

ENVIRONMENTAL IMPACT ASSESSMENT IN CONTEXT OF WATER STRUCTURES**Martina Zelenakova¹, Lenka Zvijakova²**^{1,2}*Technical University of Košice, Vysokoškolská 4, 042 00 Košice, Slovakia.
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Abstract. The process of Environmental Impact Assessment (EIA) has been successfully applied as a tool for environmental planning and environmental policy in many countries. It can be seen as a process of identification, prediction, assessment and mitigation of environmental, social and other relevant effects of proposed projects and specific activities and plans and programs prior to the decision-making. The process of the Environmental Impact Assessment represents complex evaluation of impacts of proposed activities (Environmental Impact Assessment - EIA) and proposals of strategic development documents (Strategic Impact Assessment - SEA) on the environment already in the state of their preparation, before their approval and permission. It signifies an efficient and required instrument to prevent the origination of major causes for the deterioration of the components of the environment. Pollution of the individual components of the environment is a major problem and in many cases is a source of unacceptable risks to human health and the environment. Risk analysis is an integral part of a single integrated system analysis of the process of assessing the impact of buildings on the environment, which is to identify, quantify and evaluate potential impacts. This work is focused on the selection criteria for the assessment of water structures, determining of the likelihood and consequence of quantifying the degree of risk, which has been designed after considering the current state of risk analysis methods and the use of environmental quality assessment. Sustainable development, protection and development of the environment take a firm position in the policy of Slovakia. Water as a vital component of environment is closely connected with hydrotechnical structures. Possible negative and positive influences of hydrotechnical structures to the environment are assessed in Slovakia according Act No 24/2006 on Environmental Impact Assessment.

Keywords: Environmental Impact Assessment, water structures, criteria, likelihood, consequence, risk analysis.

1. Introduction

An Environmental Impact Assessment (EIA) is a preventive policy tool that is now well established world wide. It is a process that is aimed at producing early and adequate information about the likely environmental consequences of certain plans and projects, and proposing alternatives as well as measures to mitigate harm.

A more recent tool, also relevant in the area of water resources management, is Strategic Environmental Assessment (SEA) which can be understood as a process to estimate the environmental impacts of legislation, policies, plans and programs.

The impact of human activities on natural cycles and processes is becoming critical in today's world. Water infrastructure developments such as barrages, dams, dikes, harbours, pipelines, or water treatment plants can have significant effects on the environment.

However, many other kinds of projects that are not directly linked with water resources can also alter water cycles, pollute waters, dry wetlands, or affect river catchments. EIA is one of the most important preventive

instruments to describe and value the potential effects of activities that may have an adverse impact on water resources (IUCN ELC 2003).

Considering the sustainable development, EIA is essentially considered as a planning tool of a project. People ask for comparing different alternatives for every kind of project and plan (Höpner and Lattemann 2002).

The way in which an EIA is carried out is not rigid: it is a process comprising a series of steps. The main steps in the EIA process are (Dougherty and Hall 1995):

- Screening;
- Scoping;
- Prediction and mitigation;
- Management and monitoring;
- Audit.

Methods of risk analysis could be a most useful tool in the impact identification and prediction steps in EIA.

In the Slovak Republic the environmental assessment has been carried out since 1994. At present the Act

No. 24/2006 Coll. on environmental impact assessment and on amendments to certain acts is applied, which entered into force on 1st February 2006.

Nowadays, in Slovak Republic, the aims of environmental assessment according to (The Act No. 24/2006) are:

- To ensure a high standard of environmental protection;
- To ascertain, describe and evaluate direct and indirect impacts of a proposed activity on the environment and others.

Using of the methods of environmental assessment are inevitable for performance of these aims. The most important ones are special expertise methods, overlaying maps, checklists, matrices and the others.

The environmental assessment methods use qualitative phases for probability of the event occurrence. Lack of certainty factor demands the result to be presented qualitatively. In comparing the environmental assessment methods, following items can be pointed out (Nouri *et al.* 2009):

- Dependence on expert's opinions: It means that the final results do not depend on the data analysis process, but will directly be asked from the experts. It seems that experts can be useful in information presentation.
- Lack of certainty.
- Lack of consideration of the comparative impacts of components (in the construction or operation of the project).
- Lack of unity.
- Lack of consideration of the comparative impacts of the components result from the changes happened in the environment.
- Lack of possibility of benefiting from aggregative opinions of expert.

2. Materials and methods

However, at present, there is no universally agreed methodological and procedural framework to integrate method of risk analysis (RA) into EIA process in water management and there are only a limited number of practical recommendations for improvements in the EIA process that would facilitate such integration.

RA is a special assessment procedure that aims at tackling uncertain consequences of human activities. RA emerged in the 1950s as an instrument to study technological performance and avoid failure at chemical and nuclear plants (engineering risks) after the World War II (World Bank 1997a).

Risk analysis is the measurement of the likelihood and severity of harm. Risk analysis is usually made up of risk identification and risk estimation; the latter is the attempt to estimate scientifically, mathematically, statistically, or by some other rigorous procedure the probabilities of an event and the consequences associated with it. Generally, risk analysis is the most time-consuming, costly and technically difficult part of risk

management, requiring data collection and analysis, in areas where needed data often do not exist and where analysis of these data is more of an art than a science. Because risk analysis often involves probabilities, statistics and epidemiological data, it may be difficult to convey the results of an analysis to the public and to non-specialists (Grima *et al.* 1986).

Two key benefits of Environmental risk assessment (ERA) within EIA, discussed further below, are that it provides a means to (Hyett 2010):

- Systematically identify potential hazards of a proposal and scope the detailed investigations required for the EIA; and,
- Set EIA priorities and manage uncertainty.

The field of risk analysis has assumed increasing importance in recent years given the concern by both the public and private sectors in safety, health and environmental problems. Risk analysis encompasses three inter-related elements: risk assessment, risk perception and risk management.

Risk is defined by the risk management standard AS/NZS 4360:2004 as (p. 4) (Middelmann 2007):

“The chance of something happening that will have an impact on objectives. A risk is often specified in terms of an event or circumstance and the consequences that may flow from it. Risk is measured in terms of a combination of the consequences of an event and their likelihood”.

“Likelihood” describes how often a hazard is likely to occur, and is commonly referred to as the probability or frequency of an event.

“Consequence” describes the effect or impact of a hazard on a community. Both likelihood and consequence may be expressed using either descriptive words (i.e. qualitative measures) or numerical values (i.e. quantitative measures) to communicate the magnitude of the potential impact (AS/NZS 4360:2004).

The calculation of risk can be given as:

$$R=L \times C \quad (1)$$

where R is the risk (for environment), C is severity of harm environment (consequence), L is the likelihood of the occurrence of that harm.

Risk analysis, is defined by AS/NZS 4360:2004 as “the systematic process to understand the nature of and to deduce the level of risk. It provides the basis for risk evaluation and decisions about risk treatment.”

The type of risk analysis varies depending on the situation being considered. This is succinctly described in the standard AS/NZS 4360:2004 (18):

“Risk analysis may be undertaken to varying degrees of detail depending upon the risk, the purpose of risk the analysis, and the information, data and resources available. Analysis may be qualitative, semi-quantitative or quantitative or a combination of these, depending on the circumstances.”

3. Results and discussion

The assessment of stressors impact to the compounds of the environment is the first step of the risk management process. Developing and evaluation of stressors - risk criteria requires decisions to be made on specifically which risks are to be evaluated, and may be based on any number of types of criteria.

The risk analysis should be consistent with the risk evaluation criteria established up front. Important evaluation criteria which should be considered are: the consequences that will be addressed, how likelihood will be defined, and how it will be determined and very important steps is determining the risk level.

For each stressor impact is necessary to establish the parameters of the likelihood and consequences of indicators for the determination of the risk.

We have decided to use four levels for identification of likelihood and four categories for identification of consequence (Zeleňáková 2009). The levels and categories are defined in Table 1.

The likelihood levels can be described as source of stressor. The consequence levels are described in terms of consequences for environment.

Table 1. Relevant criteria for risk calculation

Stressor: Emission	Impact to atmosphere		
	Likelihood	Level „L“	Emissions of particulate matter [t.year ⁻¹ .km ⁻²]
	negligible	1	< 1
	low	2	1 - 5
	medium	3	5 - 10
	high	4	> 10
	Consequence	Category „C“	The concentration of PM ₁₀ in the air [µg.m ⁻³]
	negligible air pollution	1	< 15
	low air pollution	2	15,01 – 20,00
	medium air pollution	3	20,01 – 40,00
high air pollution	4	> 40,01	
Stressor: Waste water	Impact to water environment		
	Likelihood	Level „L“	Number of population equivalent [t.year ⁻¹ .km ⁻²]
	negligible	1	< 2 000
	low	2	2 001 – 250 000
	medium	3	250 001 – 500 000
high	4	> 500 001	

Continuation of **Table 1**

	Consequence	Category „C“	Quantity of discharged wastewater [·10 ³ m ³ .y ⁻¹]
	slight pollution of stream	1	< 200
	medium pollution of stream	2	< 1 000
	heavy pollution of stream	3	< 15 000
	extreme pollution of stream	4	> 15 000
Stressor: Floods	Impact to water environment		
	Likelihood	Level „L“	Total average monthly precipitation in % of normal for the year
	negligible	1	< 100
	low	2	101 - 110
	medium	3	111 - 120
	high	4	> 121
	Consequence	Category „C“	Number of days with the achieved degree of the flood activity
	endangered area	1	0 – 10
	medium threatened area	2	11 – 50
	highly threatened area	3	51 – 100
extremely threatened area	4	> 101	

Determination of these values is based on the standards, legislation or literature, as well as subjective suggestions.

An analysis of the hazardous events should include estimation of likelihood (probability) and consequence. Often a semi-quantitative approach is chosen, just giving categories of likelihood and consequence. The combined likelihood-consequence categories could then be inserted in a risk matrix, see example of risk matrix in Table 1. The lowest value of the risk factor may be 1 (likelihood = 1; consequence = 1) and the highest is 16 for each indicator.

Table 2. An example of a Risk matrix

Likelihood	Severity of consequences			
	1	2	3	4
1	1	2	3	4
2	2	4	6	8
3	3	6	9	12
4	4	8	12	16

In cases where there is no specific legislation or the other appropriate guidance, the use of the risk estimation

matrix can also be helpful in deciding which assessed variant is more risky for environment under the EIA process. The following risk estimation matrix, in Table 3, can be used.

Table 3. Risk Categories

Low	Medium	Serious	High

We have decided to use four distinct levels of risk: Low, Medium, Serious and High. Our risk level definitions are presented in table 3.

The risk value for each stressor impact is calculated as the product of consequence and likelihood values, illustrated in a two-dimensional matrix (Table 2). The shading of the matrix visualizes the different risk levels. Based on the acceptance criteria, the risk level High is decided to be unacceptable. Any source of stressor impact at this risk level must be treated in order to have its risk reduced to an acceptable level.

4. Conclusion

EIA is an essential tool for the sustainable management of water structures. A new approach to environmental impact assessment, based on method of risk analysis has been present.

We have always faced many challenges in dealing with environmental risks. Successful risk analyses require scientists and engineers to undertake assessments to characterize the nature and uncertainties surrounding a particular risk. One also needs social scientists to characterize the factors that influence the perception of a risk. Finally there is a need for develop strategies that involve risk communication, economic incentives, standards and regulations for the managing these risks.

We have used risk criteria to define the acceptable risk level for the environment. We cannot expect to achieve a risk level equal to zero. Thus we have to define which level of risk we consider as acceptable for the environment we are analyzed. The risk criteria should be based on the acceptability requirements for the environment.

The methodology is currently under development and an important element of this development is its application to hydrotechnical structures.

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