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## **Methods for assessing the influence of investments in transport infrastructure on the environment**

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### **ABSTRACT**

The article discusses the environmental effects of transport, with a particular focus on the natural environment. The author presents methods used for assessing the influence of investments in transport infrastructure on the environment and the main problems related to assessment.

**Keywords:** transport; environment; environmental impact assessment

### **1. INTRODUCTION**

In the modern economy transport is the most dynamically growing sector. Transport is one of the vital factors determining the regional, national as well as the world's economic growth. Efficient transportation system stimulates economies to grow, while at the same time its inefficient management can significantly hinder their capacity to flourish (Rydzkowski and Wojewódzka-Król 1997: 7). Unfortunately the increasing demand for transportation services leads to higher concentration of traffic and, consequently, to aggravated risk to our natural environment. A huge increase in traffic, which occurred in the second half of the twentieth century, not only has dramatically affected the balance in the natural environment of humans causing not only serious pollution of air, water and soil or increased noise levels but

it has also deformed natural topography, devastated vegetation and endangered numerous animal species<sup>1</sup>. The gravity of transport related threats forced decision makers to take them into consideration in analyses that precede transport investment planning. The most recent EU publications and documents (COM (2009) 279), (Deffner and Götz 2010), (C 15/4 2011), (C 354/23 2010) emphasise the important role that local and regional authorities play in taking measures to alleviate the local environmental problems. Considering the fact that in the EU the majority of new infrastructural projects, including the transport infrastructure, have to comply with the environmental impact assessment (EIA) regulations and/or the environmental protection laws, the Committee of the Regions claims that the directive on the strategic environmental impact assessment (Directive 2001/42/EC) and the directive on the environmental impact assessment (Directive 85/337/EEC) are the key instruments of local and regional policies of environmental protection. The methods used to assess the impact of transport on the environment are very diverse: from simple identification of individual impacts to complex methods of predicting the investment effects on a given element of local environment. A large number of criteria and their various implications that must be taken into account make the process very difficult. Some of the popular methods do not address many essential factors, or they are not accurate enough. A vital methodological dilemma is, firstly, the way in which we can integrate the ratings granted by different experts using plenty of methods and parameters which describe the effects of various factors on a given environment component, and secondly, the way in which we will present these ratings to make them comprehensible for all the participants of the environmental protection procedures<sup>2</sup>. The purpose of this article is to present the methods used for assessing the influence of investments in transport infrastructure on the environment and the main problems related to assessment.

## **2. THE EFFECTS OF INVESTMENTS IN THE TRANSPORT INFRASTRUCTURE**

The authors of many publications (Madejski et al. 1980), (Wierzbicki 1975), (Hofman 1968) emphasise the close relation of the transportation systems with the economic, social and ecological ones. The above systems influence one another and overlap. The mutual dependencies and their effects are presented in Figure 1.

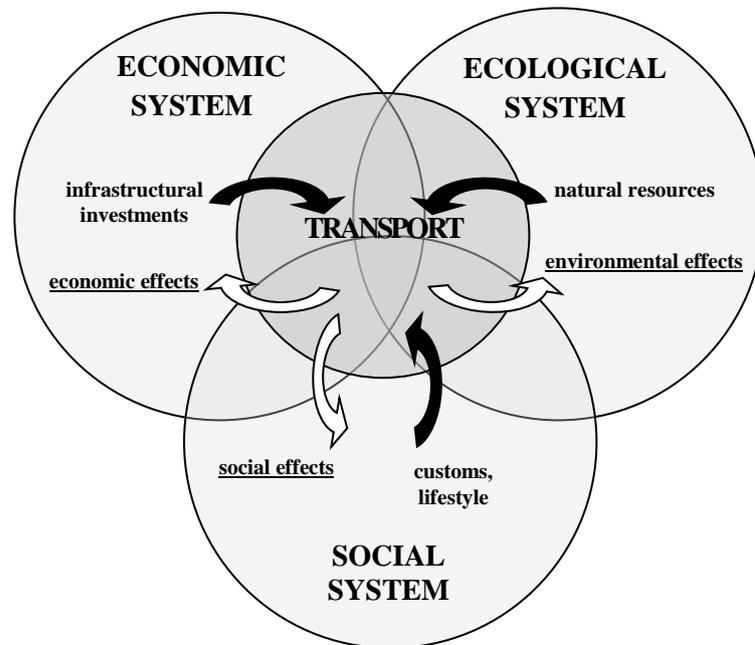
On the one hand there are their ‘expectations’ of the economic, social and ecological system in relation to the transportation one (the tasks resulting from the needs and available resources). On the other hand, however, the transportation system influences the functioning of the other ones causing particular effects: economic effects (e.g. shortening of the transport time, lowering transport costs, construction, maintenance and operation costs, income from infrastructure service fees, etc.), social effects (e.g. increased mobility, growth of economic activity resulting from better transport availability) and environmental effects (e.g. polluted air, water and soil, noise, vibrations, road safety, impact on preserving cultural heritage, plant and animal species).

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<sup>1</sup> See more: (Łatuszyńska and Strulak-Wójcikiewicz 2011: 189-210); (Strulak-Wójcikiewicz and Łatuszyńska 2012: 121-132).

<sup>2</sup> As the participants of the environmental protection procedure we understand an investor, environmental assessment experts dealing with a given environment element, a decision-making organization and the public.

**Figure 1.** Mutual influence of individual systems and the examples of the impact of transport on these systems



Source: own study on the basis of: (Litman 2011), (Schade and Rothengatter 1999).

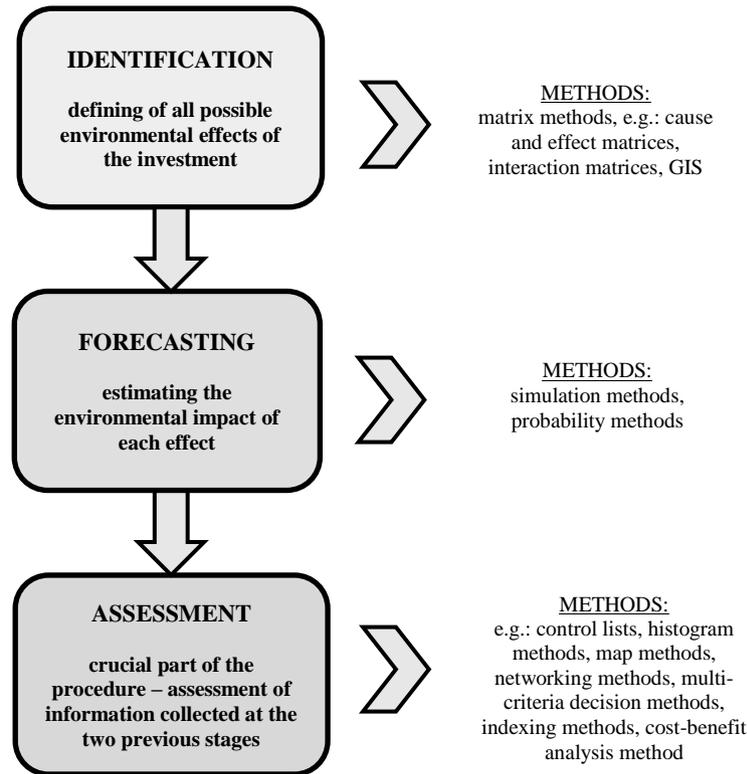
All the above effects should be evaluated before a decision concerning the choice of a particular investment variant made in the process of the environmental impact assessment. In a modern approach to transport-related problems it is recommended to take into equal consideration the interrelated effects of the transport growth. As a result, the analyzed system becomes particularly complex thus coercing the application of specific research methods.

### 3. METHODS USED IN THE ENVIRONMENTAL IMPACT ASSESSMENT

The environmental impact assessment (EIA) is a systematized mode of operation based on interdisciplinary identification and assessment of the impact of future projects and their alternatives on a given area and on the processes taking place there. The EIA essence is to determine the environmental impact of every investment in terms of *measurable and unmeasurable environmental effects* that differ not only on account of their type, but also due to their duration, geographical scope and mutual reactions. It serves the purpose of finding the solutions which will minimize the conflicts that can appear in the social-economic-environmental sphere as a result of the planned investment. The EIA also helps to make a decision concerning the implementation of an investment project. The assessment should be complex, suggest alternative solutions in a view to avoid risks and, finally, contain the analysis of local and global effects, non-reversible changes as well as of the long-term impact (Adamczyk 2004).

The EIA is performed according to the procedure consisting of three main stages: identification, forecasting and assessment. At each of the stages the application of specific methods and tools is required. (Fig. 2).

**Figure 2.** The stages of the environmental impact analysis (EIA)



Source: own study

At the stage of identification all possible effects on the environment are defined. Every affecting factor is confronted with the affected object. Due to a large number of factors and impacts at this stage the matrix methods are used for the sake of which the cause and effect matrices or interaction matrices are constructed. On the identification stage the Geographic Information Systems (GIS) are common for data collection and processing<sup>3</sup>.

Forecasts carried out at the second EIA stage concern the parameters of a specific condition of the environment. They are carried out on the basis of the simulation of the course of a given environmental impact, by means of probability methods or by means of a qualitative assessment, which help define a projected state of a given element of the environment with the probability of its incidence.

Table 1 presents the environmental elements usually taken into account in the EIA of transport infrastructure investments with the applied methods of their estimation with the division into quantitative and qualitative methods.

<sup>3</sup> See: (Brzozowska et al. 2009), (Głowacki 2005), (Longley and al. 2006), (Gotlib et al. 2007), (Kwiecień 2006), (Bielecka 2006).

**Table 1.** Selected elements of the environment and applied method of assessment of the investment impact on a given element of the environment.

No	Assessed environment elements	Applied method of assessment of the investment impact on a given element of the environment
1	impact on air quality	<b>quantitative assessment:</b> e.g.: emission per hour on the edge during the day/night in kg/h
2	noise emission	<b>quantitative assessment:</b> e.g.: level of noise emitted along the edge for the means of transport in dB(A)
3	impact on surface water	<b>qualitative assessment:</b> – VS – very sensitive water environment – S – sensitive water environment – LS – less sensitive water environment (other).
4	rainwater	<b>quantitative assessment:</b> e.g.: concentration of total suspension in mg/l and annual volume of rainwater disposed from impervious road surfaces in m <sup>3</sup> /year
5	impact on soil	<b>qualitative assessment:</b> based on the comparative analysis of investment variants and in view of the range of valuable soil and sensitive crops resources as well as the need for their protection.
6	impact on wildlife	<b>qualitative assessment:</b> of the impact on: – animals, – plants, – natural habitats, – the area of Natura 2000 in a form of the impact characteristics and character
7	impact on cultural assets	<b>qualitative assessment:</b> in a form of the impact characteristics and character: – continuous, durable, long-term; – significant, insignificant; – negative, positive; – reversible, irreversible.
8	impact on landscape	<b>qualitative assessment:</b> to determine the conflict level: – high, – medium, – no conflict.

<b>9</b>	<b>impact on underground waters and mineral resources</b>	<b>qualitative assessment:</b> to determine the conflict level: – high, – medium, – no conflict.
<b>10</b>	<b>impact on humans</b>	<b>quantitative assessment:</b> e.g.: health hazard quotient

Source: own study

As it can be seen in the above Table 1, the impact of investments on some of the aforementioned environment elements can be measured or counted by means of specific methods. As far as other elements are concerned we are merely able to estimate the impact intensity of a given investment on an agreed, usually three-step scale describing e.g.:

- the conflict rate (high, medium, no conflict);
- the sensitivity of a given environment element (large, medium, small);
- the impact characteristics and character (1) continuous, durable, long-term); (2) significant, insignificant; (3) negative, positive; (4) reversible, irreversible, etc.

The decision about the choice of a method or methods is made by the experts who prepare documentation. The forecasts are made by specialists representing different scientific fields. There are experts who study the impact of pollution of the atmosphere, others examine its effects on surface and ground water or soil, on acoustic climate and nature, etc. What is more, every expert uses different research tools – the existing ones or the ones created specifically for the sake of a given study.

Table 2 presents the examples of IT aid tools that can be applied at the forecasting stage in relation to some of the aforementioned environmental impacts of transport. It can be easily noticed in the Table that the most of the tools refer to two effects simultaneously with the exception of the GIS-type tools that, unfortunately, do not allow to show the forecast effects on the time axis, which is crucial in case of the effects cumulated in time.

The assessment, i.e. the essential part of the procedure, covers the integration of data collected at the two previous stages and is performed by means of various methods and techniques (EKKOM 2008): comparative breakdown of the planned investment impacts on particular environment elements expressed in various, often incomparable, units (e.g. dB, mg/m<sup>3</sup> etc.); qualitative and quantitative characteristics of all the environmental impacts of the investment; relatively objective proposal of the investment variant that would be possibly the least harmful to the environment.

The cumulative assessments can be performed by means of the following methods: the control lists, the histogram methods, the map methods, the networking methods, the Multi-Attribute Utility Theory), the multi-criteria decision methods, the indexing methods as well as the cost-benefit methods. IT tools are seldom used for cumulative assessment – mainly for preparing investment variants where the multi-criteria decision methods are applied.

**Table 2.** Review of computer tools aiding the EIA

No.	Effects Tools	Land take and disintegration (e.g. impact on landscape, impact on plant and animal species)	Pollution emissions		Noise emissions	Road safety
			Air	Water and soil		
1.	CALINE 3	-	+	-	-	-
2.	COPERT III	-	+	-	-	-
3.	COPERT IV	-	+	-	-	-
4.	OpaCal3m	-	+	-	-	-
5.	AERO 2010	-	+	-	-	-
6.	INFRAS	-	+	-	-	-
7.	EDMS, ALAQS, ADMS	-	+	-	-	-
8.	NMPB-Routes 96	-	-	-	+	-
9.	RMR (SRM II)	-	-	-	+	-
10.	ECAC.CEAC	-	-	-	+	-
11.	SoundPLAN	-	+	-	+	-
12.	SON2	-	-	-	+	-
13.	IMMI	-	+	-	+	-
14.	VISUM	-	+	-	-	+
15.	Vissim	-	-	-	-	+
16.	Geographic Information System (GIS)	+	+	+	+	+

Source: own study

#### 4. CONCLUSIONS

All in all, the assessment of the influence transport has on the environment is a methodically complicated process which involves many experts using plenty of methods and techniques as well as dedicated IT tools. It should be noted that the integration of information is a substantial problem in the EIA which occurs on two levels. The first one concerns a single environment component which can be affected by numerous factors (e.g. pollution, noise,

etc.) which lead to its transformation. The forecast transformation of a given environment component is described by means of many different parameters that are often interrelated. The second level relates to the choice of environment components to be assessed when it is also necessary to define the mode of integrating the assessment results of the transformation of individual components which eventually leads to the cumulative assessment of the impacts (Gruszczyński 2006). The additional complications result from the fact that the assessment of the impact of any transport infrastructure investment must simultaneously cover such aspects as the space range of the environmental effects, long investment time range followed by its long-term operation as well as the uncertainty factor (Łatuszyńska 2004).

## **References**

- [1] Adamczyk W. (2004). *Ekologia wyrobów – jakość, cykl życia, projektowanie*, Państwowe Wydawnictwo Ekonomiczne, Warszawa.
- [2] Bielecka E. (2006). *Systemy Informacji Geograficznej. Teoria i zastosowania*, Wyd. PJWSTK, Warszawa.
- [3] Brzozowska L., Brzozowski K., Drąg Ł. (2009). System informacji przestrzennej jako integrator systemu komputerowego do oceny jakości powietrza, *Ekonomika i Organizacja Przedsiębiorstwa* 5 (712).
- [4] COM (2009) 279. *Zrównoważona przyszłość transportu: w kierunku zintegrowanego, zaawansowanego technologicznie i przyjaznego użytkownikowi systemu*, Komunikat Komisji. Bruksela, of 17.06.2009, COM (2009) 279 final version. Dz.U. C 255 of 22.9.2010, pp. 110-115.
- [5] C15/4 (2011). *Opinia perspektywiczna Komitetu Regionów „Rola władz lokalnych i regionalnych w przyszłej polityce ochrony środowiska”*, Dz.U. C 15 z 18.1.2011, s. 4-9.
- [6] C354/23 (2010). *Opinia Europejskiego Komitetu Ekonomiczno-Społecznego w sprawie europejskiej polityki transportowej w kontekście strategii lizbońskiej po 2010 r. oraz strategii na rzecz zrównoważonego rozwoju (opinia rozpoznawcza)*. Dz.U. C 354 z 28.12.2010, s. 23-29.
- [7] Deffner J., Götz K. (2010). *„Przyszłość Transportu” Przyszłość Mobilności w UE*, document developed upon the request of the EP Transport and Tourism Committee, the Institute for Social and Ecological Studies, Frankfurt am Main, European Parliament, Brussels.
- [8] Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of certain plans and programmes on the environment. Polish special edition: Chapter 15 Volume 06 P. 157-16.
- [9] Directive 85/337/EEC of the Council 27 June 1985 on the assessment of the effects of certain public and private projects on the environment. Polish special edition: Chapter 15 Volume 01 P. 248-256.

- [10] EKKOM (2008). Podręcznik dobrych praktyk wykonywania opracowań środowiskowych dla dróg krajowych, Biuro Ekspertyz i Projektów Budownictwa Komunalnego „EKKOM”, Kraków.
- [11] Głowacki T. (2005). Projekty GIS, Administracja i użytkowanie, Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław.
- [12] Gotlib D., Iwaniak A., Olszewski R. (2007). GIS. Obszary zastosowań, PWN, Warszawa.
- [13] Gruszczyński S. (2006). Ocena i prognozowanie stanu gleb na potrzeby planów i programów, Inżynieria Środowiska, T. 11, z. 1, Akademia Górniczo-Hutnicza im. S. Staszica w Krakowie.
- [14] Hofman L. (1968). Ekonomia żeglugi śródlądowej w zarysie, Wydawnictwo Morskie, Gdynia.
- [15] Kwiecień J. (2006). Trendy rozwojowe GIS, Przegląd Geodezyjny, Rok LXXVIII, Nr 6.
- [16] Litman T. (2011). Well Measured: Developing Indicators for Sustainable and Livable Transport Planning, Victoria Transport Policy Institute.
- [17] Longley P., Goodchild M., Maguire D. Rhind D. (2006). GIS. Teoria i praktyka, PWN, Warszawa.
- [18] Łatuszyńska M. (2004). Modelowanie efektów rozwoju międzynarodowych korytarzy transportowych, Wydawnictwo Naukowe Uniwersytetu Szczecińskiego, Szczecin.
- [19] Łatuszyńska M., Strulak-Wójcikiewicz R., Ekologiczne aspekty rozwoju infrastruktury transportu, [w:] Trendy i wyzwania zrównoważonego rozwoju. Pr. zb. pod red. B. Kryk, Uniwersytet Szczeciński, Szczecin 2011, s. 189-210.
- [20] Madejski M., Lissowska E., Morawski W. (1980). Rozwój i integracja, WKiŁ, Warszawa.
- [21] Rydzkowski W., Wojewódzka-Król K. (1997). Współczesne Problemy polityki transportowej, Polskie Wydawnictwo Ekonomiczne, Warszawa.
- [22] Schade W., Rothengatter W. (1999). Long-Term Assessment Of Transport Policies To Achieve Sustainability, 4 th European Congress on Systems Sience, Valancia.
- [23] Strulak-Wójcikiewicz R., Łatuszyńska M., Ocena oddziaływania inwestycji w infrastrukturę transportu na środowisko – aspekty prawne i metodologiczne, Handel wewnętrzny Tom 3 - Trendy i wyzwania zrównoważonego rozwoju w XXI wieku, Instytut Badań Rynku, Konsumpcji i Koniunktur, Warszawa 2012, s. 121-132.
- [24] Wierzbicki T. (1975) (red.). Podstawy informatyki w transporcie, WKiŁ, Warszawa.

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