Knowledge Support for Planning in Transition – Spatial Vulnerability Analysis for Canton Sarajevo

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Summary

Planning process is inevitably a complex one, involving many actors and interactions which eventually lead to negotiated decisions on development and protection of natural resources. Different political and social circumstances lead to a set of professional and political tasks which is usually to some extent formalized as national planning legislation. In transition countries, economic changes, private property and foreign investments led to strong pressures for development. In Bosnia and Herzegovina (BiH) the political-administrative function of planning is highly challenged, potentially leading to decisions which would be detrimental for sustainable development. The planning legislation tries to avoid this threat by explicitly requiring vulnerability studies as one of the inputs in planning process. Such ex-ante evaluation of environmental impacts of planned activities would ensure that environmental requirements are considered in land use plans. This contribution presents an environmental vulnerability study, which was prepared for spatial plan for Canton Sarajevo and will serve as a model case for other plans. It considered a whole set of land uses from the plan and environmental objectives such as protection of nature and human environment, cultural-historical heritage and natural resources, landscape identity, regional and urban development and potentials for strategic land uses. Vulnerability is used in different planning steps/tasks, such as: finding appropriate sites for certain land uses, developing and comparing alternative planning proposals, designation of protected areas, strategic environmental impact assessments, definition of development regulations. GIS format ensures flexibility in scales, transparency and relatively easy implementation, which is important in situation of limited resources at most of the administrative entities in BiH. Rather than being a burden for development, it helps to ensure that it observes the principles of sustainability.

1 Introduction

The idea of sustainable development requires that societies engage all their resources, including markets, rules, norms and scientific information. One of the potentially effective responses, linking all of these levers, is spatial planning. Planning process consists of expert and administrative tasks, which are more or less overlapping and intertwined. Their roles are formalized in planning legislation with an aim to ensure a high effectiveness of plan as a tool for sustainable development. Legalization of planning procedure is only one condition for the effectiveness of the plans, the other is their legitimacy. Plans are legitimate only as long as they are based on professional knowledge and convincing arguments and only as long as they can win public support. While the latter is being
ensured by increased participation of public in the planning processes, the former can be ensured by developing the solutions on solid expert knowledge.

In transition countries, economic changes, private property and foreign investments led to strong pressures for development. The plans, their restrictions and the time needed for plan approval, are considered a burden and a barrier for faster development. The politicians are tempted to change the planning legislation in ways as to impede the legitimacy and therefore the effectiveness of plans. An example is, the Spatial Planning Act of Slovenia, adopted in 2007 (ZAKON O PROSTORSKEM NACRTOVANJU, 2007), which restricts already well established standards for both public participation as well as expert knowledge by omitting the mandatory expert studies and analyses as a basis for planning decision. On the other hand the spatial planning legislation of an ex-Yugoslavia republic Bosnia and Herzegovina Federation explicitly requires several types of analyses as a base for planning (ZAKON O PROSTORNOM PLANIRANJU I KORIJENJU ZEMLJIŠTA NA NIVOJU FEDERACIJE BiH, 2006). The government has obviously recognized the threat of ad-hoc decisions regarding land use and the importance of the plans to be based on solid expert knowledge. One of the required inputs is environmental vulnerability analysis, which should ensure that environmental requirements are considered in land use plans and thus optimize land uses in terms of their impacts on nature and human environment, cultural-historical heritage and natural resources, landscape identity, regional and urban development and potentials for certain activities (METODOLOGIJA, 2004).

This contribution presents an environmental vulnerability study, which was prepared for spatial plan for Canton Sarajevo and will serve as a model case for other plans. Canton Sarajevo is one of the administrative units of Bosnia and Herzegovina, covering 1,268.5 km² within the Dinarides mountain massif at a border between the Danubian and Adriatic geographic units. Sustainable development of the area is challenged with several circumstances. Its administrative borders, which were designated by Dayton agreement in 1995, relate neither to historical, nor to economic or natural characteristics (GOSAR ET AL., 2006). This has several implications, such as migrations, difficulties with use of infrastructure and unbalanced settlement development as well as governance difficulties. At the same time, the reviving economy attracts foreign investments driven with strong development interests. In such situation Canton is even more susceptible to the negative effects of transition and globalization processes, also known to other eastern and southern European countries. The administrative structure including spatial planning is rather unsuccessful in coping with these challenges. Extensive erosion and land sliding caused by development on unstable slopes is just one of the most visible examples. With so many challenges and disturbed political-administrative function of the planning process, effective and convincing expert part of the planning process plays an even more important role.

Spatial plan for Canton Sarajevo for the period 2003-2023 (PROSTORNI PLAN, 2006) comprises goals and general principles of spatial development, strategic program and land use plan for all 9 municipalities of the Canton. According to plan, urban development should take place within existing boundaries of cities with internal development having priority over urban sprawl. Planned development includes new housing and industrial areas near existing urban centres, tourism and recreation facilities in the highlands, near thermal springs and in the areas of special natural qualities and new transport corridors. Plan also includes restrictions for development: agricultural land according to its quality, areas of
natural and cultural heritage and endangered areas (mine fields, erosion areas, land slides etc.). The aim of the vulnerability analysis is to verify the proposed development vis-à-vis protection aims and environmental qualities at the actual sites.

2 Method

‘Spatial vulnerability’ means the potential negative impact of planned activities on natural and man-made environmental values (STEINITZ 1967). Vulnerability concept developed in the fields of environmental and landscape planning in early 70s, when the focus on environment in planning brought several approaches with different names; such as impact models (LYLE, 1985; STEINITZ, 1990), sensitivity of resources (LYLE, 1985, KOZLOWSKI, 1986), sensitivity to threat (KOZLOWSKI, 1986), development constraints (PATRI, 1972, KOZLOWSKI 1986), development thresholds (KOZLOWSKI, 1986). Vulnerability analysis has been applied as a protection oriented part of suitability analysis, which aim is to determine fitness of a given tract of land for particular land use (McHARG, 1969; HOPKINS, 1977). Limitation (vulnerability) criteria of suitability reveal the conditions, which may trigger increased environmental impacts in case of land use; i.e. unstable slopes for housing development. Such division was originally implemented in environmental impact assessments (NATIONAL, 1970) and was later introduced also into spatial planning (PATRI, 1972; STEINITZ, 1967).

Vulnerability analysis is applied in the process of spatial planning, with an aim to optimize the distribution of land uses in terms of their environmental impacts. Since the expansion of computer support, especially GIS, they became a regularly used tool in planning practice (STEINER, 2000; STEINITZ, 2003; MARUŠIČ, MLAKAR, 2004). Their further development was spurred by various types of (in)formal procedures, such as (strategic) environmental impact assessments, comparative evaluation of alternative options, sustainability assessments, which all aim to ensure adequate consideration of environmental protection in decision making processes. These procedures require the methods, which explicitly treat environmental protection aspects in an accurate and legally defensible manner (NDUBISI, 2002). The contemporary definitions and applications of vulnerability concept are answering this demand by focusing on obtaining objective criteria for deciding the site of a specific territorial intervention and for determining impacts associated to different alternative futures (STEINITZ ET AL., 2002; MARULL ET AL., 2007; MEHAFFEY ET AL., 2008; SHEARER ET AL., 2006). Vulnerability approach is also applicable within strategic impact assessments (SEA), as required by the European legislation (DIRECTIVE, 2001). MARULL ET AL. (2007) for example use “territorial vulnerability index” to quantify the vulnerability of the biosphere, lithosphere and hydrosphere in a SEA of impacts arising from implementing development proposals.

Vulnerability analysis follows a structure of a deduction based approach, where the concepts are built according to some theoretical base. The first step involves understanding the phenomenon that is being studied and the main processes that are involved (modelling). The second, reductionist, step involves identifying the main processes to be included in study and how they are related. The third step involves selecting the indicators for these
processes and assigning values and weights (NIEMEIJER, 2002). These three phases are implemented in our vulnerability analysis as follows.

The starting point for the analysis is a two-dimensional interaction matrix (LEOPOLD, 1971) known and widely applied in environmental impact assessments practice. The matrix involves definition of environmental components on the first axis, and activities or project actions on another one. The planned activities for the presented study are taken from the existing spatial plan for Canton Sarajevo as well as from short and medium term development initiatives, and include: housing, agriculture, extraction of mineral resources, open air recreation, transport infrastructure, energy infrastructure, utilities, industrial zones, warehouses, technologic and business centres, shopping centres. The environment on the other side was divided in physical components as objects of three basic conservation aims; i.e. protection of the human environment from all forms of pollution, conservation of natural resources for the future generations, and conservation of nature as a holder of inherent values (MARUŠIĆ, 1995). We consider the following environmental components: air/climate, geomorphology/soils, rivers and streams, biosphere, forests, agricultural land, water resources, mineral resources, potentials for recreation and housing, human environment, landscape and cultural heritage. Every environment/action component couple represents a potential impact. Since not all of them are actually probable or significant, a selection of 99 impacts identified by experts as relevant was included in the analysis.

Each of the impacts identified in the matrix is described by a vulnerability model. This step begins with the definition of the factors (characteristic of the environment) affecting the size of the impact, indicators and the interrelation function. Similar to other complex systems involving a lot of indirect relations and uncertainties about cause–impact, environmental vulnerability is more likely explored by qualitative indicators and methods (NIJKAMP, VAN PELT, 1989; SCHINDEGGER, TATZBERGER, 2004; JACOB ET AL, 2008). We developed the model concepts based on literature and expert opinions. The first drafts of the models were prepared by a core project team. These were later presented to experts from relevant fields and familiar with local situation (i.e. geologist, biologist, forestry and agricultural experts…) and were adequately adjusted according to their opinion. The possible states of the environment were classified according to the level of potential impact in 5 vulnerability classes; 1 describing the state, where no change is foreseeable, 5 describing the state leading to an impact exceeding (formally established or otherwise justified) threshold of acceptability. The classes in between are defined so as to describe the intermediate level of expected impacts. Each model concept includes the definition of thresholds between the classes for individual factors. The thresholds of each value class are described by a set of qualitative criteria such as legislative requirements, existing studies and expert knowledge. For example the slope gradient bellow 10% is considered as not requiring any change in geomorphology (vulnerability class 1), gradient higher than 60% is considered as not allowing any interventions (5), while classes in between are distributed according to the extent of additional change of terrain because of the required technical measures (example of a vulnerability model is presented in table 1). The total vulnerability of an environmental component is obtained by aggregating vulnerabilities of individual factors following the expert rules as expressed in matrices. As a general rule, the average value was considered. However, the matrix approach also enables to define specific situations, where certain combination of factors either reduces or (more importantly) significantly increases vulnerability. For example, the very steep slope can be little
probabilistic in coincidence with very stable soils, while even a moderate slope can be very vulnerable on highly unstable soils. This approach is flexible and enables to best describe the problem in question, but it is also sensitive to decisions of evaluator(s) as well as difficult to explain and follow. It is therefore very important to document all the decisions to be able to track back and discuss the decisions made. All the models were in our case discussed in expert workshops and agreed within the project team. The calculated vulnerability class is then attributed to each spatial unit.

**Tab. 1:** Example of model description: vulnerability of soils and relief due to housing development

<table>
<thead>
<tr>
<th>potential impacts</th>
<th>vulnerability criteria</th>
<th>spatial data and categories</th>
<th>mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>reformsations and transformations of relief</td>
<td>steep slopes, because major terrestrial and construction interventions are needed and changes will be much bigger</td>
<td>slope 0 – 10%</td>
<td>1</td>
</tr>
<tr>
<td>endangering or damaging special or distinct geomorphologic formations or exceptional type of soils</td>
<td>less stable and unstable slopes, because major construction works are needed to ensure adequate stability</td>
<td>10 – 20%</td>
<td>2</td>
</tr>
<tr>
<td>increasing potentials for erosive process</td>
<td>unstable soils</td>
<td>20 – 30%</td>
<td>3</td>
</tr>
<tr>
<td>pollution of soils because of discharging fuels</td>
<td>conditionally stable</td>
<td>30 – 60%</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>unstable soils</td>
<td>&gt; 60%</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>areas with special or distinct relief formations or configuration that could be damaged or destroyed</td>
<td>geomorphologic heritage</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>areas of natural heritage and natural monuments where all above mentioned impacts present a degradation of site</td>
<td>+ buffer 100m</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>100 – 200 m</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>200 – 500 m</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 500 m</td>
<td>1</td>
</tr>
</tbody>
</table>

The size and shape of the spatial unit must satisfy two criteria: it must allow the assumption of homogeneity in terms of the expected impact and it must provide the information useful for taking decisions. The grid size of 20 × 20 m corresponds to the quality of available data as well as to the level of planning (i.e., land use planning on scale of 1:200,000 to 25,000).

The second part of the assessment is synthesis of the results, which involves the decisions on the level and the format of aggregating individual model results. The use of the results as decision-making support required synthesis of separate vulnerabilities, which means a combination of factors with heterogeneous measurement types (quantitative and qualitative) and units. This aggregation was enabled by classification of separate vulnerabilities on a numerical scale. Our primary concern was to aid planning decisions regarding designation of land uses. Therefore, the synthesis aggregated models across the
environmental components resulting in a model for each of the considered activities, representing its potential impact on all considered environmental components. The aggregation of the models follows the maximum rule whereby the highest potential impact (or the most vulnerable component) is taken into account. This approach is consistent with the precautionary principle, which is commonly followed in environmental protection issues. The problem with following this approach is that it may result in very large part of an area classified as highly vulnerable. This may prove to be too restrictive regarding the development and space for its optimization. This problem was avoided by defining the threshold for highest vulnerability mark so as to strictly include only those environmental situations where the development would absolutely not be acceptable.

The calculation and spatial representation of the models was done by raster spatial analysis of GIS programme ProVal 2000. Indicators were represented by corresponding attributes of geo-referenced data such as digital elevation model, land cover, ground and underground water inventory, settlements; etc.

Like every assessment method, the overlay of factors using expert rules is sensitive to the issues inherent with combining different types of variables (MEHAFFEY ET AL, 2008). The inconsistency in evaluations can be checked for example by sensitivity analysis to changes in parameter values and/or aggregation rules. A simple analysis was performed on a chosen set of models using two methods: one was a holistic visual assessment, where a general pattern of vulnerability classes was compared; the other was verification of the results for few chosen sites, which were previously identified as potentially problematic from the modelled aspect. Such validation for example proved that model for vulnerability of soils and relief due to housing development is not very sensitive to the distribution of slope gradient classes, since the vulnerability largely depends on data on soil stability. The results consistently revealed similar areas as critically vulnerable.

3 Results

The results of individual models are presented on maps showing areas of different vulnerability levels. As an example we present the model dealing with already mentioned problem of development on unstable slopes. Corresponding vulnerability map (Fig. 1) shows vulnerability of soils and relief due to housing development (including social infrastructure, such as medical centres, schools, post offices, grocery stores etc.). Darker areas on vulnerability map are more vulnerable.
Fig. 1: Vulnerability of soils and relief due to housing development
Fig. 2: Joint vulnerability map for housing development
Figure 2 shows the joint vulnerability map for housing development, considering potential impacts on all environmental components. Vulnerability map for housing shows high vulnerability in the areas of preserved nature and important cultural heritage, on steep slopes and highly valued agricultural lands. Development in areas with the highest vulnerability class should be avoided. In other areas classified as vulnerable the development should comply with regulations requiring technical solutions to prevent environmental impacts.

Vulnerability maps for all activities show similar areas: Rakitnica, Bjelašnica, Treskavica, a part of Visočica and Jahorina, Skakavac, Vrelo Bosne, Bentbaša, Bijambare, Ozren, Debelo Brdo, Čemerska planina, Podlipnik etc. These areas should be considered as priorities for complex protection in forms of nature protection areas or ecologic networks. The maps mostly differ in the level of expected impact for different activities. Areas of high vulnerability include also water resources and proximity of streams. Vulnerability of human environment is highest in and around existing settlements; but levels for activities differ according to the type of expected emissions and their impact on quality of living. This result questions the general planning orientation to locate new settlement within existing boundaries of cities. While such orientation seems well in line with modern trends of sustainable urban development aiming at preventing urban sprawl, it proved problematic when faced with specific environmental conditions. One of the conclusions of the study was therefore to reconsider this guidance and to provide better and more detailed bases for planning in areas identified as highly vulnerable.

4 Discussion and Conclusions

Vulnerability analysis is a multi-attribute evaluation of the natural characteristics of Canton Sarajevo area from the aspect of land use planning. It identifies the combinations of environmental factors which restrict certain type of development and maps potential severity of environmental impacts of proposed development. The future development should primarily be directed into least vulnerable areas, development in the moderately vulnerable areas should comply with appropriate restrictions and recommendations, while the most vulnerable areas should be avoided.

The most effective application of the vulnerability analysis is ex-ante, as a part of expert input at the beginning of a planning process. In the case of Canton Sarajevo, the legislation which required vulnerability analysis came into force only after the plan was adopted. It will therefore serve as a tool for parallel evaluation of plan implementation, as a guidance for planning on lower levels and, very importantly, as a model for plans which will be adopted on all levels of planning in BiH. Another potentially useful application is in Strategic environmental assessments for different planning documents, as required by EU Directive 42/2001. An important benefit of using vulnerability study in SEA is that it enables consideration of spatial distribution of impacts, which most other impact models omit. Another advantage of vulnerability study is that it is adapted for use from the beginning throughout the planning process as required by Directive. Most other impact models can not be run without detailed input information, which is usually not available at the beginning of the planning process.
By its different modes of application, vulnerability analysis enables that environmental aspects are treated equally with social and economic consistently and through different decisions about spatial development. Vulnerability analysis explicitly focuses on those factors, which have a restrictive meaning for development since they reveal high sensitivity of environmental components. As such it differs from the traditional suitability analysis, (McHarg, 1969; Hopkins, 1977), which is based on both opportunity (attractiveness) as well as restriction (vulnerability) criteria. Focusing on vulnerability criteria was partly influenced by sustainability paradigm and its explicit treatment of environmental aspects as reflected in different (in)formal procedures, which can be effectively supported by vulnerability analysis. As a land use planning support, vulnerability analysis can be supplemented by its developmental counterpart based on the opportunity (attractiveness) criteria. The explicit confrontation of both mapped aspects can help to reveal either sites of potential conflicts or alternative sites, where both aspects could be satisfied. It must nevertheless be noted that a GIS attractiveness analysis is only indicative since it can only model factors depending on physical characteristics of environment. In the real world development often follows other location criteria, which are difficult to map, such as ease to obtain land, “image” of an area, sociologic and administrative situation, etc.

References


National Environmental Policy Act (NEPA), [42 U.S.C. 4321 et seq.].


