

Development of Road Infrastructure in Environmentally Valuable Areas – Sustainable Designing

Rozwój infrastruktury drogowej na obszarach cennych przyrodniczo – zrównoważone projektowanie

Dariusz Boruszko, Wojciech Dąbrowski, Wiater Józefa

*Białystok University of Technology, Faculty of Civil and Environmental Engineering,
Ul. Wiejska 44E, 15-351 Białystok, Poland
e-mail d.boruszko@pb.edu.pl*

Abstract

The paper contains analysis of the problems of sustainable development in terms of road infrastructure development in environmentally valuable areas. We have seen a dynamic development of roads and related engineering objects in the last several years. The aim of the paper is to discuss the issues of sustainable development (and inaccuracies in terms of environmental conditions) influencing on the solution of engineering objects of road infrastructure, including bridges, carried out in the areas of National Parks and Natura 2000 areas. The article presents problems associated with a number of road investments designed and implemented in North-Eastern Poland, for which the authors developed Reports on the environmental impact. They also referred to the road building on protected areas from other countries. Problems arising from the lack of understanding of the preconditions for sustainable development, and on the other hand, construction and building conditions, have been presented. Differences between the approaches of road construction engineers and the requirements deriving from environmental regulations in these areas, have been also elucidated. Solutions making possible to reconcile designers with environmentalists have been pointed out. Analysis of these investments gave the plane to formulate questions and key comments for the solution of problems at the stage of road designing in protected areas. A proper understanding of these issues provides an opportunity to design the environmentally friendly, and at the same time, functional and safe road facilities.

Key words: road infrastructure, sustainable development, environment, environmentally valuable areas

Streszczenie

W artykule przeprowadzono analizę problematyki zrównoważonego rozwoju w kontekście budowy infrastruktury drogowej na obszarach cennych przyrodniczo. W ciągu ostatnich kilku lat obserwujemy dynamiczny rozwój dróg i związanych z nimi obiektów inżynierskich. Celem pracy jest dyskusja, jak perspektywa rozwoju zrównoważonego wpływa na przyjmowane rozwiązania odnoszące się do obiektów inżynierskich infrastruktury drogowej, z uwzględnieniem mostów, na obszarach parków narodowych i obszarów Natura 2000. Przedstawiono problemy dostrzeżone przy wielu inwestycjach drogowych zaprojektowanych i realizowanych w pñ.-wsch. Polsce, dla których autorzy przygotowali Raporty o wpływie na środowisko. Omówiono także podobne przypadki z innych krajów. Zwrócono uwagę na problemy wynikające z niezrozumienia uwarunkowań rozwoju zrównoważonego, a także konstrukcji i warunków budowlanych. Ukazano różne podejścia do inżynierii budowy dróg i wymagania wynikające z regulacji ochrony przyrody. Analiza tych inwestycji umożliwiła sformułowanie pytań i kluczowych wyjaśnień odnoszących się właściwego rozwiązywania problemów na poziomie projektowania dróg na obszarach chronionych. Właściwe zrozumienie tych spraw daje szansę na projektowanie prośrodowiskowych, a zarazem funkcjonalnych i bezpiecznych dróg.

Słowa kluczowe: infrastruktura drogowa, rozwój zrównoważony, środowisko, obszary cenne przyrodniczo

Introduction

Construction investments are inextricably linked to the economic development of each country. Expansion of towns and settlements, construction of industrial, commercial, recreational and communication network is necessary and results from regional development strategies. In order to make their implementation possible, it is necessary to prepare the land earmarked for development. In many regions of our country, lands under construction are increasingly limited, and furthermore the investors often care of an attractive investment location. For this reason, more and more construction projects dangerously close to areas of high natural values and protected, and often enter these areas. To minimize the negative impact of the investment on the environment, several variants are developed and then assessing their positive and negative effects, some alternative that is the best and the least disturbs the environment, is selected (Szafranko, 2017).

Nowadays, Poland is the largest road construction site in Europe. One of the main reasons for this situation are many years of neglect and abandonment in the construction and expansion of Polish roads. The dynamic growth in the number of vehicles on Polish roads, including vehicles with large masses in transit, has led to a critical situation, in which a need for well-prepared development of the road network is the order of the day. On one hand, the road network in Poland to be closer to European standards, which would contribute not only to increase the safety and traffic flow, but also to improve the living and working conditions of people living in the vicinity of roads. On the other hand, the road infrastructure with traffic generate various factors, which are not only a threat to human health, but also to the environment. There is no doubt that the social considerations require removal of transit traffic to the correct distance beyond the regions inhabited by man. However, this leads very often to conflicts of interests between local community and the environment. This is particularly apparent when we consider the Polish regions, where a large number of valuable nature sites (mostly Natura 2000 areas) have little room for maneuver during the expansion and reconstruction of existing roads (Kobryń, 2007).

Rapid implementation of road investments cannot, however, be carried out to the detriment of the environment. Can universal globalization be reconciled with the protection of nature? (Drogi przyjazne środowisku... 2017, Pawłowski, 2009). Road construction is undoubtedly a branch of the engineering industry contributing heavily to the degradation of natural resources. Starting from the stage of natural resources extraction, through the technology of building materials production, to planning and designing of routes, as well as implementation and operation of the routes, a harmful or destructive inter-

ference with ecosystems takes place. It has consequences in a form of fragmented habitats, disturbance of hydrological relations, or disturbance in the landscape harmony. These phenomena are accompanied by majority of road projects (Leniak-Tomczyk and Łagoda, 2007).

With reference to the above development of the road infrastructure on environmentally valuable areas in Europe and in the world a multidimensional-ness of the sustainable development and his following aspects are putting their name down:

- the ethical dimension (the issue of humanity's responsibility for nature),
- the ecological dimension (nature conservation, protection of the environment created by humankind, spatial planning),
- the social dimension (since the social environment – and not merely the natural one – may experience degradation),
- the economic dimension (taxes, grants and other economic instruments),
- the technical and technological dimension (new technologies, being economical with raw materials),
- the legal dimension (environmental law),
- the political dimension (formulation, implementation and enforcement of sustainable development strategies) (Pawłowski, 2009).

It is therefore necessary to develop appropriate mechanisms to assist in making the optimum decisions in the field of the road infrastructure development taking into account the negative impact both on the environment, but also on the health of users and people living in the immediate vicinity of roads.

Range of problems of the sustainable development

Investments, that are most commonly the cause of a collision with valuable nature areas, and consequently also the subject of environmental conflicts, cover a wide range of projects. However, one can identify the objects that are most likely the cause of such a situation. Basic groups of these facilities primarily include linear investments, especially of great length, whose course is difficult to determine with complete excluding areas with high natural values. In the group of linear investments, the road projects are included within the most conflict-collision making ones (in particular, motorways and expressways, city ring roads, and other roads with heavy traffic). In the last few years, it can be seen an increase in the intensity of social conflicts related to the implementation of projects that may cause significant negative changes in the resources and natural beauty of environmentally valuable areas. The term *conflict* is often confused with the notion *human impact on the environment* or *environmental degradation*. However, not every negative impact of human activities

on nature creates conflict. The occurrence of environmental degradation (which can also be referred to as collisions with the environment) is not always associated with the creation of the conflict, since a social subject (person, group) must be found, which reveals the emergence of this degradation and finds that it is in contrary to its interests or views. In addition, conflicts can arise even when environmental degradation has not occurred yet, and only guess that it may occur in the future. Locating the investment in environmentally valuable areas is a growing problem not only when environmental conflicts arise, but always when it results in irreversible losses or changes in the environment. Genesis of the growth in the number of investments located in environmentally valuable areas and emerging as a result of environmental conflicts recorded in recent years, is relatively complex. Among the root causes, Kistowski (2008) lists:

- rapid and often chaotic privatization of large areas, carried out mainly in the 90s of the twentieth century, in areas of the former state farms, part of post-military, municipal and forestry areas, during which, the interests of the state and part of the citizens to have the right to use and control of natural areas has not been taken care;
- Polish accession to the European Union, which on the one hand resulted in the influx of huge funds, most of which has already been allocated for investments, e.g. roads, and on the other hand, which leads to the necessity of compliance with EU law, for example The Habitat Directive (92/43/EEC), which is the basis for creation of Natura 2000 areas;
- lack of a stable legal system, in particular in the field of nature conservation as well as planning and land use;
- investment pressure due to the increased dynamics of socio-economic development during the last few years, combined with declarations of a compliance with the constitutional principles of environmental protection and sustainable development;
- changes in behavior and preferences of Polish society; on the one hand increasing the environmental awareness and associated rights to live in the natural environment with good quality, on the other hand, increasing public demand for material goods and the use of comforts of life often invested in environmentally valuable areas or in their vicinity is considered a factor enhancing the attractiveness and thus the economic value of these objects.

It is possible however to notice, it is reasonable to suggest that we possess the technology to allow protected areas to be maintained in a state that does indeed allow future generations undiminished possibilities for making use of them. The problem here is that, thanks to the high costs involved – and (in part in consequence of that) a perceptible lack of will to

act, there is ongoing degradation of protected areas – so ongoing in fact that an *irreversible* state of degradation may be being approached in certain areas. Thus, while humankind may be in possession of the appropriate technical and technological power allowing for environmental sustainability to be achieved, this aim is not being pursued in many areas on account of an absence of the will to target the necessary material resources at the problem (Pałowski, 2009).

Problems of the road infrastructure development within the protected areas

Poland is one of the few countries in Europe where relatively a lot of valuable natural areas have been maintained and where populations of rare species of animals, such as bison, moose, bears, lynx and wolves, have been survived. These biocoenoses are our contribution to the natural resources of united Europe, and because of the particular geographic location of Poland, they appoint us as an important link in the process of Western Europe colonization by species eradicated there in previous centuries (Leniak-Tomczyk and Łagoda, 2007).

The north-eastern territory of Poland, including Podlasie, is located in an area of outstanding individual features in comparison with other regions of the country. A significant individuality of the region is at the same time accompanied by a multitude of natural objects and perfect state of their preservation. These are the areas of highest worldwide virtues, for instance Białowieża Forest (included in the global system of Biosphere Reserves), or Biebrza River Valley (the largest natural complex of bogs in Central Europe). In particular, the presence of large and poorly fragmented forests, a large area of meadows and bogs, and the abundance of lakes in the area of young glacial landscape in the north of the region, represent an enormous attractiveness of the area. Białystok, which is the capital of the region, occupies a central position relative to most major complexes. Within several kilometers, there are: Knyszyn Forest, Biebrza River Basin with the National Park, Narew River Valley with the National Park. Within a radius of several tens of kilometers, there are: Augustów Forest, Białowieża Forest, Borecka Forest, Romińska Forest, Suwałki National Park, Wigry National Park, and Bug River Valley. Almost all of these objects entered in whole or in part, within Podlasie province, in the ecological network Natura 2000 (Kwiatkowski and Doroszkiewicz, 2007).

Against the background of the country, this region stands out above average natural values. A large natural values of the province are determined by a large proportion of forests (29.2%), grasslands (19.8%), wetlands (3%), and waters (3%). Forests are preserved in the form of large complexes. They are: Białowieża Forest, Knyszyn Forest, and Augustów Forest. The province is intersected with broad river

valleys: Narew, Biebrza, and Bug. The post-lake landscape represents the area north of Suwalki. Ecosystems, natural habitats, specimens of species and their habitats, forms of nature and landscapes, deserving special protection, are covered by different forms of nature protection. In Podlasie province, there are 12 special birds protection areas and 24 areas for Community Importance (designed special areas for habitat protection), representing over 31% of Podlasie province territory. Location of special bird protection areas is related to the concentration of a birdlife in the valleys of following rivers: Biebrza, Narew, and Bug, and forests areas: Białowieża, Knyszyn, and Augustów. Special habitat protection areas are associated with wetlands, especially river valleys, bogs, water reservoirs, forests, as well as extensively performed grasslands (Natura 2000, 2017). In the face of this rich set of *natural objects*, it becomes clear that the road network in the region repeatedly crosses the areas covered by different forms of protection. Of particular importance here is the role of bridges (Karaś and Bohatkiewicz, 2015). Consequently, development of road infrastructure in Podlasie region more and more often raises environmental and social conflicts. It is applied to a long process of investment planning and overcoming a series of procedures aimed at reducing the negative impact on the environment. New legal grounds and establishing the Natura 2000 areas significantly changed the mode of road implementation in Podlasie province and often made even impossible the continuation of investments having been already underway. Desire to leave the region with possible the largest protected areas is almost always in collision with infrastructure development in the region, enabling the financial advancement of Podlasie society and improving the standards of people living in villages around the routes (Górnjak and Wiater, 2007). Similar issues are regarding the development of a system specially protected natural areas (SPNAs) in the context of the concept of sustainable development in Russia. The authors suggest ways of finding a balance of economic, environmental and social interests in SPNAs, which will not lead to a decrease in their number or area, however, prevent a number of economic and social problems. The change in approaches to the management of the system of SPNAs including in terms of their creation, modification of their boundaries or termination of their operation will allow including SPNAs in the system of social economic relations of regions and certain countries, provide an opportunity to withdraw from the current one-sided bias solely in favor of environmental factors. This will ensure the necessary balance of the interests of the local population, business and protection of nature (Anisimov, Lidzheeva and Ryzhenkov, 2017).

Economic and the economy importance of environmental impact assessments for the development of Irish road projects was underlined among others in

the Foundation report for the Economics of Sustainability FEASTA (Douthwaite, 2007).

In Lithuania an intense influence of the development of the road infrastructure and meaning of the sustainable development were also emphasized to natural environment and environmentally valuable areas. Transport infrastructure, its components, relations with other objects, even participants play a great role in the formation of an attractive living environment. The influence of transport infrastructure on the living environment can be described by the number of indicators which are determined and systemized while preparing development projects. The social-economic assessment is usually used for transport investment providing a comprehensive evaluation of projects profitability and cost-effectiveness. The results are used in the process of decision making seeking to determine whether it is appropriate to implement separate development projects and to form priority options for investment. However, even the social-economic assessment often faces uncertainty (Griškevičiūtė-Gečienė and Griškevičienė, 2016).

In Latin America within protected areas to read about problems of the development of the road infrastructure we can among others in the Natural Capital report & Roads. This document illustrates how incorporating ecosystem services into road project design and development can lead to more sustainable, cost-effective roads while maintaining or enhancing the additional benefits nature provides to the region's citizens, from clean water and air, to food and timber (Lisa Mandle and Rob Griffin, 2014).

The Twenty-First Century will see an unprecedented expansion of roads, with at least 25 million kilometers of new roads anticipated by 2050 (Laurance et al. 2014). Nine-tenths of these new roads will be in developing nations, which sustain many of the planet's most biologically rich and environmentally important ecosystems (Laurance et al. 2015). While roads are critical for economic development, these ecosystems and the services they provide are vital for sustaining life. Roads are key drivers of land use change and deforestation, threatening biodiversity. In Latin America and the Caribbean, commercial agriculture facilitated by transportation networks is a leading driver of deforestation (Watkins, 2014).

The challenge is for road development to proceed without having detrimental effects on the environment and local communities (Quintero, 2012).

Environmentally friendly roads

In the last several years, the authors worked on reports on the environmental impact of several road projects designed and implemented in North-Eastern Poland, for which environmental decisions were achieved.

During development of those reports, a series of criteria and factors for variants of road projects, were set out. It included the following main criteria for

further review of different options of investments (Abu Dabous and Alkass 2008, Dytczak 2010, Szafranko, 2017):

1. Functional criterion (length of the route of the analyzed variant, accessibility for transport (number of nodes), bandwidth of the route and the level of movement freedom, etc.);
2. Technical criterion (number and area of engineering objects, technical solutions, engineering-geological conditions, collisions with the technical infrastructure, etc.);
3. Movement criterion (travel time, traffic safety, etc.);
4. Economic criterion (value of the project, rate of benefits, value of land designated for redemption, price of the current annual road maintenance, etc.);
5. Environmental protection criterion (crossing with watercourses, length of the intersection with valuable natural areas, areas of natural habitats, which can be destroyed, intersection of animal migration routes, amount of dangerous substances emissions, number of trees to be cut, etc.);
6. Social environment protection criterion (possibility of social conflicts, compatibility of the project with provisions of the local spatial development plans, number of households covered by the negative impact zone, number of houses provided to address in connection with planned investment, etc.).

Today, when building or upgrading each route, several variants of the route are created. Each of them is subjected to a thorough analysis by the team of experts to assess whether the investment is threatening the natural environment. Among others, the impact of the construction on the status of the groundwater, plant or animal habitats, is examined. On this basis, solution that is the least detrimental to the environment, is chosen then. In a situation that the route runs through the area extremely valuable – particularly the area included in the Natura 2000 network – and it is impossible to avoid the loss in nature, the road builders are obliged to compensate the damage. Thus, they plant trees in place of the cut ones, include the positions of endangered plant and animal species with a special care, build shelters for the birds or take compensation measures. To reduce the interference of a new investment towards nature, designers and investors should use environmentally friendly technologies. At highway construction sites, non-toxic materials, harmless to the environment and safe for future road users, should be used, while ensuring the sustainability of infrastructure. Engineers in a responsible manner should also apply raw materials not depriving their natural resources. New and upgraded roads must also be environmentally friendly during their use. Therefore, they are equipped with modern infrastructure to protect soil and water from pollutants emitted from vehicles and

from a layer of bituminous pavement. Natural and artificial barriers separating the noisy route from human and animal communities are also built on the roadside. Safe passages to migrate between habitats are constructed for mammals, reptiles and amphibians. Built roads, viaducts and bridges should not violate the natural landscape, but be aesthetically composed to it. Poland is one of the few countries with such a large diversity of terrain; one can meet up with mountains of alpine character, lowlands and highlands, vast lands of lakes, as well as sand dunes and cliffs. This places high demands to architects, but also to greenery designers planning belts of trees and shrubs along the roads. In this regard, Scandinavian engineers are the role models (Drogi przyjazne..., 2017) .

Key issues to solve

The above problems and conditions allow the isolation of a number of key issues, whose solution and proper understanding gives the chance to design environmentally friendly and at the same time functional and safe road facilities.

One of the key issues to solve are in general the legal aspects. We can on the one hand talk about the faulty national legislation, and their too often changes. As regards, for example to the law on spatial planning and development (e.g. insufficient rank of the condition study in a municipality or no obligation to produce or eco-physiographic development or a prediction of the impact on the environment at some levels of planning), turning off the localization of part of the project from the provisions relating to spatial planning. In addition, over the past several years, major changes in regulations took place repeatedly affecting the way to take into account natural conditions at the stage of investment location, and in particular the manner of developing an environmental impact assessment. Only part of these changes can be regarded as conditioned by objective factors, e.g. Polish accession to the European Union. This resulted in the situation that subsequent phases of the investment process took place against various provisions in force. Often during this process, e.g. an obligation to prepare environmental impact assessment appeared, which previously did not exist, or widened (or *narrowed*) the range needed to draw up the assessments. These changes generally complicate and prolong the investment process. On the other hand, we still can talk about inconsistency of part of Polish legislation with the EU law; there are still shortcomings in the implementation of EU law into national law. Of course, deficiencies in national law also arise in part from inconsistencies in EU law. In three the most important directives governing these issues: on the assessment of the effects of certain plans and programs on the environment (Dyrektywa, 2001), on the assessment of the effects of certain public and private projects on the environment (Dyrektywa, 1985),

and on the conservation of natural habitats and wild fauna and flora, there are considerable differences in the approach to take into account the natural circumstances in the course of the investment location, especially the obligation to carry out an environmental impact assessment. These provisions in a different way have the approach to the issue of obligation to produce a number of alternative solutions of a given investment, which does not facilitate the formulation and evaluation of alternatives during the process of planning and localization (Twardowska, 2007).

Another important issue affecting the sustainable designing of road infrastructure is insufficient public participation in planning procedures, and within them, in the environmental impact assessment at this stage. In the last decade, the level of social interest in those processes in an early stage of planning has increased. The desire to participate is reported mainly by social organizations (usually ecological), and not by local residents. Residents – to a small extent – are interested in the impact of the investment on nature mainly when it has already to be formed and may directly threaten their economic interests or their quality of life.

An important cause of various conflicts is still often poor quality of the projects of spatial plans, design of projects, and reports and forecasts of the environmental impact. Unfortunately, it often stems from the weak skills of their contractors. While in the case of urban planners and architects, there is a system of authorizations and professional associations of these bodies (SARP, TUP), which may use disciplining instruments, the preparation of environmental impact assessments does not currently require any certificate, experience and education (in practice, everybody can make them). Errors made in these assessments may have far-reaching negative consequences for the environment. On the other hand, not only people conducting the assessment should be blamed, because they have a limited impact on the final form of the project design or policy, strategy or plan, for which they prepared the report or EIA forecast.

An important issue, although fortunately occurring in ever smaller scale, is so-called investor's arrogance. As a rule, they *push* only one variant of the project guided mainly by economic criteria and they do not allow the possibility of significant changes in their concepts and projects. Still it comes to attempts of forcing the administration favorable decisions or determination of not always environmentally friendly solutions to the designers, making financially-dependent contractors. Because investors bear the costs of preparing the reports on the impact on the environment, they often demand favorable opinion in relation to the authors of those studies.

The above issue is related to still frequent insufficient commitment of administration. Because of low wages, labor shortages and cases of lack of competence, the local administration at various levels often does not sufficiently affect the implementation of en-

vironmental issues to the localization process. One can distinguish too passive and too active attitude in the administration. The former consist e.g. in a lack of sufficient control over the investment process or level of planning, design and document assessing the impact on the environment studies. Too active attitudes involve promoting or obstructing the investors *at any cost* (Kistowski, 2008).

Still, we can also speak in many cases, about the lack of adequate and current information on nature. Often the knowledge about resources and natural beauty is insufficient. Wider knowledge of the resources and values of nature exists only for protected areas (nature reserves, national and landscape parks, Natura 2000 areas). This often causes the need to carry out costly and long-term natural inventory in areas of planned road investments at the expense of investor.

Summary

Among the great diversity of engineering facilities needed for economic development, the linear objects deserve special attention (Szafranko, 2013). Their implementation is related to a number of problems, mainly due to the fact of their great length, often tens of kilometers, which often come into conflict with the surrounding natural environment. Therefore, measures to reduce the possible harmful effects of these investments on the environment should be carried out at the stage of investment planning (Siuta, 2016). The most important group of actions is the right location and plotting the route in the initial stage. Solutions that as little as possible disturb ecosystems and natural areas are analyzed at the planning stage. At the designing stage, decisions are made on the construction details, technology solutions, and materials, and for the protection of animals and plants. Designed solutions also affect the inconvenience during the works as well as during the entire period of operation (Green Building..., 2010, Broniewicz et al., 2009). From the presented analyzes and considerations it follows that the main cause of the collision and environmental conflicts in the process of road investment location is defective way of spatial planning, especially disregarding the natural conditions to the sufficient degree. Reliable process of environmental impact assessment is the most important instrument for solving the problems. The most important factors that can help to alleviate the above described problems, collisions and conflicts, include first of all the increase of the legal importance of study on conditions and directions of spatial management of a municipality as well as legislative strengthening of the rank of eco-physiographic studies for the concept of spatial development of the country, including preparation of local development plans. Moreover, the EIA procedures should not be carried out by the same institutions or offices that performed the project or plan. It is also very important the liquidation of financial depend-

ency of the EIA report contractor and sometimes the EIA forecasts from the investor, which significantly affects the reliability and quality of the EIA documents. These studies should be financed by funds from the investor (representing e.g. a specific percentage of the investment project), collected, for instance, on sub-accounts of institutions reconciling the evaluated projects; and also these institutions, not investors, should choose the contractors for assessment (Kistowski, 2008). It seems reasonable to restore permissions, or the requirement of a proper experience and education in relation to contractors of EIA studies, in order to make them by persons with the appropriate preparation, for which disciplinary instruments could be used. It seems also important to increase the importance and rank of the opinion formulated by the National and Provincial Committees on Environmental Impact Assessment in relation to the location of major investments (e.g. large industrial plants, major transmission networks, motorways and express roads, water reservoirs, especially in the case of locations threatening Natura 2000 areas). Currently, members of these committees perform their functions, in principle, socially.

Acknowledgment

The study was conducted as a research project S/WBiIS/3/2014 in Faculty of Civil and Environmental Engineering at BUT and was financed by Ministry of Science and Higher Education.

References

1. ABU DABOUS S., ALKASS S., 2008, Decision support method for multi-criteria selection of bridge rehabilitation strategy, in: *Construction Management and Economics*, vol 26 (8), p. 883-893.
2. BRONIEWICZ E., MIŁASZEWSKI R., GODLEWSKA J., 2009, *Ekonomia i zarządzanie ochroną środowiska dla inżynierów*, Oficyna Wydawnicza Politechniki Białostockiej, Białystok.
3. DOUTHWAITE R., 2007, *Sustainable Development Evaluation of Road Infrastructure Programmes and Projects, Section 1 The Economic Content of Environmental Impact Assessments for Irish Road Projects*, Foundation for the Economics of Sustainability FEASTA.
4. DYREKTYWA RADY EUROPY 85/337/EWG z dnia 27 czerwca 1985 r. w sprawie oceny skutków wywieranych przez niektóre przedsięwzięcia publiczne i prywatne na środowisko naturalne, in: *Dz. U. L 175*, 5.07.1985, p. 1-17.
5. DYREKTYWA 2001/42/WE PARLAMENTU EUROPEJSKIEGO I RADY z dnia 27 czerwca 2001 r. w sprawie oceny wpływu niektórych planów i programów na środowisko, in: *Dziennik Urzędowy Unii Europejskiej*, 15/t. 6, p. 157-164.
6. DYTCZAK M., 2010, *Wybrane metody rozwiązywania wielokryterialnych problemów decyzyjnych w budownictwie*, Politechnika Opolska, Opole.
7. GDDKIA, DROGI PRZYJAZNE ŚRODOWISKU, www.gddkia.gov.pl/dane/gddkia_dps.pdf (20.02.2017).
8. GÓRNIAK A., WIATER J., 2007, Present and future road net and town rings, their environmental collision on the example of Podlasie Voievodship, in: *The scientific research problems of building, vol. 1 Problems of civil engineering on ecologically valuable areas*, ed. Broniewicz M. and Prusiel J.A., Białystok 2007, p. 151-158.
9. GRIŠKEVIČIŪTĖ-GEČIENĖ A., GRIŠKEVIČIENĖ D., 2016, The Influence of Transport Infrastructure Development on Sustainable Living Environment in Lithuania, in: *Procedia Engineering*, 134, p. -215-223.
10. KARAS S., BOHATKIEWICZ J., 2015, Sustainable Bridge Design, in: *Problemy Ekorozwoju/ Problems of sustainable development*, vol. 10, no 1, p. 123-132.
11. KISTOWSKI M., 2008, Problemy lokalizowania inwestycji na terenach cennych przyrodniczo, in: *Ochrona przyrody*, ed. Gwiazdowicz M., Studia Biura Analiz Sejmowych Kancelarii Sejmu, vol 10, Wydawnictwo Sejmowe Kancelarii Sejmu, Warszawa, p. 139-163, [http://orka.sejm.gov.pl/WydBAS.nsf/0/FC325CEFAEBEB50AC12573F400348B31/\\$file/Ochrona%20przyrody.pdf](http://orka.sejm.gov.pl/WydBAS.nsf/0/FC325CEFAEBEB50AC12573F400348B31/$file/Ochrona%20przyrody.pdf).
12. KOBRYŃ A., 2007, Selected problems of road construction in the light of the environmental impact by pollutants, in: *The scientific research problems of building, vol. 1 Problems of civil engineering on ecologically valuable areas*, ed. Broniewicz M. and Prusiel J.A., Białystok, p. 203-210.
13. KWIATKOWSKI W., DOROSZKIEWICZ J., 2007, The problems of development of transport infrastructure in Podlasie Region related with Natura 2000 areas, in: *The scientific research problems of building, vol. 1 Problems of civil engineering on ecologically valuable areas*, ed. Broniewicz M. and Prusiel J.A., Białystok, p. 97-114.
14. LAURANCE W. F., CLEMENTS G.R., SLOAN S., O'CONNELL C.S., MUELLER N.D., GOOSEM M.O., et al., 2014, A Global Strategy for Road Building, in: *Nature*, vol. 513, p. 229-234.
15. LAURANCE W. F., PELETIER-JELLEMA A., GEENEN B., KOSTER H., VERWEIJ P., VAN DIJCK P., LOVEJOY T.E., SCHLEICHER J., VAN KUIJK. M., 2015, Reducing the Global Environmental Impacts of Rapid Infrastructure Expansion, in: *Current Biology*, 25(7), p. 259-262.
16. LENIAK-TOMCZYK A., ŁAGODA G., 2007, Bridge structure in traffic routes – ecological barrier or tool for environmental protection?, in: *The scientific research problems of building, vol. 1 Problems of civil engineering on ecologically valuable areas*, ed. Broniewicz M. and Prusiel J.A., Białystok, p. 115-122.
17. MANDLE L., GRIFFIN R., 2014, *Natural Capital & Roads, Managing dependencies and impacts on ecosystem services for sustainable road investments*, p. 1-42.
18. PAWŁOWSKI A., 2009, The Sustainable Development Revolution, in: *Problemy Ekorozwoju/ Problems of sustainable development*, vol. 4, no 1, p. 65-76.
19. RDOŚ BIAŁYSTOK, *Natura 2000*, <http://bialystok.rdos.gov.pl/natura-2000> (24.02.2017).
20. SIUTA J., 2016, Istota i zadania inżynierii ekologicznej (ekoinżynierii), in: *Inżynieria Ekologiczna*, vol. 46, p. 1-15.

21. SZAFRANKO E., 2013, Sieć dróg w Polsce – element sieci komunikacyjnej Europy i Regionu Nadbałtyckiego, in: *Drognictwo, Miesięcznik Naukowo-Techniczny SIITK*, vol. 5, p. 138-142.
22. SZAFRANKO E., 2017, Inwestycje budowlane a ochrona przyrody i środowiska, in: *Ecological Engineering*, vol. 18, Issue 1, p. 183-188.
23. TWARDOWSKA K., 2007, *Wariantowanie rozwiązań drogowych w kontekście uwarunkowań środowiskowych na przykładzie korytarza transportowego Via Baltica (w województwie podlaskim)*, Uniwersytet im. A. Mickiewicza w Poznaniu, Wydział Nauk Geograficznych i Geologicznych, Instytut Geografii Fizycznej i Kształtowania Środowiska Przyrodniczego.
24. U.S. ENVIRONMENTAL PROTECTION AGENCY, 2010, *Green Building Basic Information*, January.
25. QUINTERO J., D., 2012, *A Guide to Good Practices for Environmentally Friendly Roads*, Latin America Conservation Council, p. 1-104.
26. WATKINS G., 2014, *Approaches to the Assessment and Implementation of Sustainable Infrastructure Projects in Latin America and the Caribbean*, Technical Note No. IDB-TN-739, Inter-American Development Bank, Washington.