

MODELING OF THE OPTIMAL DISTRIBUTION OF MOTORWAY OVERPASSES ON THE EXAMPLE OF THE A4 MOTORWAY SECTION

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The developed, innovative method of estimating the impact of motorway on agricultural land allows determination of all the losses associated with the directions of this impact. The basis for the determination of losses is the analysis of variability in land use and the quality classes and location of access roads to the land along the axis of the planned motorway. The approved measure of the multidirectional impact of the motorway on agricultural land is a change in the value of land, which is designated taking into account the differentiation of their suitability for agricultural production.

The developed method of determining the impact of motorway on agricultural land was presented on the example of A4 motorway section between Bratkowice and Mrowla. The existing section of motorway was assessed and then for the same section the calculations were made again, but with an alternative location of the motorway overpasses.

In the case of the existing section, the construction of one kilometer of the section of motorway under consideration will result in a reduction in the value of agricultural land of 1725 cereal units. Acquisition of land for the construction of the motorway and its negative impact cover about 69% of the total reduction in value of agricultural land. The remaining 31% of the land value reduction is related to the increase in transport and the deterioration of the parcels layout. On the other hand, in the case of the section with alternative arrangement of viaducts, the value of agricultural land is reduced of 1538 cereal units. Acquisition of land under construction and its toxic impact will be equal 75%, while the combined effect of transport growth and deterioration of the layout makes 25%.

Keywords: value of agricultural land, motorway impact, farm land layout.

INTRODUCTION

In this paper the simplified method for assessing the impact of motorways on agricultural land is used to elaborate the presented research. It enables evaluation of this impact during the initial phase of the motorway designing (Bacior, Harasimowicz 2000). This method includes only general and preliminary assumptions about the motorway parameters, such as: course of the motorway axis, its width or the presence of protective green belts and consists in analyzing of the motorway axis course on the registry map. The analysis also requires information on the variability of soil quality on the motorway route, the layout of roads and motorway overpasses, the areas of agricultural land to which access is connected with the crossing of the motorway lane, parameters of the parcels layout cut by the motorway and the presence of protective green belts. These data are the basis for determining the variability under the influence of motorway construction of these land features which affect their production suitability and are then used for a comprehensive assessment of the impact of motorway construction on agricultural land.

The used method enables the comprehensive assessment of the impact of the motorway on agricultural land, including: the loss of land taken over for the construction of a road lane, decrease in production capacity of land located near the motorway as well as the deterioration of the farmland outlay cut over by the axis of the motorway. The accepted measure of the multidirectional impact of the highway is a certain variation in the value of this land, at which determination only its suitability for production was taken into account. This value is therefore a measure of valorisation of agricultural suitability of land for agricultural production.

In this paper, the existing highway section was assessed and then similar calculations were made for the same section but with an alternative location for the motorway overpasses. This analysis shows the impact of motorway overpasses location on the losses related to the motorway construction.

The used method has simplified nature, what significantly reduces its labour intensity and enables its use when evaluating the variants of the motorway course. The calculation procedure for determining the impact of the motorway was automated with the use of a developed computer program, what also facilitates its application. (Bacior 2010)

Characteristics of the studied section of the A4 motorway

Simplified method for assessing the impact of motorway on agricultural was used on the section of the A4 motorway between Bratkowice and Mrowla. This section is located in the Podkarpackie Voivodeship and the Rzeszów District. The highway runs through the villages of Bratkowice and Mrowla, and the length of the section is equal 10.834 km.

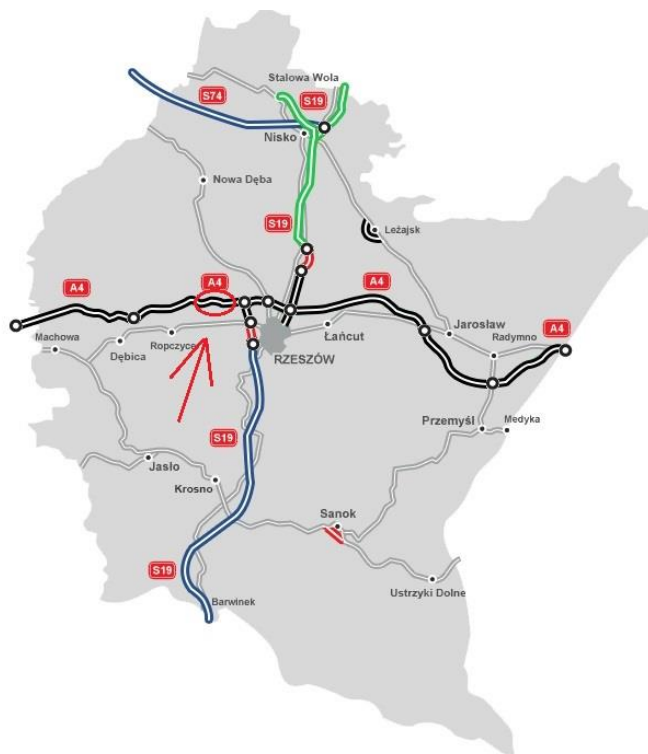


Figure 1. Location of the analyzed section of the motorway A4 (<http://www.gddkia.gov.pl>)

Properly designed motorway route should run along the village borders and at the greatest possible distance from larger clusters of buildings. Such a course allows a great extent of limitation of increase of agricultural transport on the roads caused by cutting off the land from the settlement and also it reduces the negative impact of car traffic on local residents. The section of motorway covered by the survey meets the above mentioned requirements to a large extent. The motorway route bypasses the main settlement centers of the village at the greatest possible distance and bypasses larger belts of compact buildings, but in cases where it is not possible crosses them in places, where the density of these buildings is the smallest.

The examined section of the planned A4 motorway crosses 30 roads, of which 8 are equipped with motorway overpasses; however, most of these are roads securing transport only to the parcels on which they are located. Motorway overpasses are at an average distance of 1354 meters from each other. Distance between motorway overpasses is one of the initial parameters used to assess the impact of motorway on the growth of agricultural transport. Due to the large number of viaducts and the short distance between them the impact of highway construction on rides to land is relatively low.

In the alternative version of the same section of the motorway also 8 overpasses were designed, however, the overpasses were designed on other roads. The average distance between them is the same as for existing viaducts and is equal 1354 meters.

For the estimation of the impact of the motorway section on agricultural land it was assumed, that its width is close to the maximum and is equal 70 m without the protection green belts. It has also been assumed that the protective belts have a width of 30 m. The total width of the motorway lane will vary from 70 to 130 m, depending on the presence of one or both of the green protective belts. Thanks to adopting such assumptions, it is possible to estimate the relatively high cost of buying a wide highway lane. They may, however, be reduced accordingly to the actual width of the belt.

The protective green belts on both sides cover only the first 2 kilometers of the examined section of the motorway. And there the width of the land taken over for the construction of the motorway is 130 meters, while on the remaining part the width is equal 70 m.

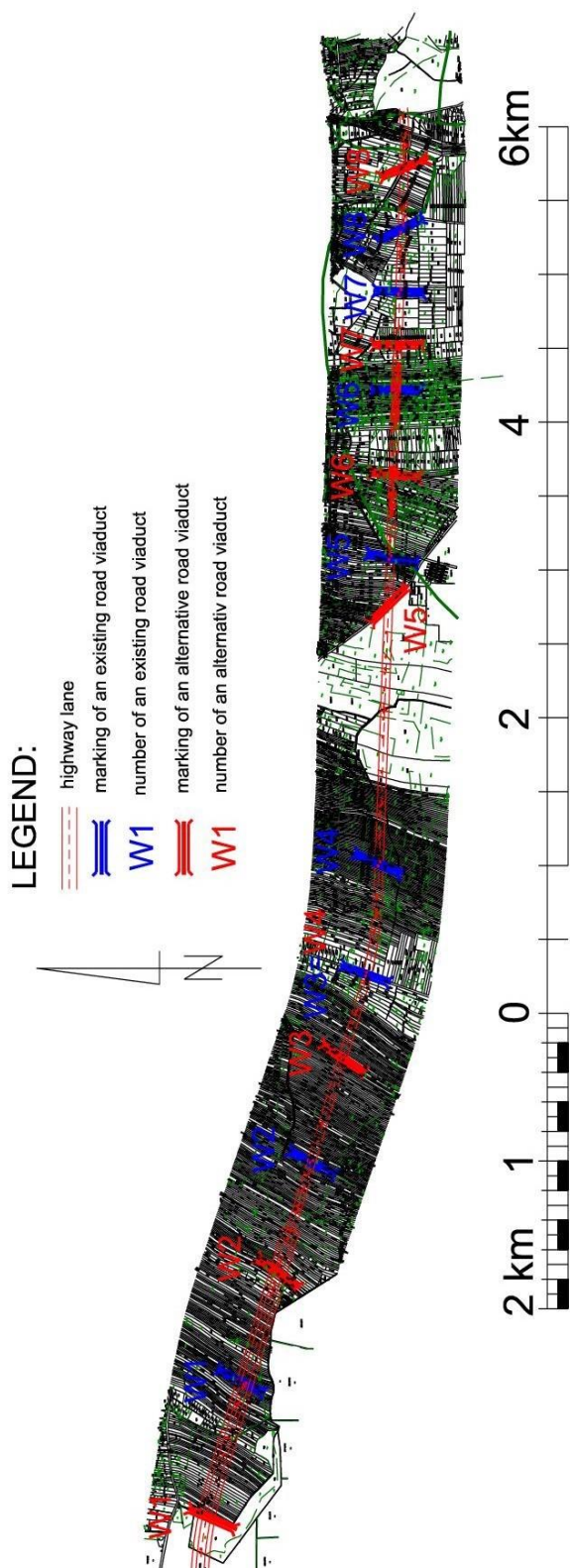


Figure 2. Location of the analyzed section along with overpasses on the registry map (own elaboration)

METHODOLOGY

A. Specifying initial parameters

In order to estimate the initial parameters, it is necessary to draw on the registry map the motorway axis and then to mark the characteristic points. These points are located in places where there is a change of use or the soil quality class and on the borders of the villages.

The next step is to measure the distances between the points and insert them into the table containing all the initial parameters.

Another parameter is the width of the area with access through the highway. This width is estimated for all roads crossed by the highway, except for the roads that are fitted with motorway overpasses. To calculate the value of this attribute - the knowledge of the rules of agricultural transport is necessary. The value depends primarily on the location of the development zones, the roads system and the village boundaries.

Next, the number of the agricultural parcels cut by the axis of the motorway and the width and length of the representative parcel have to be determined. On the basis of these this data, the impact of the highway on the size and shape of the parcel is calculated.

The last element is the information about the presence of protective green belts. On the basis of this information, the width of the motorway and the reduction of value of land directly adjacent to the lane are determined. It is assumed that the width of the green protective belt on one side of the motorway is equal 30 meters.

B. The area and quality of land taken over for the construction of the motorway and located in the belt of the highway impact

The area of land taken over for the construction of a motorway can be calculated as the product of the motorway axis length and its width. It follows that the area is dependent on the presence of protective green belts and their widths. Depending on the presence of green belts, the freeway may have a width of 70 m, when these belts are not present and 100 m or 130 m, assuming that the designed green belt has a width of 30 m.

On the basis of the measured segments between the characteristic points, the area of the agricultural land and the sil quality classes can be calculated as the product of the sum of the corresponding sections and the width of the motorway lane. By calculating the area of the soil quality classes, the information about soil quality is obtained. Measurement along the motorway axis enables accurate determination of the agricultural land structure covering the area within 10 to 20% of the area of the motorway lane. Despite this, such measurement is sufficient, because the accuracy of estimation of individual surface elements, taken over for the construction of the motorway depends on the length of the analyzed section and for a 2 km section we obtain an accuracy of about 5 - 10% (Bacior, Harasimowicz 2000).

C. The increase of distance of access to land

A motorway construction significantly affects the local transport. It crosses many roads and cuts off the land from the settlements. This increases the length of access to land, and hence, increases the transport costs. Very often it happens that the existing access is not possible and the new one is by an indirect route. Usually new commuter routes run along the motorway to the nearest overpass. In this case, the extension of access road to the land is about half the distance between the overpasses. (Curzydło 1994, Wilkowski 1995)

Determination of the area, to which the commute will be changed due to the construction of the motorway and increase of the distance to this area, using traditional formulas is an extremely labor-intensive activity. This is mainly due to the necessity of determination of the area of land with access through the highway and the extension of access to these lands. Thanks to the data included in the initial parameters, estimating these parameters is very simple. We obtain them basing on the kilometers of roads and overpasses and the width of the area with access through the motorway. The obtained values are very accurate and best reflect the actual situation.

D. Deterioration of the parcels layout

Another consequence of the construction of the motorway is the deterioration of the parcels layout. The motorway crosses parcels, causing the reduction of their area and giving them an unfavorable shape. Most of the parcels are divided into two parts. In order to determine the change of parcels layout it is necessary to determine the number of parcels intersected by the axis of the motorway and their dimensions. Since the parcel is usually divided into two parts, the length of the created parcels and their areas are reduced by half. As a result of the intersection of parcels by the motorway, two new parcels of smaller area are usually created. It follows that the degree of change of parcels layout depends on the ratio of the length of the parcel and the width of the motorway. (Harasimowicz 1997)

E. Determination of land value decrease as a result of the motorway construction

The presented method of estimation of the value of agricultural land and its changes caused by the construction of the motorway includes only the suitability of land for agricultural production (Bacior 2010).

This method covers all basic directions of the impact of motorway on agricultural land, namely:

- land acquisition for motorway construction,
- increase in expenditures on agricultural transport and deterioration of parcels layout,
- deterioration of land quality in the immediate vicinity of the motorway.

The value of agricultural land calculated using this method does not apply to the determination of its market value, and not for determining value when buying land for development. This value should be considered as an indicator of suitability for agricultural production of land, which was determined by the characteristics of the parcel and the farm. The area of interest is the range of changes in this value due to the construction and unfavorable impact of the motorway.

The decline in the value of land that followed the construction of the motorway is directly related to the change of these characteristics, which have a particular impact on the suitability for agricultural production. It is estimated on the basis of the difference between the value of agricultural land before the construction of the motorway and after the investment. (Harasimowicz 1998, Quinet 1997).

REDUCTION OF THE VALUE OF AGRICULTURAL LAND DUE TO THE CONSTRUCTION OF THE MOTORWAY

Tables 1 and 2 represent a decrease in the value of agricultural land due to the construction of the examined section of the motorway, divided into four considered directions of its impact on the examined section. The obtained values reflect both changes in the unit value of land and the corresponding land areas in a certain direction, as a result of the motorway impact. Table 1 presents the results for the existing section, while Table 2 shows the results for an alternative version of the section with motorway overpasses located in other places.

Table 1. The reduction of the land value caused by the motorway construction for existing section (own elaboration)

No	The cause of reduction of the value of the land	The value of one hectare of land [cereal unit/ha]		The area covered by the change [ha]	Reduction of income value				
		Before the change	After the change		In the village [cereal unit]	Structure [%]	Per kilometer of motorway [cereal unit/ha]	Per kilometer of motorway section going through agricultural land	Structure [%]
1	The takeover of land for the construction highway	87.11	-	81.02	7057.8	100.0	651.4	716.7	41.6
2	Deterioration in the quality of land located near the motorway	87.11	57.41	155.83	4628.8	65.6	427.2	470.1	27.3
3	The increase in distance of land from the farm due to changes in the communication system	87.11	74.50	283.08	3569.9	50.6	329.5	362.5	21.0
4	Deterioration of layout of parcels cut by the highway lane	87.11	83.04	423.18	1725.2	24.4	159.2	175.2	10.2
Total		-	-	943.10	16981.6	239.3	1567.4	1724.6	100.0

Table 2. The reduction of the land value caused by the motorway construction for alternative version of existing section (own elaboration)

No	The cause of reduction of the value of the land	The value of one hectare of land [cereal unit/ha]		The area covered by the change [ha]	Reduction of income value				
		Before the change	After the change		In the village [cereal unit]	Structure [%]	Per kilometer of motorway [cereal unit/ha]	Per kilometer of motorway section going through agricultural land	Structure [%]
1	The takeover of land for the construction highway	87.11	-	81.02	7057.8	100.0	651.4	716.7	45.5
2	Deterioration in the quality of land located near the motorway	87.11	57.41	155.83	4628.8	65.6	427.2	470.1	29.8
3	The increase in distance of land from the farm due to changes in the communication system	87.11	76.72	202.02	2099.9	29.8	193.8	213.3	13.5
4	Deterioration of layout of parcels cut by the highway lane	87.11	83.04	423.18	1725.2	24.4	159.2	175.2	11.1
Total		-	-	862.29	15144.9	214.6	1397.9	1538.0	100.0

Both for the existing section and the section in the alternative version, where overpasses were designed in different locations, the value of land taken over for the construction of the motorway is equal 716.7 grain units/ha per kilometer of the motorway running through agricultural land. These parcels are usually purchased by the investor. On the basis of the carried out research it can be stated that the redemption of land for the motorway covers only a small part of losses, incurred by farms in connection with the construction of the motorway. However, usually the purchase price of land under the motorway is 3 to 4 times higher than the average price of agricultural land (Žak 2002). In the investigated cases the acquisition of land for the construction of the motorway is equal 41.6% of the total loss of land value due to the construction for the existing motorway and 45.5% for the alternative version. This result is due to the fact that only about 2 kilometers of the section under test has protective green belts on both sides.

Lowering the quality of land near the motorway is equal in both cases 470.1 grain units/ ha per one kilometer of motorway, what includes 27.3% of the total reduction of agricultural land value in existing version and 29.8% for the alternative conception. As in the case of taking over land for the construction of a motorway, this percentage is largely dependent on the amount of protective green belts. Lack of protective belts increases the area of land affected by the adverse impact of the motorway. In the first case the total impact of land acquisition for motorway construction and its harmful effect on the land located in its vicinity is equal about 69% of the total impact of the motorway on agricultural land. On the other hand, in the case of an alternative concept of the motorway, this percentage is slightly about 75%.

Deterioration of the spatial structure of villages and farms caused by the motorway construction including negative changes in the layout of parcels and increase of their distance from the settlements leads in both cases to the loss of value of agricultural land of 175.2 grain units/ha per kilometer of the motorway (it is 10.2% of its total impact on these grounds for the existing motorway section and 11.1% in the alternative version).

Only in the case of a decrease in the value of agricultural land due to the increase in distances caused by their isolation from the settlements by the motorway the values for examined conceptions differ from each other. The reduction of the value of agricultural land caused by this direction of motorway impact is equal 362.5 grain units/ha per kilometer of the motorway (it is as much as 21.0% of total losses associated with the investment). While in the alternative version, where the same number of overpasses was designed but operating on other roads the decrease of the value is much smaller and is equal 213.3 grain units/ha per kilometer of the motorway what accounts for 13.5% of total losses.

FINAL CONCLUSIONS

The simplified motorway impact assessment methodology presented in this article takes into account all main directions of a motorway impact on agricultural land simultaneously presenting this impact in a measurable manner and in comparable units. The great advantage of the used method is its very low labor intensity due to the fact that many simplifications have been introduced in the motorway impact assessment, which greatly limits the scope of obtaining initial data needed to analyze the course of the axis of the motorway. Automation of computerized calculations is also highly influential (Bacior 2000).

The simplified highway impact assessment method is particularly useful during initial estimation of the impact of motorway construction on agricultural land, being made when deciding on the motorway course and when assessing the considered variants of the designed sections of the motorway (Bacior 2012).

Carried out examination of two versions of the motorway, which have the same course but different locations of motorway overpasses aims to illustrate the usefulness of this method, when considering different possible variants of this investment design and how much of the decrease of the value of agricultural production is due to the location of the motorway crossings. The reduction in the value of land caused by the construction of the motorway on the existing section is equal 1724.6 grain units/ha per kilometer of the motorway section, while in the alternative version having changed layout of overpasses it is equal 1538.0 grain units/ha per kilometer of the motorway section. This difference is affected by the decrease in value associated with the increase in the distance of land from the settlements as a result of changes in the communication system, which is definitely better in the case of the alternative motorway concept.

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