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Vulnerability assessment of households and its possible reflection in flood risk management: The case of the upper Myjava basin, Slovakia

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A B S T R A C T

As a result of a change in the flood risk management paradigm from flood control to flood adaptation, the strategy of vulnerability reduction has become an inseparable part of flood risk management. A key aspect of vulnerability management is knowledge of the social system's vulnerability at the local level. The aim of this paper is to present an assessment of household vulnerability to flood hazards in the six villages of the upper Myjava basin (Slovakia), based on data obtained from a household survey, and to discuss the possibility of vulnerability reduction in the framework of flood risk management. Questionnaire issues are related to the exposure of each household to flood hazards, proxy variables affecting the susceptibility of household property to damage, susceptibility of households to physical and mental harm and the household ability to recover from flooding. Assessment of the household vulnerability in the municipalities through proxy variables is based on rules, justifiable criteria and indices representing individual aspects of vulnerability, as well as overall vulnerability. In relation to the vulnerability assessment, individual and institutional measures are specified for each community to reduce the vulnerability of households to flood hazards.

1. Introduction

In spite of diverging views on the fundamental scientific principles of risk assessment and management [1,2], flood risk assessment remains a set of activities for the identification, measurement and quantification of risks connected with flooding. Flood risk management is a set of policy options aimed at reducing flood risk. As suggested by [3], some authors do not distinguish between risk assessment and management and therefore incorporate risk assessment within the realm of risk management. Regardless of the hierarchical context in which the assessment and management are interpreted, the assessment of flood risk represents the rational base for flood risk management. The key to effective flood risk management is the establishment of a strategy and corresponding measures in relation to flood risk assessment.

In the case of traditional engineering flood risk management, flood risk assessment is limited only to the assessment of flood hazards caused by the natural overflow of water from a river channel (i.e. river flooding). The emphasis in this assessment is put on the capacity of river sections (i.e. stability and capacity of their cross-section profiles) to transport the maximum discharge under a specified probability. If the river reaches do not meet safety standards (i.e. to carry the discharge of a specified magnitude) established for different types of residential zones and economic activities, flood risk management is then based on the application of some of the following solutions: storing the run-off (e.g. retention basins, wetlands, reservoirs); increasing the river capacity (e.g. bypass channels, channel deepening or widening) and separating the river from the population (e.g. dikes). The aim is to limit the scope of river flooding and protect both residential and industrial zones from damage. Therefore, according to the engineering approach, the linkage between flood risk assessment and risk management is comparatively simple.

However, the change of the paradigm of flood risk management 'from flood control to flood adaptation' [4–8] significantly changes the perception of flood risk and its assessment, which is reflected in the link between flood risk assessment and flood management. Within new paradigm risk is the expected loss (of lives, persons injured, property damaged, and economic activity disrupted) due to a particular hazard for a given area and reference period [9]. The general definition of flood risk as a product of hazard and vulnerability is commonly used and exposure to hazard is, as a rule, implicitly or explicitly considered to be feature of hazard or vulnerability [10]. The flood adaptation concept is based on a more comprehensive (integrated) flood risk assessment and originates from an idea that emerged in the 1970s that in 'evaluating the disaster risk, the social production of vulnerability

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needs to be considered with at least the same importance that is devoted to understanding and addressing natural hazards' [11].

Thus, in addition to flood hazard assessment, flood risk assessment also includes society's assessment of vulnerability, which, due to the link between flood risk assessment and its management, is much more complicated. The strategy of reducing vulnerability becomes an inseparable part of flood risk management. Another reason that flood risk management is currently becoming more demanding is society's changing value system, such that preserving a sustainable environmental system is considered to be generally beneficial and valuable in terms of the further development of society [12].

The systematic implementation of vulnerability reduction measures is becoming important not only because of the changing paradigm of flood risk management, but also because of the relative nature of flood protection by technical measures. Current climate change, as well as land cover change, in river basins additionally increases the chances of extreme climatic and hydrological phenomena, and existing flood protection infrastructure may not be sufficient against their devastating effects [13]. Conversely, its failure can cause disaster. Absolute flood protection through technical construction does not exist and society must be prepared to deal with natural catastrophic phenomena. One way to achieve this is to reduce individual as well as institutional vulnerability, and to increase the ability to cope with the negative consequences of floods [14].

The transition from engineering to integrated flood risk management is a relatively complex and slow process. In countries with a strong tradition of construction of technical water management structures, such as Slovakia, there is a tendency for flood protection through the modification of watercourses, and construction of dikes, water reservoirs and polders, to be automatically considered the core of flood risk management. Actions that reduce vulnerability are not regarded as important systematic measures and are only considered as addenda without fundamental significance.

One reason for such an attitude may be the lack of data on vulnerability at a local level. In most cases, vulnerability assessment is based on data that can be obtained from commonly available databases such as the population census. In addition to taking only some of the factors affecting vulnerability into account, these data also have limitations, particularly with regard to their availability only for administrative units (e.g. municipalities, districts, higher administrative units). On the basis of census data, it is possible to gain some insight into the spatial variability of vulnerability and to identify administrative units with the greatest and least vulnerability, but they are not sufficient to suggest specific measures to reduce vulnerability. As shown by the work of [15], the key to vulnerability management is knowledge about the vulnerability of individuals or social groups, residential and industrial zones and infrastructure that provides transport, water, energy and services. Rational vulnerability management therefore requires vulnerability assessments based on much more detailed data than census data, which can be obtained through field research or questionnaire surveys on a local level. The aim of this study is to present a vulnerability assessment of the six municipalities of the upper Myjava basin, based on data obtained by a household questionnaire survey, and to outline some possibilities of vulnerability reduction. The questionnaire survey also included issues related to flood hazard itself. The results of how households perceive flood hazard and what measures they consider important to reduce it are presented in [16,17].

2. Concept of vulnerability

In relation to natural disaster management and sustainable development of society, the concept of vulnerability has been elaborated in social, economic, environmental and geographic disciplines. Individual disciplines have come to define vulnerability from their own points of view such that a number of different vulnerability concepts are encountered in the literature, as well as various methodological approaches to its assessment [18–20]. The minimum common basis is the perception of vulnerability as the potential of a social, economic and environmental system to be damaged or physically and mentally harmed (susceptibility concept), its ability to withstand floods at the time of their duration (resistance concept) and its ability to cope with the negative consequences of floods after their termination (resilience concept). The susceptibility concept represents the passive (negative) component of vulnerability, such that vulnerability increases with increasing susceptibility. On the other hand, the concepts of resistance and resilience (adaptation) are active (positive) components of vulnerability, such that the system vulnerability decreases with increasing resistance and/or resilience [21].

Vulnerability assessment in the framework of potential is carried out regardless of the flood hazard attributes; it is hazard-independent [21,22]. Within this approach, vulnerability research develops in two directions with respect to research objects. The first direction is focused on the vulnerability assessment of objects within the system itself. In a social system, these objects include individuals or social groups, such as the family, community and nation [23–25] and is also referred to as social-based vulnerability [11,21,26]. Less attention is devoted to the analysis of vulnerability concerning economic objects (economic-based vulnerability) and the environment and natural resources (environmental-based vulnerability). The second direction concerns place-based vulnerability [22,27–31] and assesses site vulnerability (e.g. rasters, polygons, administrative spatial units, regions, etc.). The level of vulnerability associated with a place is composed of the social, physical and built characteristics of the environmental system that make places unequal from the point of vulnerability [27].

As stated by [32], it is not possible to measure vulnerability directly; it can only be expressed by means of indicators (e.g. proxy variables), which should express the internal predisposition or potential of the social, economic and environmental objects of a system to suffer damage and harm, and the ability to cope with the negative consequences of floods. One way to quantify the level of vulnerability is to express it through indices that are determined on the basis of proxy variables [27,28,33]. The general basic methodological stages for determining vulnerability indices are analysed in [32,34–36], amongst others. They can be split in two phases: preparation and assessment.

The preparation phase contains following steps: 1. conceptual framework, 2. structural design, 3. analysis scale, 4. indicator selection. In conceptual framework it is decided whether social, economic or environmental aspect of vulnerability are chosen to be included in the assessment. Structural design provides us with choice of building an index in deductive, hierarchical or inductive way [32]. Another important aspect of creating an index is the scale of research (national, regional or local). The last step in the preparation phase is the selection of proxy variables, which should be selected with respect to their availability and also their validity. Selection of vulnerability indicators can be carried out by either deductive or inductive means. The deductive approach is based on the logically reasoned dependence between indicators and negative effects [22,30,33,34]. The inductive method of indicator selection is based on the reduction of the great number of variables, using methods of factor or principal components analysis, to several latent factors representing vulnerability [27,28].

The assessment phase consists of four steps also: 1. transformation, 2. normalization, 3. weighting, 4. aggregation. In the process of transformation it is determined how the proxy variable is to be represented (e.g. counts, proportions, etc.). In order to agregate different variables it is nessesary to normalise them in one common scale. The next step is weighting, which gives us the degree of variable's importance among other variables. Agregation is combination of proxy variables (sub-indices) into the final output. Based on rules, it is possible to use additive aggregation models, multiplicative aggregation models or model of an ideal point.