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Risk analysis within environmental impact assessment of proposed construction activity

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ABSTRACT

Environmental impact assessment is an important process, prior to approval of the investment plan, providing a detailed examination of the likely and foreseeable impacts of proposed construction activity on the environment. The objective of this paper is to develop a specific methodology for the analysis and evaluation of environmental impacts of selected constructions – flood protection structures using risk analysis methods. The application of methodology designed for the process of environmental impact assessment will develop assumptions for further improvements or more effective implementation and performance of this process. The main objective of the paper is to improve the implementation of the environmental impact assessment process. Through the use of risk analysis methods in environmental impact assessment process, the set objective has been achieved.

1. Introduction

Environmental impact assessment (EIA) is now 45 years old (beginning on 1 January 1970 when President Richard Nixon signed the National Environmental Policy Act in the USA). Environmental assessment is the procedure of the identification and evaluation of impacts on the environmental compounds of the proposed activities (Petts, 1999; Wang et al., 2006; Cashmore, 2004; Pope et al., 2004; Gilbuena et al., 2013; Bond et al., 2014). EIA is a mandatory process before approval of infrastructure projects with significant impacts on the environment (Tamura et al., 1994) such as roads (Zhou and Sheate, 2011), water supply systems (Al-Agha and Mortaja, 2005) and flood protection constructions (Ludwig et al., 1995). Flood protection objects (FPO) are constructed to mitigate flood effect and reduce flood damages and losses (Poulard et al., 2010; Gilbuena et al., 2013).

Several researchers have investigated application of the risk analysis in assessment of projects' proposals (Zavadskas et al., 2010). Although application of the risk analysis (RA) regarding to water constructions, especially FPO assessment are seldom, we can found some research works related to this topic (Larsson, 2012; Gorantiwar and Smout, 2007). In common risk analysis methods the risk indexes are calculated by multiplying probability and consequences, but analysis of the other factors involved is often omitted (Dikmen et al., 2007).

Different approaches for integrating risk analysis into the EIA process have been applied (see, e. g. AGIP KCO, 2004; Demidova and Cherp, 2005; Department of Health, 2010). AGIP KCO (2004) presented the methodology for EIA based on the definition of impact intensity, spatial impact scale and temporal impact. Demidova and Cherp (2005) proposed a model of integrating risk analysis into EIA of power plants, dams and water reservoirs, waste treatment plants and landfills for human health. The findings of the Demidova and Cherp (2005) are useful for involvment of risk assessment within EIA for projects that are in high risk. They propose a model of integrating RA into EIA which may be considered as a framework for consistent treatment of human health impacts of high-risk and high-profile projects including chemical and nuclear power plants, dams and reservoirs, waste treatment and disposal facilities. Demidova and Cherp (2005) propose a model for procedural and methodological integration of EIA and RA based on reported best practice approaches. The proposed model stipulates dembedding RA into EIA and is organized in accordance with the generic stages of the EIA process. The model forms the basis for the proposed "evaluation package" which can be used as a benchmarking tool for evaluating the effectiveness of integration of RA within particular EIAs.

USEPA has presented a risk-based approach for health impact assessment within EIA in Western Australia (Department of Health, 2010).

However there is no reference, as far as the authors know, of application of risk analysis in the EIA of FPO worldwide. The applicability of the risk analysis in EIA in Slovakia is also yet to be established. Slovakia can benefit from adopting risk analysis in EIA, thus it is important to provide references of its application.

The need for integration of RA and EIA emerges from the knowledge of not sufficient assessment of all impacts within EIA. A lot of authors (e.g. Grima et al., 1986; Andrews, 1990; Arquiaga et al., 1994; Canter, 1996, 1998) integrated complex health impacts assessment in the EIA with using "scientifically based" risk analysis approaches (Demidova

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and Cherp, 2005). EIA and RA have a crucial role – "the rational reform of policy-making" (Andrews, 1990). Both provide predictions of potential consequences of planned projects to choice the optimal alternative. Specifically, EIA concentrate on the identification of impacts of proposed activities, while RA analyse the impacts – state the probability, consequences, magnitude and frequency of impacts.

Nowdays the strong emphasis on the risk analysis in impact assessment is in South Australia and New Zealand. Risk analysis should be a component part of EIA.

At present time of scientific and technological progress, new concepts, tools and methods of solving problems fulfill the principles of a democratic society, which dictate the obligation to provide a good environment for future generations. Part of this challenge is timely assessment of the potential impacts of proposed activities on the environment and human health with acceptable environmental risk. It is necessary therefore to develop theory and apply appropriate methods for the systematic investigation, analysis and evaluation of the effects of projects, constructions, plant, equipment and other activities on the environment and population.

Floods are the most common disasters worlwide, causing high damage of property and environment. At present, intensity of extreme rain mainly due to climate change is increasing. More frequent and more intense floods are occuring. In consequence of floods, mainly flash floods, human life as well as their property and environment are endangered. In the last 30 years floods affected >2.8 billion people worldwide and killed >200,000 (Menne and Murray, 2013). Recent studies on climate change (EC, 2009; Pollner et al., 2010; EEA, 2012; Kundzewicz et al., 2013) proved that European Region will be vulnerable to floods with huge damages more frequently and demands for flood protection objects will increase. Flood protection measures are inevitable as well as assessment of their impacts on the environment. The construction of FPO has become very valuable mainly in urban areas (Everard, 2004; Gilbuena et al., 2013). Consequences of these constructions have to be assessed before the planned activity. The use of proper EIA procedures can help the decision-makers to approve suitable measures (Shah et al., 2010; Gilbuena et al., 2013).

In the Slovakia, through Act of Law No. 24/2006 on environmental impact assessment of proposed activities EIA is mandatory for planned flood protection objects. The commonly used EIA methods (i.e. ad hoc methods, simple checklist, questionnaires, decision trees, network diagrams, expert opinions) are generally descriptive and have qualitative character (e.g. Department of Public Works and Highways, DPWH, 1998; City Office of Navotas, 2009, Galas et al., 2015). According to Lexer et al. (2006), MoE and SEA (2012) and Zvijáková et al. (2014) one way to advance the EIA system also in the Slovakia is to develop methodology or guidance how to apply risk analysis in EIA to provide better transparency and to help maintain the impartiality of the entire process, the result of which should lead to the choice of future activity quantified with minimum risk to the environment.

The proposed methodology assesses the magnitude of the impact on the environment of water structures and activities in the field of water management, according to the purposes of Slovakian Law no. 24/2006 Coll. as amended, as well as the European Directive 2014/52/EU of the EIA. Similarly, they can be used to evaluate and prioritize risks in areas of the proposed activities.

The objective of the paper is to propose a methodology for assessing environmental impacts of activities in water management, exactly flood mitigation measures with goal to select the best option for the permission process. This methodology is intended to streamline the process of EIA of constructions in the field of the water management. Due to the persistently high frequency of flood-related disasters, which are exacerbated by the on-going effects of climate change, the impacts of flooding on cities and towns can be devastating and deadly, resulting in the need to design and assessment of flood protection object (FPO). In their preparation, implementation, evaluation and authorization it is necessary to ensure consistent application of the environmental impact assessment (EIA). Risk analysis (RA) is an appropriate tool to determine the level of the risk of the proposed flood mitigation measures and through which it is possible to choose the alternative with the lowest level of risk for the environment. EIA and RA processes are rarely used to complement each other despite potential benefits of such integration. The application of developed methodology for the process of EIA will develop assumptions for further improvements respectively more effective implementation and performance of this process. This paper investigates the advantages of using the risk analysis in the assessment of FPO by testing the proposed methodology of the EIA of proposed FPO project in Slovakia, in village Kružlov. One of the paper's tasks is to create a system of EIA of water constructions through risk analysis evaluation of options, the result of which should lead to the selection of future activity quantified with minimum risk to the environment. Comparison of alternatives and designation of the optimal alternative will be implemented based on selected criteria which objectively describe the characteristic lines of the planned alternatives of activity and their impact on the environment. Proposed *Guideline for environmental impact assessment of flood protection object* uses the method of multiparametric risk analysis. According Tichý (2006) it is the risk analysis method which is suitable to enhance the transparency and objectivity of the assessment process. Its modifications may also find application in other infrastructure projects.

This paper outlines the literature review of EIA and risk analysis and their interconnection. Proposed methodology for EIA of selected proposed activities based on risk analysis is described in the next part. The next chapter describes the results of research - application of the proposed methodology of EIA of flood mitigation measures in Kružlov village (north Slovakia). The conclusions of the research, theoretical and practical benefits of the paper as a tool for decision support and promote sustainable development and suggestions or recommendations for further research in the field of methodology of the EIA process are presented in the last part of the paper.

1.1. Risk analysis and assessment within environmental impact assessment

Framework of risk assessment and EIA are similar. These processes deal with the prediction of the future impacts (nature, frequency etc.) of the proposed activities (USEPA, 2009a, b). They aim to manage the decision making process about the significance, magnitude and character of impacts, the acceptability of risk and proposals of mitigation measures. The European Union has encouraged its member's states to apply risk assessment in EIA, particularly to extreme events but very little specific guidance is available on how to apply risk assessment or risk analysis in EIA (USEPA, 2009a, b). The origins and development of EIA and risk assessment were described in Gough (1989). In that report a relationship between EIA, risk assessment, technology assessment and social impact assessment was proposed. A modified version is shown in Fig. 1.

It shows EIA and risk assessment both contributing to environmental risk management. It takes into account the assessment and the decision and includes communication, implementation and monitoring of the selected option. Lexer et al. (2006) focused also on using of risk assessment in EIA. They examined the extent of extreme hazards in European Union Member States in EIA practice. The environmental risk assessment (ERA) framework can be integrated with the general EIA procedure (DEAT, 2002). There is an overlap in the basic principles of the EIA and the ERA (Fig. 2).

The two processes are complementary in that the EIA addresses, whereas the ERA is a structured approach to dealing with mainly ecological impacts (DEAT, 2002). The ecological aspects to the EIA can then be assessed alongside social and economic requirements.

2. Methodology and research design

Floods are the most frequent natural hazard worldwide and a major natural disaster in Europe in terms of social and economic impacts. In