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ENVIRONMENTAL COMPENSATION AND MITIGATION IMPACTS OF ROAD INVESTMENTS IN EIA IN POLAND

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Summary

Planning and spatial management are very often associated with the best providing human needs that require adjustment to environmental conditions. Thus interpreted, the rational spatial management brings many benefits to the local community, often the price of it is the degradation of the environment. System solutions reduce the negative effects of the investment on the environment and society. As a part of that, an investment in the implementation of apply optimal solutions in terms of environmental and social protection are procedures for environmental impact assessments (EIA). The aim of this study was to determine the operations to minimize negative environmental impacts and methods of environmental compensation in EIA procedures in the planning and implementation of the linear investments in Poland on A2 highway from Stryków I to Konotopa section ‚E' case study. To determine the most effective mitigation methods the negative impact of the highway and activities in terms of environmental protection, simplified EIA was carried out. The most threatened elements of the natural and social environment were identified: groundwater, soil, human health, acoustic climate.

Keywords: sustainable development, environmental impact assessments, highway, environmental compensation

INTRODUCTION

The interference in environmentally valuable places in the implementation of projects is often inevitable, especially in linear investments as roads, railway lines (Ricca and Guagliardi, 2015). In such a case the principle of mitigation of the project's environmental impact and compensate losses is implemented. Enforcement of environmental compensation are procedures of environmental impact assessment (EIA) and a number of recommendations specifying the scope of assessment, the contents of reports and requirements in relation to the decision-making process. Compensation measures, mostly independent of investment project compensate for its significant negative effects on the environment (Warnback and Hiding-Rydevik, 2009; Villarroya, Puig, 2013; Soria-Lara et al., 2016). While the mitigation actions reduce or even eliminate the negative impact on the natural and/or social environment.

In the case of communication linear investments there is a high risk of conflict due to the seemingly divergent goals: the development of infrastructure and environmental protection (Therivel and Ross, 2007; Wojterska et al., 2010; Blicharska et al., 2011). The scale of this project often forces to take many and various measures to mitigate the negative impact on the natural and/or social environment (Bohatkiewicz et al., 2008; Dagiliute and Juozapaitiene, 2015). In many cases, the community submits welfare of the whole society over the individual citizens (Yuanjing et al., 2015). The legal solutions are used to minimalize the negative effects of the investment on natural and social environment. Within the framework of legal solutions primarily it implements the act of 3 October 2008 on the Provision of Information on the Environment and its Protection, Public Participation in Environmental Protection and Environmental Impact Assessments (Dz.U. Nr 199, poz. 1227, tekst jedn.). An example of a system solution is the EIA procedure, which requires collecting and interpretation of data relating to environmental elements that are vulnerable to the negative impact of the investment in the planning, implementation and use. Research and investigations carried out in the EIA are characterized by complexity, focusing on the environment as a whole and separately on each of its component. The EIA specifies the size of potential losses that will result from the project and identifies alternative solutions during the implementation and use of investment (Falandysz, 2011). In the EIA it can be indicated the location of investment, which is as little as change the balance of the local ecosystem and/or cultural landscape. The investment should eliminate conflicts or minimize their occurrence. For the local community it is important that investment is as little as possible to cause a threat to human life and health. The EIA can be an efficient tool for environmental protection (Lenar and Tyszecki, 1998; Wellington, Levis, 2016). Some of the investments, despite the indicated alternatives due to favourable of environmental

protection are implemented for economic, business or political reasons. Therefore an important element of the EIA procedure is minimization and compensation of the negative impact of the investment on the environment. The aim of this study was to determine the operations to minimize negative environmental impacts and methods of environmental compensation in EIA procedures in the planning and implementation of the linear investments in Poland on A2 highway from Stryków I to Konotopa section ‚E' case study.

MATERIALS AND METHODS

Environmental compensation in terms of EU and Polish law

The methods of environmental compensation and minimization of negative impacts on the environment are measures to protect environmental elements around the investment. This environmental compensations may relate to: (i) protect plants, animals, fungi and their habitats, (ii) protection against pollution of air, water and soil, (iii) protection against noise, (iv) protection of the landscape, (v) local society protection against the effects of cuts.

Environmental compensations are regulated by Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds and Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. The purpose of the compensation is balancing a negative impact of the investment on wildlife and their habitats. The compensatory measures should be used only when already implementing the investment having a negative effect on Nature 2000 sites while stating the occurrence of significant impact on species and habitats of animals and the ineffectiveness of other activities. According to the principles of good practice, the scope of compensation measures should include: (i) restoration of habitat in order to maintain its protective qualities, (ii) creation of new habitat which concerns the new areas as a result of an increase of the surface area of an existing protected area, (iii) enrichment of natural habitat in order to improve the quality of the rest of the habitat area proportionally to the losses incurred by the investment, (iv) conservation of species living in their habitat in order to prevent further disintegration of the Nature 2000 network (Bohatkiewicz et al., 2008).

In accordance to Polish legislation art. 3 par. 8 of the Environmental Protection Act (Dz.U. 2001 Nr 62 poz. 627) natural compensation is a set of actions, including in particular the construction work, earth work, soil reclamation, forestation, stand density or the creation of clusters vegetation, leading to the restoration of the natural balance in the area, compensation for damage made to the environment through the implementation of the project and preservation of landscape. There are no national recommendations for the methods, procedures and rules for implementation of the compensation. In Polish legislation the nat-

ural compensation is defined broader than under EU law, and refers not only to the Nature 2000, but also to areas that negatively affect investment. Polish legislation treats the natural compensation as all actions aimed to minimize or mitigate the negative impact of the investment on the environment. Additional regulations, which are in some extent contradictory with the definition in the Environmental Protection Act for environmental compensation are in the Nature Conservation Act (Dz.U. 2004 Nr 92 poz. 880) and implements the art. 6 par. 3 and 4 of the Habitats Directive. For the research were assumed the set of actions defined in the Environmental Protection Act as environmental compensation.

The study area

The study relates to a section of A2 highway from connecting points: 'Wiskitki', 'Tłuste', 'Pruszków,' 'Konotopa' in the Mazowieckie voivodship. The section between Stryków and Konotopa divided into 5 pieces of 'A' (29.2 km), 'B' (17 km), 'C' (20 km), 'D' (17.6 km), 'E' (7.1 km). The research included section 'E' of 10 Passenger Service Point (PSP) and 2 Circuit Board Maintenance Centers (CBMC). The total area of traffic lane takes 684 ha and occupancy index – 15.3 ha·km^{-1} of highway (EKKOM, 2008). In the section 'E' of A2 highway the contractor was obliged to: (i) build 2 PSP in Pruszków and Konotopa, (ii) build 7 road overpasses, (iii) build a highway bridge over the river Utrata, (iv) demolish a part of the infrastructure and rebuild sewage treatment plant in Pruszków in the district Żbików, (v) build CBMC in the area of the connecting point Pruszków including: an administrative-social building, a workshop-repair building, a service station, a car wash, a parking, a weather station, the sheds for storing equipment and accessories, (vi) the modernization and resurfacing a part of routs in the traffic lane highway, (vii) the reconstruction of the existing roads at the collisions with the motorway route, (viii) construction of the highway drainage system, (ix) construction of the facilities for environmental protection, (x) construction of the highway lighting and communications. The construction of the section ‚E' is divided into two stages: the first stage includes two roadways with two lanes each the second stage involves an expanding the roadway for an additional lane in each direction.

Spatial conditions in the investment area
Soil

Soil was studied in the areas that are impacted by the highway, in the distance of 500m from the centreline of the road. The analysis was carried out based on soil-agricultural maps in the scale of 1:5 000, of the city Pruszków, village Duchnice, Konotopa and Jawczyce. In the area of the highway, within the administrative borders of Pruszków, is located arable land of classes V, IVa and IVb and a small area of class IIIb and IIIa. Land along the river Utrata is dominated

by grassland complex 3z. Between the wastewater treatment plant and cemetery there is woodland. In village Duchnice, a significant part of the arable land the soil classes are IIIa, IIIb, IVa. In the village Konotopa predominant classes of soils IIIa and IIIb. In the village Jawczyce, within the highway influence prevail soils classes IIIb, IIIa and IVa. In the soil tests was omitted a part of the land located within the town Piastów because it is not used for agriculture**.**

Hydrological conditions

In the section 'E' of the highway there are small water reservoirs, which are often used by the local community for recreational purposes and therefore cannot serve as receivers of rainwater flowing down the highway. One of the reservoirs is located within the Park of Mazovia, 650 m from the highway. Other big water reservoirs are located near the village Moszna (250-500 m from the road lane of the highway). In the area of the highway flows the river Utrata, (right tributary of the Bzura), which valley is narrow and poorly formed and it is animal migration corridor. In addition, there is also a small network of canals, the largest of which is the channel Konotopa (wwww.pruszkow.pl). Groundwater is below 5 m and even closer to the surface (up to 2 m) and it is not enough isolated from contamination.

Cover and land use

On the basis of field inventory, as well as an analysis of orthophotos and topographic maps were characterized the landscape and the types of land use in the area of the highway. In the area of section 'E' of A2 highway dominate flat areas of the river valleys. The dominant type of landscape is natural-cultural with agricultural areas. An important subject is inactive landfill located just 200 meters from the highway, and in the sharp boundary of the Warsaw Protected Landscape Area (50 m from the river Utrata).

Wild animals and natural protected areas

Protected landscape areas are a part of the Utrata River Valley. This linear investment intersects the Warsaw Protected Landscape Area. The area within the road lane of the highway is about 2 ha. In the area of the highway there are monuments of nature. Highway in the section 'E' collides with the seasonal migration corridor of local importance. It has been found the presence of the following wild animals: hare, deer, raccoon, reptiles, invertebrates, bittern, (EKKOM 2008).
Social and cultural environment

The negative effects of the highway are: deterioration of the acoustic climate, water, soil and air pollution, and/or the necessity to change a place of residence (for a part of the population). It has been found the need for a demolition

of 94 buildings including 40 residential buildings and a demolition of 9 greenhouses and an expropriation of land from their owners and/or users. On some road sections, roadway goes at a distance of less than 50 m from the residential buildings. Highway will significantly reduce quality of life in these areas, which could lead to an increase in migration of people. The local community also suffer from cutting by the highway the existing roads, connecting the neighboring places. In Pruszków located only 20 m from highway there is a Roman Catholic cemetery of 1808. The highway is located at a distance of about 550 m from the Social Care Home for Children built in the early twentieth century, entered in the register of monuments under conservation protection (Falandysz, 2010).

RESULTS AND DISCUSSION

Expected impacts of section 'E' of A2 highway on the environment

The inclusion of clear demands in respect of cumulative effects in a number of national (Polish) EIA legislations, for the purposes of research 3 zones of highway impact: (i) I zone – at a distance of 50 m from the axis of the highway, (ii) II zone – at a distance of 50 to 150 m from the motorway axis, (iii) III zone – in a distance of 150 to 500 m from the motorway axis were separated. The impact zones were separated on the basis of indicators of a spread of lead and road noise in the air. The isolation zones of influence aim to identify areas located within the direct impact of the A2 highway. The importance of the phenomenon was determined on the basis of information concerning the nature and importance of the environmental element in the local ecosystem, by the inventory of the natural and social environment surrounded by highway. Three matrices showing the degree of the impact of the highway and the importance of the phenomenon were created: (i) general, in the phase of construction and operation, (ii) detailed in the operation phase, (iii) detailed summary statement.

Environmental elements most at risk of the negative impact of the highway

The analysis included 29 components of the environment, which were divided into 3 groups: the environment, human environment and regional policy. The negative effects of the highway are much greater in the construction phase than in the operation phase. In the construction phase it is not used special environmental protection, and the decisive factor is the quality of the equipment, the work schedule and the competence of service.

The construction phase

In the construction phase, the greatest negative impact of the highway noted for the following components are: ecological corridors, the standard of living of the local community, acoustic climate, soil, natural landscape, the intensity of

traffic (trucks). The smallest negative impact of the highway was found in the case of services and trade.

The operation phase

In the operation phase, the greatest negative impact was found for: soil, groundwater, human health, ecological corridors and acoustic climate. The positive impact of the highway includes: the rank of administrative and socio-economic, the link of the city with its surroundings, regional and national communication, amount of traffic, the reserve of the areas for industrial and service function, migrations of people, employment, industrial plants and warehouses, services and trade. In the operation phase there was a significant intensification of the negative impact on: groundwater, human health, the reserve areas for residential buildings, atmospheric air and soil. The other like local car traffic and transit, the nature of construction location directly on the ground, waste, risk of occurrence of accidents are only a source of potential negative impacts of the highway (Table 1).

Table 1. The impact of the A2 motorway ‚E' on particular elements of the environment

Sources of potential threats		Environmental components	
Group	Subgroup	Group	Subgroup
traffic-local	pollutant emissions	the environment	atmospheric air
traffic-transit	pollutant emissions		groundwater
	vibration and noise emissions	human environment	the standard of people's living
highway location	route of the highway	the environment	soil
	nodal point 'Konotopa'		groundwater/ surface water
other	accident risk		

The most at risk elements of the environment are: groundwater, soil, human health and the acoustic climate. The benefits from the construction and operation of the highway are: increase the rank of administrative and socio-economic region and more convenient communication links with the surroundings. There will be the new reserve areas for industrial function – service, which will stimulate the local economy and reduce amount of traffic (mainly transit) inside the cities. The most negative impact on the environment will influence traffic on the highway (transit), causing the emission of pollutants, noise and vibration. Interchange 'Pruszków' will have a positive impact on the environment by reducing transit and improve traffic in the direction of Warsaw.

Mitigating measures for reducing impact of section 'E' of A2 highway on selected elements of the environment

Methods to minimize the negative impact of the highway on specified elements of the environment were divided into measures planned, undertaken within the investment and proposed on the basis of the results of their own research.

The surface of the earth-soil environment

The problem of soil contamination is considered primarily in terms of utility. Contaminated soil has less biological activity, which contributes to reducing the value of utility, ecological and aesthetic values of plant and worsens the conditions of growth and yield of crops. The activities that have the greatest negative impact on the soil in the phase of highway operation primarily include mainly pollution by heavy metals (lead, cadmium) and during the winter season by sodium chloride (Bohatkiewicz, 2008). The highest lead content was found in a soil at the distance of up to 50 m from the axis of the road. The increased lead content reaches up to 500 m from the road (Potarzycki et al., 1999). Among these risks intentionally excludes the impact from sulphur and nitrogen compounds (emissions), the pH of the soil due to their small participation in acidification of soils. To determine the degree of soil resistance to the communication risks, it have to be taken into consideration: (i) mechanical composition of soils, (ii) the capacity of the sorption complex, (iii) the humus content, (iv) the soil reaction (Bohatkiewicz et al., 2008). Considering the above assumptions, the degree of resistance of soil based on the 5-point grading scale: 1 – resistance very good, 2 – good resistance, 3 – average resistance, 4 – resistance poor, 5 – very weak resistance. On the analysed area the most resistance soils are classified as brown soils and black earths proper. The average level of resistance were characterized by the numerous occurring brown soils leached.The lowest levels of resilience to hazards communications have organic soil and podsols. In the study area predominate soils with average resistance and that is why it should be taken some measures to minimize the negative impact of the highway.

The methods and measures to be taken to protect the soil:

1. The prevention of the spread of contaminants. Introduction of belts of vegetation from 10 to 25 m width functions as an insulation. In the demarcation line of the highway, pollution deposited on the road surface is transported with water to the drainage ditches.
2. The cultivation of proper vegetation and the removal of grazing animals. It is recommended to grow plants crops because of the large capabilities of storing of lead and other heavy metals in the root, stem and leaves. Reduced grazing stabilizes the contaminants and keeps constant level of resistance.
3. Increasing the value and soil quality. In the research area predominate acidic and weakly acidic soils (podsols and brown leached). It is

therefore appropriate liming soils, it is also recommended introducing a proper amount of organic matter (dose depends on grain size composition and soil type).

The groundwater and surface water

Risks to the aquatic environment are heterogeneous: permanent, temporary, potential, real. The different types of threats differ in the scale of impact and type of water, which affect surface water or groundwater. Significant risks to surface and groundwater are rainwater and snowmelt flowing down the highway, contaminated by suspensions organic compounds (aliphatic and aromatic hydrocarbons), heavy metals and chlorine compounds. The concentration of pollutants in runoff depends on its type (precipitation, runoff), type of road, traffic and land use within the highway (Bohdanowicz et al., 2008; Sawicka-Siarkiewicz, 2003). The largest threat to groundwater are the contaminants from snowmelt runoff after prolonged stagnation of snow; the concentration of pollutants in runoff significantly exceeds the limit values for discharges to surface water and into the ground, set out in the Regulation of the Minister of Environment on conditions to be met when introducing sewage into the water or soil and on substances particularly harmful to the aquatic environment (Dz.U. Nr 137, poz. 984). The degree of environmental pollution depends on the condition of atmospheric air, mainly nitrogen oxides (NOx), sulphur dioxide (SO2), particulate matter which contains lead, causing acidification of water and soil (Bohatkiewicz, 2010). The additional threats to groundwater in the area of highway are accidents involving spills and/or spilling of hazardous substances, among others, hydrocarbons, aldehydes, alcohols, acids, ammonia, which can penetrate infiltrating rainfall into groundwater.

As a part of the linear investment on the section 'E', are proposed the following solutions in order to minimize the negative impact on the environment: (i) drainage and grassy ditches that channel water for retention and infiltration tanks. Ditches will not have bulkheads or culverts with a valve that would protect the environment in the case of an accident and accidents on the road.; (ii) retention and infiltration reservoirs. The edges of the reservoir will be in the form of gentle slopes that will be settled by natural succession, while on the tank bottom and slopes will be permeable layer and filter through successive layers with less permeable drainage pipelines.

The methods and measures to be taken to protect the groundwater and surface water:

1. Petroleum products separator located in the area of CMBC point in Pruszków and on the bridge over the river Utrata. Separator with ferroconcrete frame of the lid and the hatch to the pre-treatment of rainwater and snowmelt flowing from roads, car parks and gas station.

2. Grassy ditches along the highway culverts equipped with a gate. The gate will allow to temporary cut off the contaminants flowing down or polluted rainwater to groundwater.

Atmospheric air

The problem of air protection in the highway environment is complex and difficult to solve, and the negative impact of the highway is sometimes impossible to minimize. It is estimated that in cities the vehicle exhaust emissions makes up 80% of all air pollution. The main pollutants include dust: Particulate matter (PM)10 and PM2.5, nitrogen oxides, carbon monoxide, aromatic hydrocarbons, benzene, toluene. It is predicted that the section of the connecting point in Pruszków to Konotopa in 2025 the average concentration of nitrogen dioxide within 74 m of the highway will reach about 190 g/m^3. In addition, there is a wet and dry deposition to arable land, surface and groundwater (Bohatkiewicz et al,. 2008).

As part of the linear investment on the section 'E', to minimize the negative impact on the environment were introduced isolation green belts (width of 10 to 20 m) which are the barrier to the spread of contaminants mainly dust by about 60%. In addition, green insulation will improve the microclimate of built-up areas in direct surroundings the highway. Acoustic screens were constructed, which may cause that the zone of the highway impact during proper weather conditions will be greater (Bohatkiewicz et al., 2008).

The methods and measures to be taken to protect the atmospheric air:

1. Carrying out indicated fragments of highway roads in tunnels. Despite the benefits of running road in a tunnel because of the topographic profile of the area and cost efficiency, this method is only suggested as an alternative. Carrying out the road in the tunnel would solve, among other problems: (i) migration of animals, that would move on soil layer on the tunnel, which would create a 'green bridge'; (ii) the spread of noise, construction elements and soil on the tunnel, would constitute an excellent insulation from road noise damping; (iii) pollution of soil and water, significantly reducing the amount of particulate matter, better ventilation space in the region of the highway.
2. Specify the conditions of land management between the highway and the city Piastów urban areas and in the north-east part of Pruszków. There should be prepared local spatial development plans. It is proposed a development of undeveloped areas in the forest, which will reduce the concentration of pollutants in the atmospheric air. In addition, it will have a beneficial effect on the acoustic climate areas adjacent to the highway.

The traffic noise

A good acoustic climate can be achieved by keeping the noise level acceptable by the Regulation of the Minister of Environment on permissible levels of noise in the environment (Dz.U. 2007 Nr 120 poz. 826). As part of the linear in-

vestment on the section "E", it proposed the following solutions to minimize the negative impact on the environment: (i) acoustic screens wall type construction along the limited sections of the road, (ii) embankments along limited sections of the road, (iii) trees planting and bushes along the road in the area of nodal point in Pruszków.

It is proposing additional methods of decreasing noise:

1. Gentle decreases in the road – the road longitudinal slope should not exceed 3%.
2. The creation of embankments connected to acoustic screens. It reduces the noise level to 25 dB. Embankment requires an additional area and they limit visibility of drivers therefore cannot be planned in the region of nodal points highway.
3. Consolidating of slopes and embankments and land cover directly neighboring traffic lanes with the use of vegetation. It is inadvisable the use hard pavement.
4. Direct screening of selected objects. Due to the cost specified only for objects valuable in terms of cultural or natural.
5. The use of modern technology called "pavement quiet". Reduce noise emissions by 3-5 dB.
6. Drawing up local plans for areas between the highway and urban areas. These areas should be managed in the forestry or manufacturing.

Natural landscape

Spatial planning for the development of new functions, such as industry or services, includes incorporation of road infrastructure in the surrounding landscape. As part of the linear investment on the section 'E', it proposed the following solutions to minimize the negative impact on the environment: (i) planting green belts of high and medium along the highway with the use of native species of trees and shrubs, (ii) culverts and other road infrastructure devices referring to the character of the surroundings in natural colours.

Additional measures were proposed:

1. Preservation aesthetics while finishing highway bridge over the Utrata River located within the area of protected landscape.
2. Preservation aesthetics of elements of road infrastructure in the area of culverts for animals. Aesthetics and natural colours and the area of wildlife crossings filled with vegetation will allow more frequent use of culverts and to preserve biodiversity.

Wild animals

Activities relating to the protection of animals: (i) complex transition for animals in the area of highway bridge within the Warsaw Protected Landscape Area. The transition will provide continuity of existing ecological corridor, (ii)

culverts preserving the continuity of migration routes and habitat areas, (iii) acoustic screens a wall type construction on the predominant section of the road.

Additional methods and technical guidelines for the protection of animals:

1. Protective fencing for animals along the road sections where there are no plans acoustic screens. Sections of fences must be combined with each other or with acoustic screens smoothly and sealed.
2. Imitation of natural environmental conditions in the area of the proposed culverts and of wildlife crossings. Planting shrubs and perennials naturally occurring in the area of the highway.
3. Antireflective screens in the area of pathway and culverts for animals. The design should be installed above wood and inlets move on the length of 50 m in both directions.

Social environment and protection of historical monuments

Most of minimizing is related to the protection of human life and health. In order to meet the cut social environment following actions were taken: (i) overbridges to maintain the flow of traffic and a network of connections between neighboring urban units. Overpasses for the maintenance of social relations and economic.; (ii) modernization and reconstruction of access roads to the highway. In addition, it is recommended to direct screening historic buildings.

CONCLUSIONS

Based on the study it was found that the most threatened negative impact of the highway during the construction and exploitation of the section 'E' of the A2 highway environmental elements are as follows: (i) groundwater, (ii) soil, (iii) human health, (iv) acoustic climate. The high degree of risks was also found for wildlife and air quality. The biggest negative impact on the environment will have pollution (mainly the exhaust gases), noise and vibration.

The benefits of the highway will be perceived mainly by the social environment. First of all the highway has a positive impact on the regional policy (will increase administrative and socio-economic rank of a region and link the city with the surroundings). The positive effects will be achieved also in respect of such elements as: (i) the reserve of land for industrial and service functions, (ii) and the traffic density in cities. The positive impact will have also other structures, developed in the context of investments and new and modernized access roads to the highway.

For selected environmental elements were specified measures to mitigate the negative impact of the linear investment. A total of 21 additional measures and methods of environmental protection was proposed. Most actions concern the direct protection against noise and in regard to wild animals. It should be emphasized that most of the additional actions influence positively on more than

just one element of the environment. Recommended additional actions are mainly aimed at strengthening protective measures planned in within the project of the highway. As a part of the work were taken into account the protection and the needs of the natural environment and social, to some extent disregarding economic aspects related to costs of realization of the highway.

On the basis of the analysis it can be concluded that the rate of negative impact of the highway will rise with the increase in the scale on which this problem will be considered. It concerns mainly the local environment and society in direct surroundings of the highway. Such a negative impact on the local section of the road environment cannot be skipped in any studies and projects. Despite the many benefits and facilities for the social environment of the construction of highways, skipping the needs of the local natural environment would lead to substantial changes. With time and the development of communication systems, this problem would grow, leading to permanent, irreversible environmental degradation.

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