analyze of the course of the motorway axis and automation of computations using a developed computer program operating in the Visual Basic environment. This method is particularly applicable during the initial estimation of the impact of the motorway construction on agricultural land carried out at the initial design stage of the motorway route and evaluation of considered variants of the course of the planned sections of the motorway.

The reduction in the value of land caused by the construction of the motorway in the case of the section under examination amounts to 5517.9 cereal units. The quality of the land located along its route has the main impact on the size of the land value reduction per unit of the motorway's length.

In total, the impact of taking over the land for the construction of the motorway and its harmful impact on the land located in its vicinity is almost 76% of the total impact of the motorway on agricultural land. However, the deterioration of the spatial structure of villages and farms caused by the construction of the motorway covering unfavourable changes in the plots' layout and growth their distance from settlements leads to the loss of value of agricultural land covering about 24% of its total impact on this land.
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