Environmental capacity determinants - spatial and temporal assessment

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Abstract. The scientific use of the concepts of environmental capacity is central to many areas of environmental protection and environmental quality management processes, and is a basic tool for the analysis of adverse effects of environmental problems both regarding state of the environment (eco-centric point of view) and potential of environmental services to humans (eco-anthropogenic point of view). While it is adequately recognized in scientific resources that environmental capacity determinants are fundamental for successful implementation of environmental protection measures, it is not so adequately recognized that determinants of environmental capacity are temporally and spatially variable. There is a list of environmental capacity determinants to be evaluated in spatial and temporal way: biophysical (environmental) and social (social in narrow sense, economic and institutional). The subject of this paperwork is aimed towards spatial and temporal assessment of abovementioned determinants. Identification and assessment of the importance of different spatial and temporal aspects should be based on quantitative and qualitative methods such as Turner's method and AHP.
Key Words: environmental capacity, determinants, spatial and temporal assessment.

Aims and background. Current problems regarding pollution of environmental systems require the assessment of the environmental capacity status, stressing the importance of it as aspect of environmental services, as well as the protection of the environment quality. Environmental capacity is for the first time defined by group of authors working within unique research framework as “a property of the environment and its ability to accommodate a particular activity or rate of an activity … without unacceptable impact” (GESAMO 1986). The concept of environmental capacity requires us to:

- evaluate the property of different environmental media to absorb/cope with adverse environmental effects that occur as a product of various human activities. This represents short or medium timeframe;
- evaluate adaptive potential of an ecosystem within a specified area. This represents long timeframe;
- evaluate environmental quality criteria, which represent a subjective category, that is, the criteria of environmental quality can vary from society to society, even in the same society, these criteria may change over time.

The Law on Environmental Protection of the Republic of Serbia defines a level of environmental capacity as “the ability of the environment to accept a certain amount of pollutants per unit of time and space without irreparable damage to the environment” (Law on Environmental Protection 2011). Similar to first one listed, the definition of environmental capacity given in the Law on Environmental Protection of the Republic of Serbia also recognizes only biophysical (environmental) determinant of environmental capacity. The Water Framework Directive introduces the concept of “environmental health” within which is possible to identify aspects of environmental capacity (Directive 2000/60/EC). Furthermore, The Water Framework Directive significantly more recognizes the importance of water resources as a part of environmental services, as an important instrument of international/inter/inner-state relations (Sofios & Polyzos 2009), particularly at the present time when the right to use the resources of the environment may be the trigger for the international conflict (Obioha 2008). Observed in time, environmental capacity has its short time component – coping capacity and long time component – adaptive capacity. Table 1 shows the development of coping and adaptive capacity definitions (Thomalla 2006).

Table 1

Development of coping capacity and adaptive capacity definitions

Coping capacity or coping strategies	*Adaptive capacity or adaptation*
Short-term response to an immediate and in habitual decline in access to food	Permanent change in the ways in which food is acquired
Ability to respond to an occurrence of harm and to avoid its potential impacts	Ability to transform structure, functioning or organisation to survive under hazards' threatening existence
Range of actions available to respond to the perceived climate change risks in a given policy context	Ability to change the set of available inputs that determine the level of coping capacity
The responses that people employ to maintain wellbeing in the face of environmental stress within the existing structures	Changing the framework within which coping takes place
'Coping Range' (2001 TAR) The variation in climatic stimuli that a system can absorb without producing significant impacts	Adaptation: adjustment in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits benefits. Adaptive capacity: the ability of a system to adjust to climate change to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.
Immediate responses to hazards such as a specific flood event	Medium - and long term strategies for changes in institutional frameworks
Design and implementation of risk management institutions — such as disaster preparedness plans — that can mitigate the most immediate climate impacts	Socioeconomic and political reforms that addresses the inequalities at the root of differential vulnerabilities
The strategies used by those living with rapid onset disasters such as flash floods, and chronic disasters, including drought and food insecurity	Change in those practices and underlying institutions that generate the root and proximate causes of risk, frame capacity to cope and further rounds of adaptation to climate change

The aim of this paperwork was to evaluate the effects influencing the spatial and temporal variations of environmental capacity. Quantitative and qualitative methods such as Turner's method and AHP are very suitable for identification and assessment of the importance of different spatial and temporal aspects.

Discussion. Although environmental capacity and carrying capacity are scientific and similar concepts, they incorporate a strongly subjective dimension. The determination of environmental quality standards, although performed by scientific approach, must rest on subjective judgement (Takic et al 2012). Various criteria may be applied to determine what acceptable environmental change is. Some can be linked directly to human health for example, and may be measured objectively. Others relate to economic productivity in the short, medium or long term. Irrespective of whether or not there are appropriate objective measures relating to the various environmental criteria, determination of acceptable change is fundamentally subjective, and depends on our wealth, our circumstances, and our attitude to risk (GESAMO 1986). Abovementioned term of acceptable change to the environment could not be scientifically explained without introduction of environmental vulnerability and resilience concept that are to be analyzed. The level of environmental quality, closely related to term of environmental services, should be recognized not only as very important to environment in narrow sense, but also as inevitable pillar that supports human wellbeing. At the other hand, environmental capacity should be considered not only as a property of different environmental media to address various human impacts (in narrow sense), but also as a capacity of humankind to manage and support different environmental processes leading to self-purification and remediation of environmental media. Furthermore, environmental capacity should be evaluated as a phenomenon that has spatial and temporal dimension. Temporal

dimension includes evaluation of environmental capacity in short and medium term, i.e. coping capacity, while long-term environmental capacity is often recognized as adaptive capacity. In a similar way, human dimension of environmental capacity has its short and long-term part. The spatial dimension of environmental capacity reflects the dynamics of change in environmental components that occurs with changes in observed area (e.g. changes from upper to lower part of river stream) (Stoica et al 2012; Stoica et al 2013; Ouyang et al 2006; Moriki et al 2013). Mentioned facts actually mean that the capacity of the environment does not represent a constant in time or in space. Figure 1 shows the interdependence between coping and adaptive capacity within the broader vulnerability – resilience frame (Berman et al 2012).

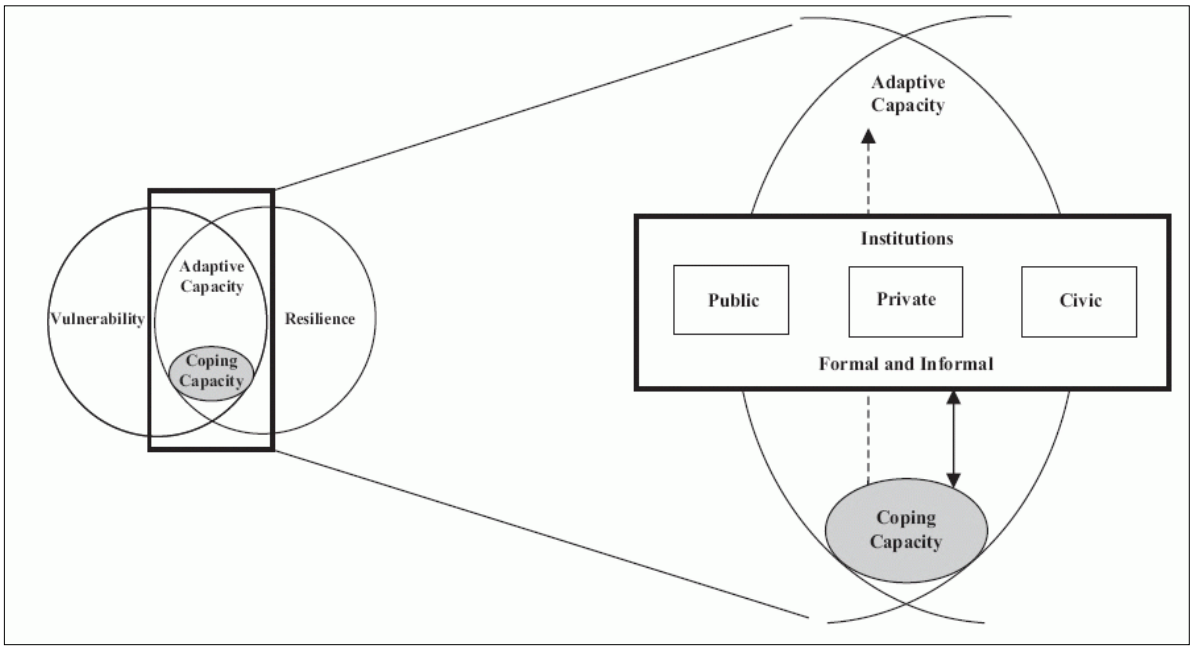

Figure 1. The interdependence between coping and adaptive capacity within the broader vulnerability – resilience frame.

The concept of vulnerability often has been used to describe the susceptibility of physical, biotic, and social systems to harm or hazard, either accidental or hazard that are continual in it's nature due to different human activities. Numerous authors outline concept of vulnerability more generally as susceptibility of observed system to damage, due to the sensitivity or exposure of a system, people, or places to impacts, stresses, or perturbations. Apart from the concept of general vulnerability or biophysical vulnerability, there is also social component of vulnerability, which is related to the characteristics and experiences of communities and people who must respond to and recover from the environmental hazards or stressors to which they are exposed, either accidentally or in continual sense (Adger & Vincent 2005; Bogardi & Birkmann 2004).

Nowadays, the concept of vulnerability has been continuously widened and broadened towards a more comprehensive approach encompassing susceptibility, exposure, coping capacity and adaptive capacity, as well as different thematic areas, such as physical, social, economic, environmental and institutional vulnerability, which is shown on Figure 2 (Birkmann 2006). Numerous examples of practical application of multi-dimensional vulnerability concept are in the field of water quality/quantity management (Bharti & Katyal 2011).

Identification, assessment and modelling of environmental capacity processes and their performance could be based on quantitative and qualitative methods such as Turner's method (identification), and Analytic Hierarchy Process (assessment).

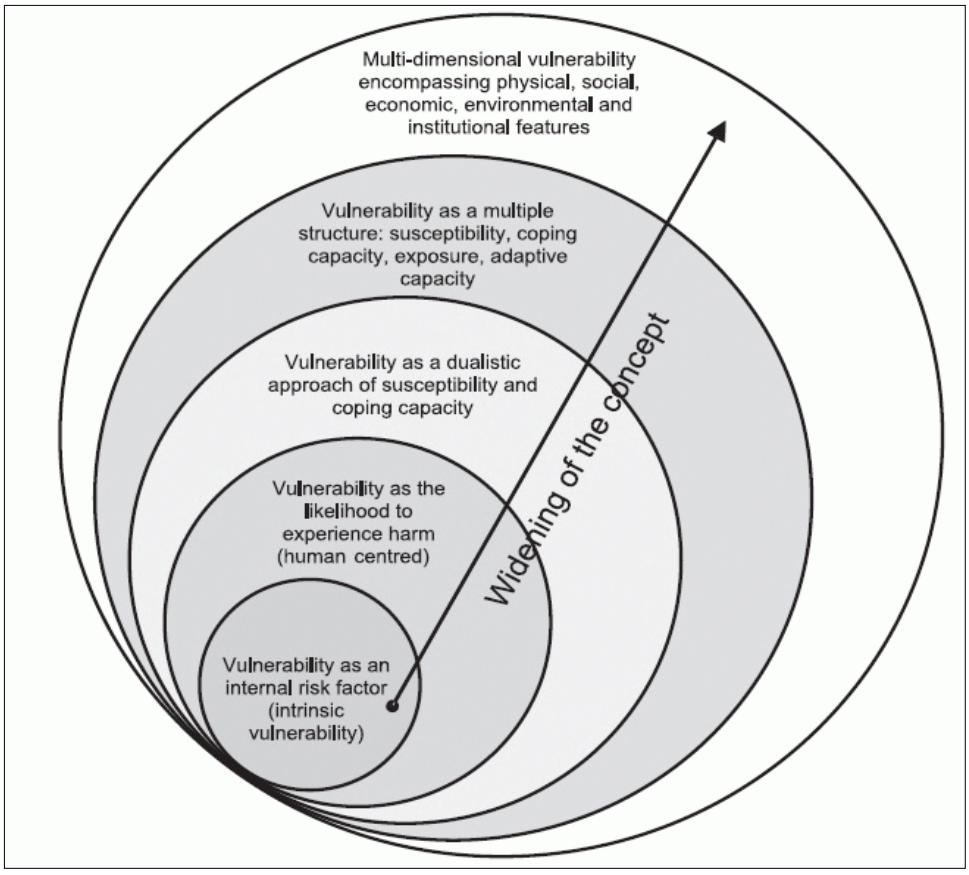

Figure 2. Comprehensive-widened concept of vulnerability.

The Analytic Hierarchy Process (AHP) is a suitable method for improving the decision-making process based on the analysis of the objectives, the criteria, the sub-criteria and the alternatives. The application of this method is simple and easy in the decision-making process due to software that provides support. The method is based on decomposition of complex problems in the hierarchy, comparison of the elements at the same level that are related to the elements of a higher level, determining the weighted coefficients and making a list of alternative solutions (Saaty 1980).

The conceptual framework of Turner defines exposure, coping response, impact response and adaptation response explicitly as parts of vulnerability. Figure 3 shows Turner et al's (2003) Vulnerability Framework.

This framework also takes into account the interaction of the multiple interacting perturbations, stressors and stresses. Another importance of Turner's vulnerability framework lies in the fact that the conceptual framework of Turner examines vulnerability within the broader and closely linked human–environment context.

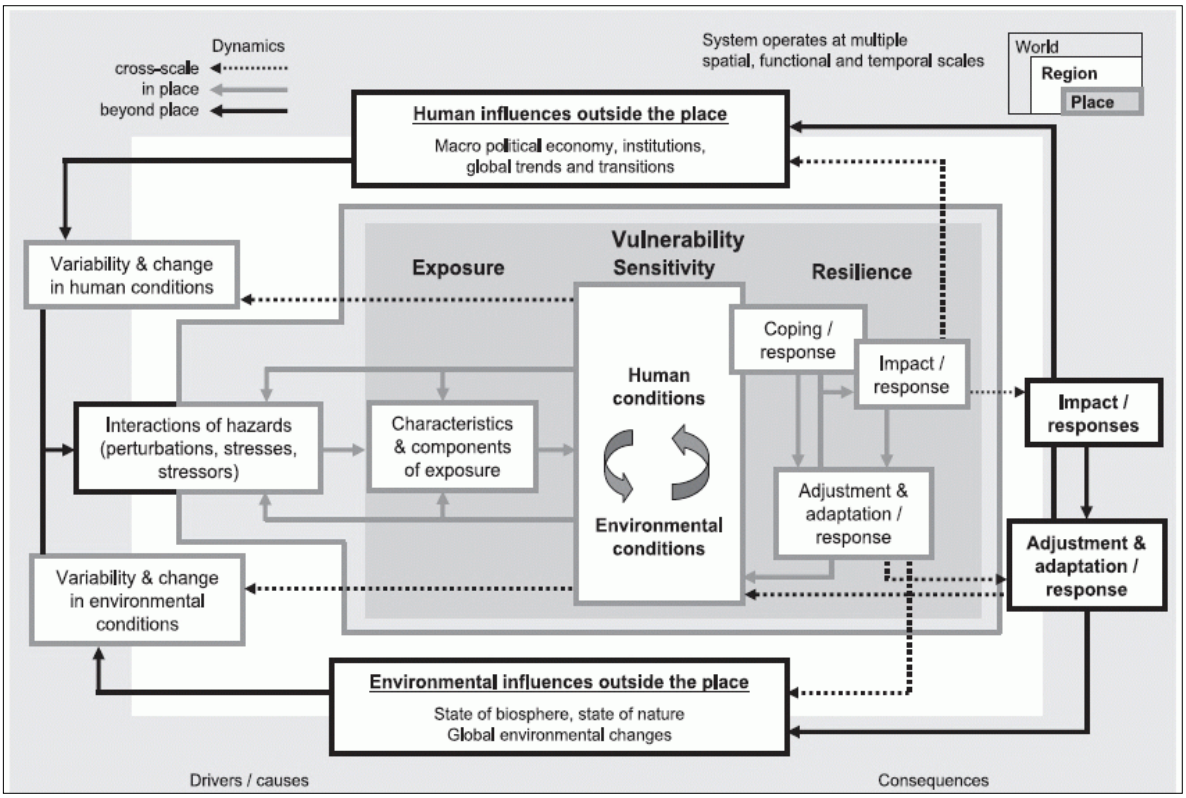

Figure 3. Turner et al.'s vulnerability framework.

Conclusions. The concepts of environmental capacity, vulnerability and resilience are interrelated and have wide application to global change science. Contemporary research in the field of environmental quality management recording an intense twist. Dominant "respond and fix" concept of environmental protection, increasingly is dominated by the "predict and prevent" concept. Forecasting changes in the environment, creating preventive actions and defining the corresponding measures are in the focus of scientific researches in this area. An essential part of preventive thinking is consideration of the concept of environmental capacity. Environmental capacity is dynamic phenomenon often in a continuous state of change either the environmental, economic or social processes that are involved within the concept. Nowadays, emerging interdisciplinary understanding of environmental capacity demonstrates the coexistence of all three pillars of environmental capacity – economic, social and environmental component. In this sense, future researches should address the rationale for environmental capacity improvement in term of benefits either for human kind or for environment.

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