PRIORITY ACTIONS PROGRAMME

LANDSCAPE PLANNING AND VULNERABILITY ASSESSMENT IN THE MEDITERRANEAN

Thematic study

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Final report

Regional Activity Centre for the Priority Actions Programme
PAP/RAC, Kraj Sv. Ivana 11 HR-21000 SPLIT CROATIA

The appointment based on the project: MEL- 2322-2664-2202

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Cover photo and photo on p. 41 by: Vid Pogačnik

Ljubljana, February 2010

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Summary

Integrated management of coastal zones should, according to the Barcelona Convention and its ICZM Protocol, apply relevant landscape management methodologies and tools to take into account the protection of landscapes and areas of ecological interest and the rational use of natural resources. The thematic study Landscape planning and vulnerability assessment in the Mediterranean brings to attention the methodologies used in landscape planning that allow for integration of various land uses and protection of landscape values through planning instruments. Landscape planning approaches, such as vulnerability assessment, are especially relevant for fragile areas such as Mediterranean region, characterised by increased competition of uses for scarce and highly valuable natural resources. Vulnerability assessment provides tools for decision making on different levels and scopes of spatial planning and management. It can be applied as an input at the beginning of a planning process; as a midterm evaluation tool or for comparing and choice of alternative options. Along with (strategic) environmental assessments, vulnerability assessment is a key tool for preventive environmental protection.

The study first gives an overview of different planning methods and their potentials to respond to two main challenges of contemporary planning and management: protection of environment and natural resources and conflict resolution by participation of stakeholders. The next chapters concern with landscape planning methods in general and then focus on vulnerability assessment. Landscape planning approach is based on the “suitability" concept, meaning the inherent fitness of the land to support a particular use. Limitation (vulnerability) criteria consider the characteristics, which may trigger environmental impacts in case of proposed land use and identify the need for protection. Level of vulnerability depends on the characteristics of a stressor (human intervention) and environment. Description of both is therefore an essential first step of the assessment, leading to identification of key elements. These elements are then used as inputs in an interaction matrix and interrelated to obtain potential impacts. Based on this matrix, a set of relevant impacts is selected for modeling in the following step. Vulnerability modeling begins with the choice of the spatial unit and development of model concept. Spatial unit must provide (relative) homogeneity of the environmental characteristics within the unit as well as useful information for decision making. For planning purposes, raster cell of suitable size is most useful, while an appropriate level of landscape or bio-geographic unit is applicable for management purposes. The aim of developing model concept is to describe the nature of human-environment interrelation; i.e. to identify which characteristic of the environment affect the size of the potential impact and in what way. Indicators and available data must also be selected. The evaluation phase involves estimation and expression of the impact size, which is ascribed to each spatial unit as a vulnerability class. The analytical part of the vulnerability assessment results in a number of models, describing the relatively homogeneous and commendable parts of the problem. Use of these results in decision-making processes requires that information is provided in a more synthetic, ready to interpret way. The partial vulnerability scores are therefore aggregated using logical or arithmetic rules.

Vulnerability assessment is a key approach of optimization-based environmental planning and management. It enables consideration of environmental requirements in an integrated (transsectoral) and transparent way by considering the needs and proposals for development. By simulating potential negative impacts of the planned activity on environment, it can inform the planning process where to avoid certain land use. Its outputs support

development and choice among alternative planning options and optimization of site for individual land use/ facility, including identification of least vulnerable corridors for infrastructure. Vulnerability assessment can help to identify areas of strategic importance for protection of natural resources and nature conservation including ecologic networks. A recently expanding field of application is in strategic environmental impact assessments as required by Dir. 42/01 EC. While these types of questions are most relevant for strategic planning, vulnerability assessments can be used also at detailed planning levels as a base for defining management measures and criteria, regulations and guidelines for land use.

The last part of this thematic study presents two examples of vulnerability assessments, which were applied in Mediterranean part of Slovenia. Both presentations include description of vulnerability assessment process and application of methodology. The case of Piran Municipality presents the use of vulnerability assessment as a part of municipal land-use plan designation process. The example shows how and in what aspects vulnerability assessment contributes to planning decisions. The case of wind farms in Primorska region is an example of identifying spatial potentials (and restrictions) for exploration of a natural resource. The results of vulnerability assessment were in this case used as an input in a multi-criteria evaluation and choice among alternative proposed sites for a wind farm.

1 Introduction

The Barcelona Convention (UNEP, 1976) states "*Contracting Parties shall commit themselves to promote the integrated management of coastal zones, taking into account the protection of areas of ecological and landscape interest and the rational use of natural resources*." Therefore, the Contracting Parties to the Barcelona Convention, at their Ordinary Meeting in Almeria in 2008, adopted the recommendation to undertake thematic studies with a view to developing relevant landscape management methodologies and tools in Mediterranean coastal areas. In addition to this, the Protocol on Integrated Coastal Zone Management in the Mediterranean (ICZM Protocol) signed in January 2008, in Article 11, also requires the protection of landscapes through various means. In this regard, it is closely linked with the European Landscape Convention of the Council of Europe.

It should be noted that coastal landscapes of the Mediterranean have never been studied or elaborated in the MAP projects per se. Landscape was taken into account only indirectly, through proposals of various documents (plans, strategies, programmes), in projects oriented to local level, such as Coastal Area Management Programme (CAMP), by using ICZM methodologies or by dealing with individual natural resources. However, the existing landscape-specific methodologies and concepts (such as landscape planning, vulnerability studies, and outstanding landscapes) have not been introduced or taken into account.

The following thematic study: Landscape planning and vulnerability assessment in the Mediterranean brings to attention the methodologies used in spatial planning, in particular landscape planning approaches that allow for integration of various land uses and protection of landscape values through planning instruments.

Although the landscape planning and vulnerability assessment in particular were not developed for any specific region, it should be noted that its concept and approach were developed to protect natural resources while trying to accommodate the needs of human uses. As such, they are especially relevant for areas where there is increased competition of uses for scarce and highly valuable natural resources and in particularly fragile areas such as Mediterranean region. Vulnerability assessment provides tools for decision making on different levels and scopes of spatial planning and management. As such, it can contribute in several ways to integrated coastal management, as mentioned in the ICZM Protocol:

- It enables a preliminary assessment of the risk associated with the various human activities and infrastructure so as to prevent and reduce their negative impacts on coastal zones, to minimize the use of natural resources and take into account future generations.
- It enables integrated consideration of different aspects of hydrological, geomorphologic, climatic, ecological, socio-economic and cultural systems so as not to exceed the carrying capacity of the coastal zone.
- It supports formulation of land use strategies, plans and programmes covering urban development, socio-economic activities and use of natural resources.
- It supports preparation of (strategic) environmental assessments of plans and programmes affecting the coastal zone.

2 Landscape planning approach in relation to other planning concepts

Spatial planning has a long history. As Wegener (2007) says, planning is not a phenomenon of modern times but has always been a prerequisite for survival under harsh conditions of life. Planning has been indispensable for creation of civilizations, for warfare and for the establishment of permanent settlements, communication networks and social systems. However, it was not until 19th century that spatial planning became a field of political attention and professional activity.

Spatial planning has always been regarded as an activity that, in seeking solutions for a certain social problem, brings a change into the territory. It primarily looks after social needs, the economical use of the resource and its fertility. Because spatial planning is essentially economic in orientation, it is generally characterized as developmental planning.

Figure 1 (Ivan Stanič)

The end of 20th century has brought big challenges for traditional spatial planning. Changed social and economic conditions as well as growing environmental awareness required redefinition of the role and responsibilities of spatial planning. Today, planning has to respond to (at least) two additional expectations of society:

- environmental and landscape protection,
- public participation.

2.1 Environmental and landscape protection in planning

The concern for environmental protection goes far back in the history (see for example Ndubisi, 2002a). In the 1960s, it became the subject of wide public interest. The book Silent Spring by Rachel Carson (1962) is widely credited with raising the awareness of the environmental consequences of our decisions and actions.

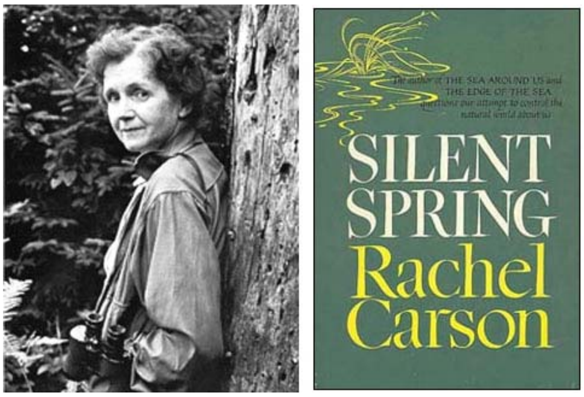


Figure 2: R. Carson and her book Silent spring

As long ago as 1976, the Vancouver Declaration on Human Settlements (UNCHS) stated that spatial planning must be tuned with environmental protection requirements. It states that human settlement policies must be harmonized also with policies on environmental and cultural preservation "*…so that each* *supports the other in a progressive improvement in well-being of all mankind*".

Political efforts for environmentally-tuned economic growth began more actively in the end of 20th century, first with the Brundtland Report (WCDE, 1987) that introduced the concept of sustainable development, which seeks to meet "… *the needs of the present without compromising the ability of future generations to meet their own needs*". As was more explicitly defined later at the United Nations 2005 World Summit the concept of sustainable development focuses on three "*interdependent and mutually reinforcing pillars*": economic development, social development and environmental protection. The Brundtland Report was followed by Rio Declaration and Agenda 21, both agreed upon at the Rio Summit (UNCED, 1992). The Rio Declaration states that the only way to have long-term economic progress is to link it with environmental protection. In Principle 4 it states: "*In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it*."

The Agenda 21 states that spatial planning should strive for "*promoting sustainable human settlement development*". It also stresses the need to change from old sector-centred ways of doing business to new approaches that involve cross-sectoral co-ordination and the integration of environmental and social concerns into all development processes.

Today, environmental protection has become very important part of development thinking and of everyday functioning, a kind of general obligation for everyone on the planet. This is also reflected in the field of spatial planning. There is a great demand for facing economic aspirations for spatial development with social interests, the need for nature and landscape protection as well as conservation of cultural heritage in order to contribute to a long-term and balanced - that is sustainable - spatial development. The demand is expressed in various world and European documents, including Habitat Agenda (UNCHS, 1996), European Spatial Development Perspective – ESDP (European Union, 1999) and Guiding Principles for Sustainable Spatial Development of the European Continent (Council of Europe, 2000). All three documents are emphasizing the significance of spatial planning and its instruments for the attainment of sustainable development.

Requirement for sustainable development and sustainable use of natural resources is particularly strongly emphasized in the areas that are on the one hand ecologically sensitive and landscape diverse and on the other hand under intense pressure from developers. Such is the Mediterranean area, whose management is defined in the ICZM Protocol. One of its objectives is to "*facilitate, through the rational planning of activities, the sustainable development of coastal zones by ensuring that the environment and landscapes are taken into account in harmony with economic, social and cultural development*".

The important message that already the Vancouver Declaration partly implied and was explicitly expressed in the Rio Declaration was: in order to achieve sustainable development, comprehensive and integrated approach in planning is needed. That is the approach, where all factors, economic, social, ecological and cultural "… *are jointly used and combined to guide land- and facility-use decisions towards sustainable territorial development*" (Council of Europe, 2007). In order to effectively and successfully guide decisions they must be confronted and combined as soon as possible in the planning process.

The call for the comprehensive planning comes also from the European Landscape Convention – ELC (Council of Europe, 2000). The ELC defines landscape as »...*an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors*". Landscape is thus a notion that grew out of a comprehensive thinking about the visible environment. Since landscape is a synthetic concept, the care for it should be comprehensive. The same applies to the three implementation policies of the ELC: protecting, managing and planning the landscape.

The comprehensiveness and integration is also highlighted in the ICZM Protocol that governs management of the Mediterranean area. To ensure preservation of the integrity of coastal ecosystems, landscapes and geomorphology, which is one of the objectives of the ICZM Protocol, "*all elements relating to hydrological, geomorphologic, climatic, ecological, socio-economic and cultural systems shall be taken into account in an integrated manner*".

2.2 Public participation in planning

Figure 3 (Ivan Stanič)

The already mentioned book Silent Spring and major ecological disasters in the second half of the 20th century (e.g., Seveso in Italy, 1976; Chernobyl in Ukraine, 1986) not only brought environmental issues into conscious of planning professionals, but also had a great impact on the development of public participation. These disasters made the public increasingly aware of the potential dangers of environmental pollution, and therefore they insisted on better and safer regulations and more openness in matters of ecological importance. Authorities were forced to involve citizens in the decision-making process and to provide more access to information.

The promotion of public participation in spatial planning policies started with The European Regional/Spatial Planning Charter, also known as the 'Torremolinos Charter' (CEMAT, 1983). Together with the need for environmental protection, public participation is also set within the context of sustainable development. It was given significant emphasis in the Brundtland Report (WCDE, 1987) and the Rio Declaration (UNCED, 1992). One of their messages was that active public participation is a prerequisite for achieving sustainable development and solving the environmental problems of the world. The value and importance of a bottom-up approach is also emphasized in the Agenda 21 (UNCED, 1992), particularly in the Chapter 28: "*Because so many of the problems and solutions being addressed by Agenda 21 have their roots in local activities, the participation and co-operation of local authorities will be a determining factor in fulfilling its objectives*". The chapter is an appeal to 'local authorities' to engage in a dialogue with all local stakeholders and to "… *seek for a new participation process where the communication … goes beyond existing and traditional consultation*". The documents were followed up by the Aarhus convention (UNECE, 1998) with full name Convention on access to information, public participation in decision-making and access to justice in environmental matters. The full name highlights the so-called three pillars of the Aarhus convention that more precisely specify the requirements for public participation in environmental matters. The call for close cooperation in spatial planning is stated also in the ESDP (European Union, 1999). It calls for close cooperation amongst the authorities responsible for sectoral policies (horizontal integration) as well as for close cooperation between actors at the community level and the transnational, regional and local levels (vertical integration). The need for participation and close coordination is as well expressed in the ICZM Protocol (Article 7) as an important requirement for integrated Mediterranean coastal zone management. In addition, European Landscape Convention in its Article 5 stresses the importance of integration of local people into decisions about the landscapes. As expressed by Marušič (2006), open and dispersed decision-making process is even more important than the physical appearance of the landscapes themselves, when an adequate evolution of landscape is in question. In other words, the processes within which the landscapes are changed, intentionally or spontaneously, are even more important than inventory, recognition or evaluation of landscapes, their physical structure or their visual appearance alone.

Today, public participation from the very early stages of the planning process is generally accepted as necessary part of spatial planning to reach development, which is both sustainable and accepted among wider public. It should be noted that participation refers to involvement of all persons, groups or institutions with interests in a specific planning process. It is accepted that public participation can contribute to public awareness and increase support for the final decisions taken. The process of decision-making, up to and including the final decision, becomes more democratic and legitimate. Public debate on proposed planning solutions among all stakeholders at an early stage of decision-making may prevent or mitigate conflicts and adverse environmental impacts.

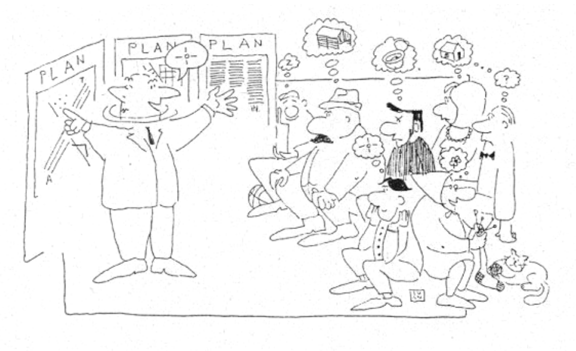


Figure 4 (Ivan Stanič)

For successful participation and engagement of the stakeholders, the decision-making process must be not just close to them and open for them from the beginning. It must also be transparent and systematic. Transparency is an important prerequisite for active and equal participation that would lead to a more democratic, legitimate and consensual planning solutions.

2.3 Contemporary spatial planning: declarations and implementation

In response to the call for more comprehensive and inclusive or participatory decision making, new theories of spatial planning have been developed. To be precise, on the theoretical field, the traditional model of planning as a form of top-down and rational decision-making was challenged already in the 1960s and 1970s in the books of Jane Jacobs (1961), Robert Goodman (1971), John Friedman (1973) and others. The main reason came from the recognition that traditional top-down planning is ineffective and that spatial solutions are not harmonized with the real needs and interests of people. They all claimed for a new model of planning that would be based on a dialog between all actors and where the dialog would represent a basis for mutual learning. These ideas were picked up in the work of other contemporary theoretical planners, including John Forrester (1999) with the model of communicative planning and Patsy Haley (1997) with the model of collaborative planning.

However, changing theories of planning, to include concept of sustainability and principles of integration and public participation at the most general levels are not enough. The authors of the publication Landscape and sustainable development (Council of Europe, 2006) have hit the heart of the problem when they wrote: "*Proclaiming the principle of integration (of environment in the development process) is all very well – it is integration methods and tools that pose most problems*".

There are many different spatial planning approaches across countries, reflecting diverse territorial and political contexts. Accordingly diverse methods and tools for integration of environmental concerns into spatial planning have been developed. Some are more effective and support more comprehensive approach than others. In many European countries, the increased environmental concerns led to stronger role of the sectors whose responsibility to protect nature, natural resources and cultural heritage has been supported by several legal instruments. These approaches prevailingly rely on standards and are well adjusted to management. As such, they are very important as a complement to planning, but can and should not substitute for it. For example, concentration on legally protected parts of environment leads to neglect of others, which may be in certain specific or local context of great value, but have no legal protection. Also, some environmental components are easier to set standards for (for example air emissions) other (for example landscape amenities) much more difficult. Secondly, sectors tend to impose their protection regimes in a form of spatially defined areas (i.e. protected agricultural land, nature conservation areas…), which inevitably confront with other uses of space. Since they are often not obliged to go through negotiation and conciliation procedures with them this leads to one sided and potentially under optimal use of space. With increase of environmental demands, the sectors tend to expand the boundaries of the areas under their "jurisdiction", which results in bigger and more frequent conflicts with other users of land.

In addition to the successful integration of environmental considerations, methods and tools must also allow for active participation. Participation procedures in the spatial planning practices are still weak, ad-hoc and inadequate (eg. Kalopedis, 2007; Marušič, 2006; Nilsson, 2007). Making decisions is often overpowered by main political and economical actors. Participation in the planning process is usually done only through selective consultation and not through inclusion. Inactive public participation in a form of giving comments on the planning proposals at the end of planning processes usually ends in denying proposals instead of developing joined consensual solutions. Similar to environmental issues, the biggest problem of public participation is the lack of methods and tools.

Unequipped with effective tools and methods planning is powerless in ensuring balanced environmental, economic and social development. The consequence is colourfully illustrated by the words of Kristina Nilsson (2007): "*In practice, however, the concept of sustainable development seems to be used more like a mantra that is seldom realized in practical planning*".

If spatial planning is to effectively lead towards sustainable development, it must develop and apply methods and tools that would enable:

- comprehensive consideration of issues involving spatial, environmental, social and economic aspects,
- involvement of all relevant actors, including civil society and the public, on the basis of collaborative work, in the earliest stages of planning.

Transparency of the planning procedures and decision-making is one of the necessary conditions to achieve both of the above requirements. The creative component of the planning, which is inevitable due to many uncertainties involved in the task, still favours holistic, intuitive approaches, but should and need not prevent the planning to apply more transparent approaches.

2.4 The landscape planning approach

Landscape planning, often referred to as 'environmental planning' or 'ecological planning', is a way of directing or managing changes in the landscape so that human actions are in tune with nature and environment (Ndubisi, 2002a). It evolved from the belief that the fundamental instrument of environmental protection is unified approach to spatial planning that coordinates developmental interests and the demand for environmental protection. The premise of landscape planning is that natural environment is a resource and at the same times a constraint on human activities.

The definition of landscape planning, given by Dame S. Crow (R. Enis, Landscape Conference in Hannover, 1989) clearly indicated the essence of landscape planning. She defined it as 'creative conservation'. The aim of landscape planning is thus to prevent or at least limit the degradation of the environment to a minimum while increasing, as far as possible, 'creativity' in order to meet the developmental needs.

By combining approaches from the natural sciences and the planning disciplines landscape planning has developed a range of different methods and tools for integration of environmental objectives into the process of analysis and the development of planning proposals. Landscape planning approaches and methods are transparent and systematic, which makes them useful for participatory and comprehensive spatial planning.

The basic distinction between spatial planning and landscape planning is that the former is essentially economic and developmental in orientation, while the latter is more concerned with environmental and landscape qualities and thus protective in orientation. It must be noted that landscape planning does not represent a substitute for spatial planning. With developed approaches and methods, it may complement a set of spatial planning approaches and methods and contribute to larger efficiency of bottom-up comprehensive planning.

Landscape planning is also a way to effectively include the environmental requirements of different sectors into planning process. One of the most valuable approaches is vulnerability analysis, where environmental qualities are assessed from the viewpoint of potential threat resulting from planned actions. It functions as an integrating and conflict-solving tool, since it:

- includes a whole territory (of a chosen administrative / planning unit),
- considers a whole range of diverse environmental components,
- supports active dialog between stakeholders,
- may embrace all interests (natural, social, economic, and political) and evaluate their consequences and thus supports cross-sectoral or comprehensive planning, and
- supports search for an optimal solution.

3 Methods in landscape planning

3.1 Suitability as a planning concept

According to Ndubisi (2002a), landscape is the geographical template for undertaking ecological planning. Landscape planning is therefore commonly used to denote the application of ecological principles in spatial planning. The approach is based on the 'suitability' concept, meaning the inherent fitness of the land to support a particular use. The idea of suitability was introduced into planning by Patrick Geddes (1854-1932), biologist and urban planner who presented it as 'valley section'; a sketch showing different parts of territory as being inherently suitable for specific human activity (figure 5). Failing to recognize these human – landscape interrelations either does not work or requires too much energy and too high a risk.

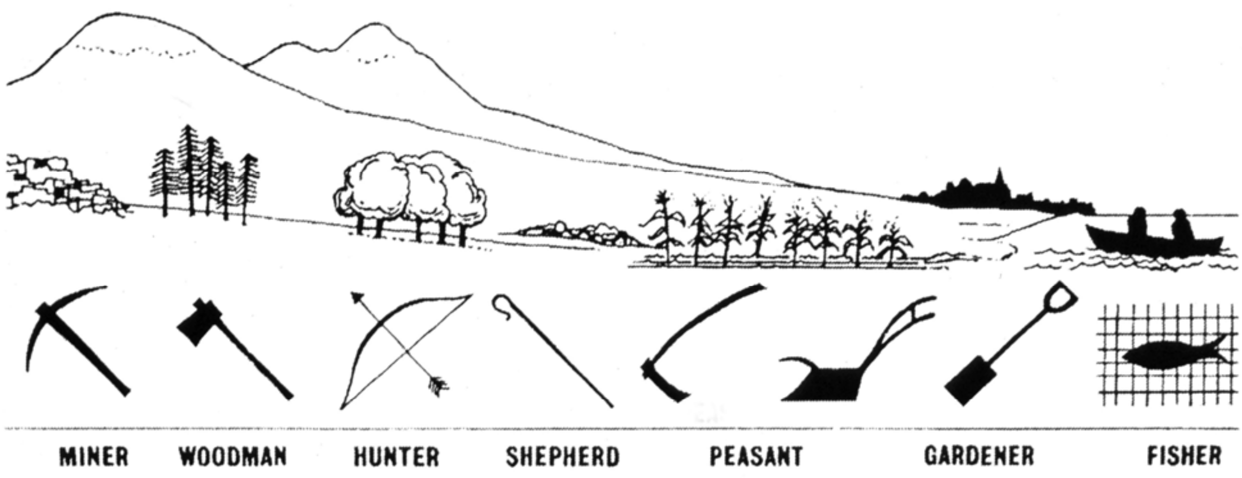


Figure 5: The valley section of P. Geddes illustrates the idea of suitability

The first applications of this idea in spatial planning were developed in New England in USA by C. Elliot (in 1880) and W. Manning (between 1912 and 1923), who were using hand-drawn overlays to determine the ability of land to support planned uses.

The growing public awareness of the negative environmental impacts of human actions increased the need for the method that was both accurate and defensible. The ecologic planning method developed by Ian McHarg was the most coherent and complete one, and was supported by convincing philosophy, described in a classical book Design with nature (McHarg 1969). His approach is based on a layer cake representation of phenomena and their interdependence. The interactions among these phenomena through time can be interpreted through human aspirations as intrinsic value (»fitness«) of environment for human use.

The majority of contemporary landscape planning approaches is still based on suitability concept, although the development in other disciplines and overlapping with them has brought variations, focusing on different aspects on nature-human relationships (figure 6).

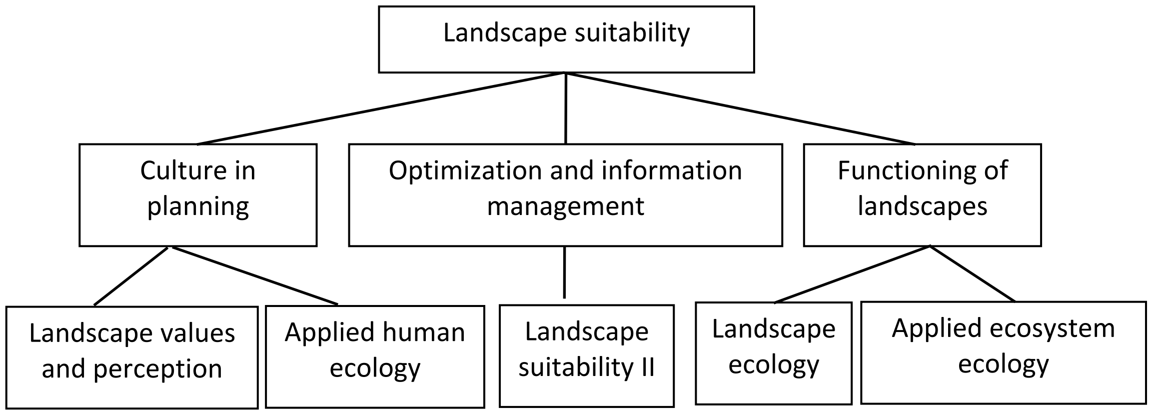


Figure 6: Major approaches to ecological planning (Ndubisi 2002b)

Landscape values and perception approach regards the landscape as physical / aesthetic expression of human values (represented by for example E. Zube, S. and R. Kaplan). Applied human ecology is based on human interaction with environment. Its focus on cultural dimension aims at overcoming the human – nature divide (I. McHarg, D. Rose, F. Steiner, M. Hough). Landscape ecology focuses on the relation between spatial (structural) and functional aspects of landscape (R. Forman, M. Godron, L. Zonneveld, M. VanBuuren, K. Kerkstra). Applied ecosystem ecology builds on systems theory, functioning and response of ecosystems on human interventions and applies concepts such as carrying capacity (E. Odum). Landscape suitability approaches of second generation explore the advancements of information technology for processing spatial data (GIS) and update the ecological criteria for distribution of land uses with social, economic and political ones (C. Steinitz, F. Fabos, J. T. Lyle).

3.2 Methods and tools

Regardless of the specific focus of individual approach, they all share the common main steps (Ndubisi 2002b):

1. Understanding the nature of interactions between human action and natural processes
2. Understanding and describing the landscape to identify areas that are homogeneous
3. Analyzing the identified homogeneous areas in light of the purposes of intervention
4. Developing alternative options for mediating the identified conflicts in human – environment interrelations
5. Detailed evaluation in terms of their technical feasibility, workability, probable effects on different groups, sustainable use of landscape, impacts on landscape
6. Developing measures for implementing the preferred option
7. Monitoring the effects

Suitability models

The most important step of the suitability analysis is describing the nature of interactions between human action and natural processes in a form, which is applicable for further processing and useful in the spatial planning process. This step is called 'suitability modeling' and can be to a different extent formalized and quantified. Suitability modeling involves: identification (and mapping) of spatial characteristics (factors) which are relevant for concerned land uses, description of their interrelation (value) for individual land uses, mapping the values and overlay of value maps (definition of aggregation function). The suitability procedure is presented in figure 7. The main step of this process is description of the spatial characteristic interrelation (value) for individual land uses, or the definition of suitability criteria. An example is presented in figure 8.

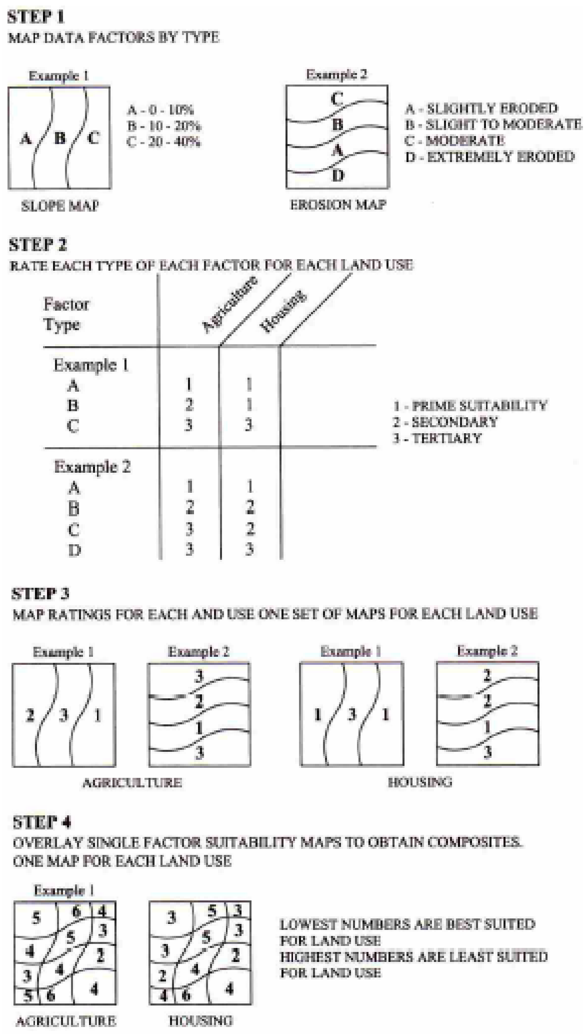


Figure 7: Illustration of the suitability procedure (Ndubisi 2002b, p. 143)

Criteria for evaluating suitability can be roughly divided according to two basic value systems – developmental and conservative. Developmental interest is described by opportunity (attractiveness) criteria. These reveal favourable conditions for land use, which can be expected to improve its output; such as vicinity of infrastructure in case of industry, fertile soils for agriculture etc. Limitation (vulnerability) criteria on the other hand represent need for protection and reveal the conditions, which may trigger increased environmental impacts in case of land use; i.e. vicinity of housing for industry or ground water reservoirs for agriculture. Such division was originally implemented in environmental impact assessments (NEPA 1970) and was later also applied in spatial planning (Patri and Ingmire 1972, Steinitz 1967). There are two main reasons for separating the two aspects:

- They reveal two inherently antagonistic interests of society: development and protection; which are usually the cause of conflicts about land use. To resolve these conflicts, it is sensible to explicitly reveal both interests and their spatial implications and use these as starting point for negotiation and consensus seeking.
- The increased environmental concerns have brought various types of (in)formal procedures, which aim to ensure adequate consideration of environmental protection in decision making processes. The explicit treatment of environmental issues can therefore be used as an input in various of these procedures; such as (Strategic) Environmental impact assessments, eco-corridor and network mapping, comparative assessment of alternative options, sustainability assessment etc.

ECOLOGICAL FACTOR	RANKING CRITERIA	PHENOMENA RANK I	II	III	IV	V	VALUE FOR LAND USE C	P	A	R	I
CLIMATE											
AIR POLLUTION	INCIDENCE MAX ► MIN	High	Medium	Low		Lowest		●	●	●	
TIDAL INUNDATION	INCIDENCE MAX ► MIN	Highest Recorded	Highest Projected			Above Flood-Line			●	●	●
GEOLOGY											
FEATURES OF UNIQUE, SCIENTIFIC AND EDUCATIONAL VALUE	SCARCITY MAX ► MIN	1 Ancient Lakebeds 2 Drainage Outlets	1 Terminal Moraine 2 Limit of Glaciation 3 Boulder Trail	Serpentine Hill	Palisades Outlier	1 Beach 2 Buried Valleys 3 Clay Pits 4 Gravel Pits	●	●		●	
FOUNDATION CONDITIONS	COMPRESSIVE STRENGTH MAX ► MIN	1 Serpentine 2 Diabase	Shale	Cretaceous Sediments	Filled Marsh	Marsh and Swamp			●	●	●
PHYSIOGRAPHY											
FEATURES OF UNIQUE, SCIENTIFIC AND EDUCATIONAL VALUE	SCARCITY MAX ► MIN	Hummocks and kettleholes within the Terminal Moraine	Palisades Outlier	Moraine Scarps and lakes along the Bay Shore	Breaks in Serpentine Ridge		●	●			
LAND FEATURES OF SCENIC VALUE	DISTINCTIVE MOST ► LEAST	Serpentine Ridge and Promontories	Beach	1 Escarpments 2 Enclosed Valleys	1 Berms 2 Promontories 3 Hummocks	Undifferentiated	●	●	●	●	
WATER FEATURES OF SCENIC VALUE	DISTINCTIVE MOST ► LEAST	Bay	Lake	1 Pond 2 Streams	Marsh	1 The Narrows 2 Kill Van Kull 3 Arthur Kill	●	●	●		
RIPARIAN LANDS OF WATER FEATURES	VULNERABILITY MOST ► LEAST	Marsh	1 Stream 2 Ponds	Lake	Bay	1 The Narrows 2 Kill Van Kull 3 Arthur Kill	●		●	●	●
BEACHES ALONG THE BAY	VULNERABILITY MOST ► LEAST	Moraine Scarps	Coves	Sand Beach			●	●	●	●	
SURFACE DRAINAGE	PROPORTION OF SURFACE WATER TO LAND AREA MOST ► LEAST	Marsh and swamp	Areas of constricted drainage	Dense stream/swale network	Intermediate stream/swale network	Sparse stream/swale network	●	●	●	●	●
SLOPE	GRADIENT HIGH ► LOW	Over 25%	25–10%	10–5%	5–2½%	2½–0%			●	●	●

Figure 8: An example of a suitability model concept (McHarg 1969, p. 108). The concerned land uses are: C-conservation, P-passive recreation, A-active recreation, R-residential development, I-commercial and industrial development

The remaining part of this study will mainly focus on the vulnerability criteria of assessment or shortly assessment. Although it can be performed as an independent and complete task, its position and reference to other aspect of planning and management should always be kept in mind.

4 Vulnerability assessment

4.1 Vulnerability concept in landscape planning and management

Focus on environment in planning brought several approaches with different names, which are all conceptually close to vulnerability analysis; 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 in landscape planning is defined as 'vulnerability to impact' meanng the potential negative impact of planned activities on natural and man made environmental values (Steinitz 1967). Vulnerability level therefore depends on the characteristics of a stressor (human intervention) and environment (figure 9).

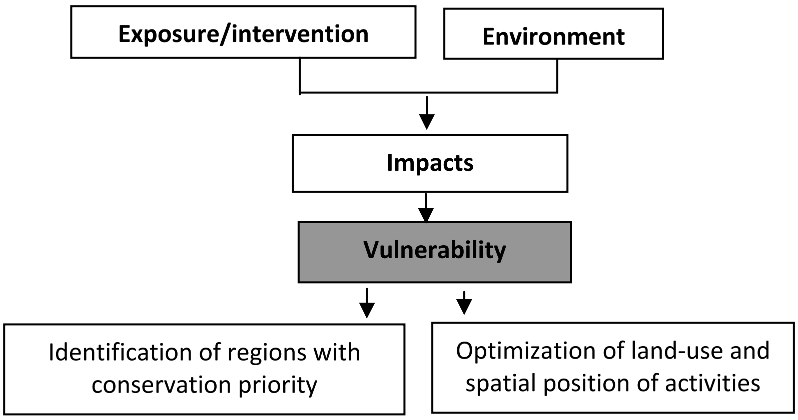


Figure 9: Vulnerability concept within the spatial planning context

As a result of increased environmental concerns, contemporary planning procedures include various types of (in)formal procedures, such as sustainability assessment, (strategic) environmental impact assessment, and comparative evaluation of alternative options. These procedures require methods, which explicitly treat environmental protection aspects in an accurate and legally defensible manner (Ndubisi 2002b). 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. 2003, Marull et al. 2007, Mehaffey et al. 2008, Shearer et al. 2006). Vulnerability approach is also applicable within strategic impact assessments (SEA), following the European legislation (SEA 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.

On the other hand, vulnerability concept has been developed and used in several other fields of science and decision making; traditionally in hazard management, social services distribution and most recently climate change. The common idea is to reveal the degree to which a system is likely to experience harm due to some threat and the common aim is to provide reliable expert information for policy and decision making. In most contexts these decisions refer to management of a natural or social system, aiming at optimization of the technology of its functioning. European (and consequently national) regional development and cohesion policies have spurred another, recently prevailing application of vulnerability assessments, which aim is to identify relatively deprivileged regions that are entitled to certain funding and policy measures. Although these concepts are analogous and based on similar assumptions, their different contexts and way of application require differences in conceptualization and implementation of analysis. The vulnerability in the context of land suitability analyses is meant as a site selection process for an intervention, and aimed at resolving environmental problems by the spatial planning procedure. On the other hand, most other vulnerability concepts refer to technological rather than spatial solutions to environmental requirements and are therefore management oriented approaches.

4.2 Step by step process of vulnerability assessment

The main characteristics of spatial planning approaches, namely their future orientation and territorial sensitivity, affect the choice of methods for vulnerability analysis: modeling and mapping of impacts. The models describe the nature of the interactions between human action and natural processes in a form, which is applicable for further processing and useful in the spatial planning process (Steinitz 1990, Steiner 1999).

Vulnerability analysis follows the 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. 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).

The following chapter presents the main steps of this approach based on theory and experience in practical application of vulnerability assessments.

I. Scoping

I.1 Definition of analyzed area

I.2 Definition of concerned land uses / activities

I.3 Definition of concerned environmental components

I.4 Identification of impacts / vulnerability models

II. Conceptualization

II.1 Definition of environmental unit for assessment

II.2 Definition of vulnerability concept for each model and definition of criteria

II.3 Identification of indicators / data sets

III. Evaluation

III.1 Evaluation of vulnerability for each model

III.2 Synthesis: aggregation of individual models

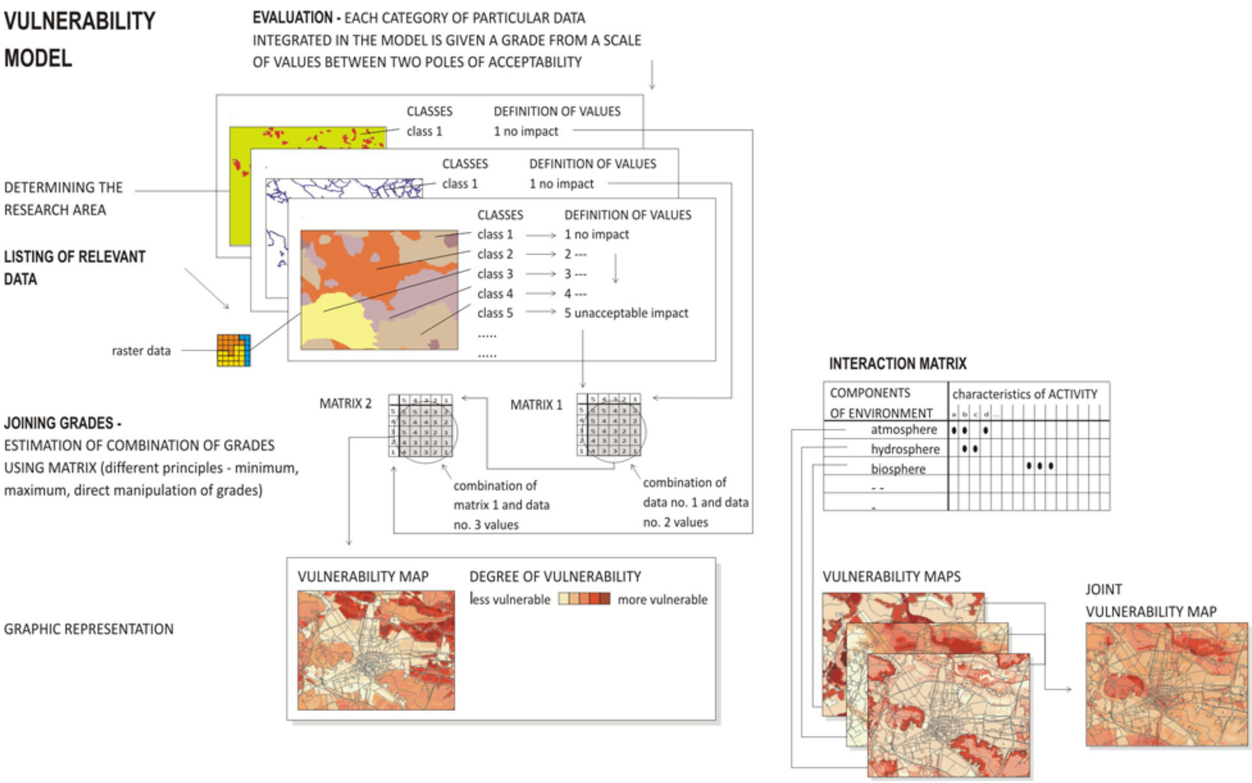


Figure 10: Main steps of the vulnerability assessment procedure (Mlakar 2004)

I.1 Definition of analyzed area

The borders of the area should be defined so as to include all potential alternative locations for prospective land uses /activities. In practice this means that the analyzed area is often wider then the site of initial proposal. If vulnerability assessment is a part of a land use planning procedure for an administrative unit (ie. municipality or region), then its borders would be considered as the area of assessment.

I.2 Definition of concerned land uses / activities

According to the definition vulnerability is not intrinsic to environment, but can only be defined in relation to potential intervention. The definition of planned activity or land use is therefore the following step of the scoping phase. This is relatively straightforward task if we plan for a single activity / object (i.e. a highway or a wind power plant), but becomes more demanding in case of assessment for comprehensive / land use plans, especially on the strategic level where prospective uses are not well defined yet. In any case, all uses demanding space, which are or can be foreseen should be considered in the assessment.

The level of detail of description is adapted to the level of planning and the type of potential impacts. The categories can be kept more general if their impact on the environment is considered to be similar (i.e. all housing types can have similar impacts) and should be further divided if the impacts are very diverse (i.e. different types of industry). Available information is another important factor affecting the level of description. If this is scarce, then standardized list of activities from i.e. statistical classification can be used. Each activity is then described in terms of its technology and actions needed for its operation (an example is presented in table 1). These and not the “activity” are namely the actual source of impacts. All phases of the operation need to be taken into account: preparatory work, building, operating and decomposition phase.

Table 1: Example of structured description of an activity

Activity/land use	Groups of actions	actions
industry	Preparation of building site, building of the objects and infrastructure	Removal of vegetation Transformations of geomorphology: leveling of the terrain, digging the foundation pits, disposing of building material Regulations of streams, drying up the wetland Transport of the building material on/from the building site
	Emergence of structures	Emergence of structures
	Operation of the facility	Use of energy for heating and operation Water take-up Release of used water Emissions in the air Disposing of waste Noise and vibration from operation of machinery Transport of raw material and products to/from the facility

Some of these actions may be common to several activities/land uses. In cases where vulnerability assessment is prepared for a set of different activities (for example in case of land use plan) it may be more operational to take these generic actions as the basic factor of impacts. Examples of such generic actions include: removal of vegetation, earthworks, transport of building material, disposals of material, energy use, presence of people, noise.... This approach reduces the number of impact models.

I.3 Definition of concerned environmental components

Environment is a system of subsystems and components, too complex to be dealt with in a holistic manner. A number of typologies of environmental components can be found in the literature (Marušič 1994b). They differ mainly to whether environmental articulation is viewed as a real-world system or as a system of values. While the former is typically found in studies of environmental impacts, treating the environment as a system of values may be more applicable in the planning and management context. Most importantly, it enables us to treat inherently different values independently and to avoid imposing trade offs between incommensurable value systems. It is therefore useful to apply procedural division for different nature of environmental protection aims. For example, Marušič (1996) identifies three fundamental conservative value systems:

- Protection of human environment (from all forms of environmental pollution) vulnerability is here determined as a function of environmental component's relevance for human well being. For example, air in the vicinity of hospitals, schools or housing areas in more vulnerable for pollution from industry than air in agricultural areas or in the forests.
- Protection of natural resources: vulnerability is determined as a function of environmental component's relevance for exploitation of present and future generations. For example; fertile agricultural land is more vulnerable for pollution from industry than built-up land or forests.
- Conservation of nature and natural processes: vulnerability is determined as a function of environmental component's "naturalness". For example, air or soils in natural areas or forests is more vulnerable

for pollution from industry than built-up or agricultural land.

The (same) change of a particular environmental component can therefore be valued differently depending on how the characteristics of the affected component are ranked within given conservation aim.

It should be noted however, that other ways of decomposing the environment as a system are possible and may be more operational in certain situations. Definition of components must consider the level of the assessment and the characteristics of environment: all the features and values that may be affected by proposed activities need to be taken into account.

Table 2: An example of describing environmental components as parts of a system

Protection aim	Environmental sub-systems	Environmental components
Protection of nature	atmosphere	air
		climate
	geosphere	bedrock
		soil
		geomorphology
	hydrosphere	ground water
		surface water
		sea
		snow-ice
	biosphere	flora
		fauna
		habitats
		biodiversity
Protection of natural resources		forests
		agricultural land
		water resources
		mineral resources
Protection of human environment	Quality and safety of life	noise
		natural and technologic hazards
		visual qualities
		recreation
		social services
	Cultural and social aspects	property
		cultural heritage
		settlements and infrastructure

I.4 Identification of impacts / vulnerability models: interaction matrix

In this step the interaction of environment and proposed activity is analyzed to determine the causal relation and to identify the potential negative impacts. The main tool for this step is interaction (or impact) matrix (Leopold 1971), which is traditionally applied in environmental impact assessments. It involves testing sub-components of an action (intervention) against a set of environmental components. The columns are filed in with the activities / actions; the rows with environmental components. Each intersection represents a potential impact.

The information filled in the matrix cells can be of different type and level of detail. On the first level, only a binary (yes/no) information can be given, identifying the existence of an impact of a particular action on a particular environmental component (figure 11).

However, any available further information is useful for the next steps of impact modeling. Traditionally, the input included two types of information: the extent of environmental change (quantification) and its meaning (qualification or evaluation). It is also useful to describe the levers and mechanisms of functioning of the activity in the environment and identify the ways in which the impacts are caused; i.e. "*installing new hydro power plant causes the existing river bed to be dammed: this leads to change of water dynamics, changes in water temperature, its gravel transport etc. As a consequence, habitats are no longer suitable for water flora and fauna...*" (another example is presented in figure 12).

The better information we have on the proposed activity, its extent, technology etc. and on the characteristics of the environment, the more accurate can these descriptions be. In lack of information we can make use of the generic descriptions of impacts, which can be found in the literature. Impacts are usually identified and described by expert judgments, based on existing knowledge, literature and case studies. Simulation models, if available, are another good source of information. Ideally this step is a result of exchange and verification of knowledge within an interdisciplinary team of several people.

Not every environmental component / action will be identified as an impact. Some types of actions may have no relevance for certain parts of environment; i.e. a dam of a hydro power plant may cause no impact on agricultural land. Among those identified as interactions, not all will be equally strong or detrimental. It may be advisable to distinguish among the levels of the interactions to avoid having to deal with an uncontrollable number of impacts. Rough categories such as strong / mild; direct / indirect; negative / positive can be used. Strong, direct negative impact will certainly be considered for detailed analysis. Depending on the aim and frame of the assessment, other impacts can be also included.

Other ways to reduce overcomplexity are:

- a more general model can be used to represent a set of more specific ones (in case where different actions have a similar impact on one environmental component),
- more environmental components can be joined in a more complex environmental subsystem (i.e. streams, lakes, rivers can be joined in »surface water«), and
- the planning question should be considered: not all of them are comprehensive and the number and choice of impact models should be made so as to best answer the question.

	cleaning surface	earth works making the ditch	land stabilization	assembling the pipe	putting down the pipe into the ditch	filling up the ditch	maintenance of the pipeline
atmosphere air							
soil		X	X			X	
geology		X	X			X	
relief		X	X			x	
surface waters	X	X					
under-ground waters	X	X	X				
snow, ice					X		
biosphere		X				X	
biotops	X						
flora	X						X
fauna	X						X
resources potentials							
agric. l.	X	X	X				X
forests	X						
water	X						
energy							
tourism	X						
amenities	X	X					
social qualities							
cultural qualities	X						

Figure 11: An example of interaction matrix with binary information on existence of impacts. Impact causing factors are actions needed for gas pipeline installation and operation.

IMPACT MATRIX					
Conservation goals	*environmental systems/components*	**earth - cut/fill operations**	**construction works**	**presence of people and domestic animals**	**land reclamation works**
NATURE CONSERVATION	Atmosphere	emissions from constructi	emissions from construction machinery	smoke - from heating facilities	
	Geosphere - soil and geomorphology	Increased erosion exposure			
		transforming of relief			
		loss of special geomorphological formations	hiding of special geomorphological forms		
		degradation of natural quality soils			
		worsen of the soils (pollution, degradation)	spills of oil, combustions - pollution of soil	damage on the soil surface	
	Hydrosphere - surface waters	spill of oil, gasoline - pollution of surface waters	spills of oil, combustions - pollution of waters	communal waste, sewer	destruction or change in existing drainage pattern
		regulation of stream and spring bodies	transforming natural bodies of surface waters		reshaping of water bodies
		change of biological conditions (flow, temperature…)	changing of hydrological conditions (change of water flow)		
	Biosphere	cut off of vegetation cover	impact because of noise	disturbance of animals because of noise	destruction of river banks vegetation and hedgerows - change of habitats
		reduced biological diversity	impact because of presence of people	catching wild animals, destroying nets	
		destruction of natural habitats	impact on natural corridors	cutting plants	
		change of habitat quality, connectedness, corridors			
CONSERVATION OF RESOURCES	Timber potentials	elimination of fires cover	destruction of forest habitat		
			reduced accessibility to forests		
	Potentials for agricultural production	erosion of productive soil	reducing of the agricultural productive land		*POS*
	Water resources	spill of oil, gasoline - pollution of drinking water	spills of oils, combustions into surface and underground water	communal waste, sewer	
				consumption of water - impact on available quantity	
	Potential for tourism & recreation		diminishing of the land suitable for tourism, recreation, reduced visual amenity		
			closing the recreational paths		
		reduced visual attractivenes			
	Potential for housing	reduced visual attractiveness	construction on land suitable for housing		

Figure 12: An example of interaction matrix with more comprehensive information on impacts. Impact causing factors are generic actions related to different activities / land uses.

II.1 Definition of environmental unit for assessment

The choice of spatial unit should observe the criteria regarding its size and shape:

- the unit is homogeneous in terms of the expected impact (at the level of inquiry);
- the unit should provide the results that are useful for taking decisions.

The common types of units in planning are physio-geographic (landscape) units, administrative units and raster cells. Physio-geographic (landscape) units are by definition homogeneous in terms of their (main) natural features. It is reasonable to expect that the impacts of an activity would be relatively similar across the unit. These units are useful especially as management support, where the types and ways of land use strongly depend on natural characteristics of an area (for example the use of natural resources, nature conservation, recreation). However, in case where impacts depend on one specific characteristic of the environment, this unit can be insufficient. They are also not useful when we plan for a new activity, such as settlement and infrastructure, which size and/or shape does not conform to the units (figure 13). In this case, the results of vulnerability assessment can not be used to optimize the location of the object, but can still give information on how strict mitigation measures need to be taken in case that certain object is located within the unit.

Administrative units are adjusted to the decisions within the administrative procedures (for example, definition of management regimes, issuing building permits or concessions for use of resources). However, it is rarely the case that these units correspond to either natural features or structure of planned activities, and are therefore not the best choice for solving planning or management problems.

The third option, raster cell is most neutral and flexible. It is defined as a regular geometric unit of a chosen size and assumed homogeneity. In order to correctly assume homogeneity of impact, the cell must be a common denominator of different environmental features and different types of planed land uses. This usually leads to cells of a rather small size (10 or 25 m). For the use in decision making, the results can be interpreted by aggregating cells into larger units. For purposes of spatial planning raster cell is usually the best option. Its applicability has been further increased by advances in computer technology, which enables processing of large amount of data meaning that very small cells can be used, where homogeneity is not a concern any more. However, it should be noted that by shrinking the size of a cell alone, the accuracy of the information can not be indefinitely improved, since it depends on the quality of used spatial data, and the accuracy of their retrieval.

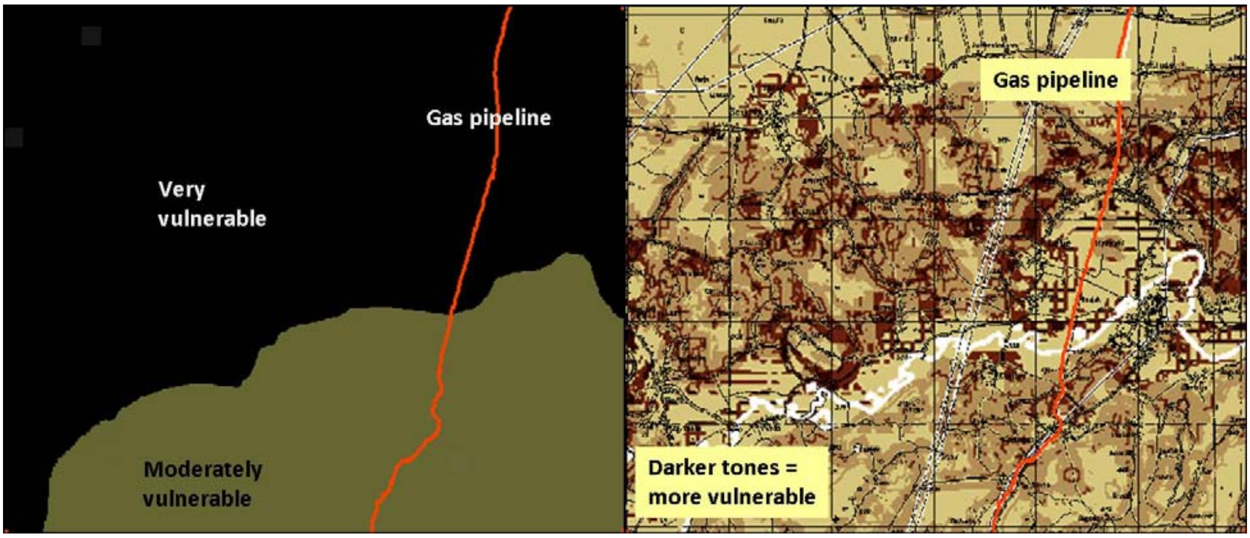


Figure 13: An example of applicability of different spatial units (left – landscape units, right – grid cell) for locating gas pipeline

II.2 Definition of vulnerability concept for each model and definition of criteria

The next step is developing the vulnerability concept for each of the impacts, which were identified in the scoping phase. The model must answer the question, which characteristic of the environment will affect the size of the impact and in what way. The size of the impact depends on the extent of the expected change and on quality of the affected environment. Installation of the same construction may for example require different amount of change depending on the characteristic of the environment: road on flat and hard lands will require less earth work than a road on steep slopes or wetlands. The loss of value in case of change will also be larger if the characteristics of the affected environment qualify it as valuable (i.e. cleaner water; more fertile land). The value depends on the protection aim, meaning that one characteristic of environmental component (for example the level of water pollution) can be treated differently, leading to separate vulnerability models for each protection aim.

Example: The impact of housing development on biosphere:

The main cause of the impacts is removal of existing vegetation due to construction work. Disturbances due to construction works, noise and transport may reach larger area around the construction site. In the operation phase, the air and water emission, noise from traffic and presence of people and pets are the main causes of impacts on biosphere.

Less human interference and the more natural state of the existing biosphere means higher vulnerability. The level of »naturalness« can be inferred form existing land cover/use and biodiversity. The existing natural features of high value, rare and endangered habitats and species are more vulnerable. Areas of higher landscape diversity (forest edges, riparian and coastal areas) reveal potentials for higher biological values and are therefore also considered more vulnerable. Green areas within and close to urban areas have high importance for human environment and ecological connectedness and are also considered more vulnerable.

II.3 Identification of indicators and data sets

This step involves selection of data that describe the vulnerability criteria. Although the experts preparing the analysis are often tempted to check the availability of data and build the model according to what is available, it is only at this stage that they should concern with the issue of data availability. This always persisting problem can be solved in different ways:

- data, identified as really inevitable, may be considered to be retrieved for the purpose of assessment. Not all data generation is very time consuming or expensive,
- missing data may be replaced with one or more substitutes or modeled from available data,
- data may simply be left out: not all data is really important. Data overload can blur the result and does not answer the question.

The originally conceived impact models may eventually have to be changed due to data issues. In any case the models developed so as to answer the problem give better results than those, which were constructed so as to explore the available data banks.

Table 3: Model parameters: indicators for impact assessment and the required data (the case of impact of settlement expansion on biosphere)

Indicator	Data
Natural qualities	Land cover /land use, Valuable natural features Rare and endangered habitats and species Natura2000 sites
Biodiversity	Habitat map Biodiversity index Ecological/migration corridors
Landscape diversity	Forest edge Habitat map Digital elevation model
Urban green areas	Land cover

III.1 Evaluation of vulnerability for each model

In this step, the size of the impacts is determined according to impact indicators (data) values in every spatial unit (cell) (see table 4). Vulnerability is expressed in a chosen measurement unit and ascribed to each cell. It can be interpreted as the extent of the expected impact in this spatial unit in case of realization of the proposed intervention. The need for synthesis in the following steps of the assessment requires that the level of vulnerability be expressed on a unified scale. Ideally, the thresholds between the classes of the scale are defined. However, this is hardly achievable for most of the impacts. The minimum requirement for the validity of such a scale is that the lowest and highest classes are unambiguously defined. The threshold of the upper class is usually determined by legal requirements such as emission limits (for the extent of change) or natural/cultural values with protection status (for quality of the environment). The lowest class threshold would be an impact bellow the level of detection. The exact (quantified) thresholds for classes in between are usually difficult to determine. However, they should be described by criteria as clearly as possible for each impact separately.

The number of classes can be different and depends on the required results. Usually four or five classes are sensible, easy to handle and sufficiently precise. Two or three class scales may prove to be too robust to differentiate between similar vulnerability levels. With higher number of classes, the thresholds can be increasingly difficult to define.

0 – no or negligible impact

1 – small impact

2 – medium impact

3 – large impact

4 – very large – destructive impact

Table 4: Example of indicator values for impact of industry on hydrology

Impact indicator	Data	Data class	Vulnerability class
Hydrologic features with buffer zones	Rivers and streams according to their natural value	Class I, I-II and II, 20 m buffer	4
		Class I, I-II and II, 20 – 100 m buffer	3
		Other classes, 20 m buffer	3
		Other classes, 20 - 100 m buffer	2
Hydrologic areas and features of higher nature conservation value.	Areas of hydrologic heritage with buffers	Area of hydrologic heritage	4
		Hydrologic monument, 50 m buffer	4
		Hydrologic monument, 50 – 100 m buffer	3
Areas of high dynamic of hydrologic processes and high biodiversity	Wetland	Wetland	4
	Flooded areas	Frequent floods	4
		Rare floods	3

The individual indicators' values now have to be combined to »calculate« the vulnerability score. A formula or, more generally, a model for combining the indicators has to be developed. Different ways are possible:

(1) Linear models combine individual velnerability classes according to some linear function such as addition. This approach enables handling a large number of indicators and use of scale with any number of value classes. It is easy to use and explain. The main problem is the levelling out: i.e. loosing the extreme values. Information on high vulnerability according to one indicator can be lost due to low vulnerability of other indicators. This is possible to ameliorate by use of weights but then the simplicity and clarity of the model are lost. Another weakness is that linear model assumes independency among the indicators, which is usually not the case, and absolute comparability among the value classes, which can also not be assured without thresholds.

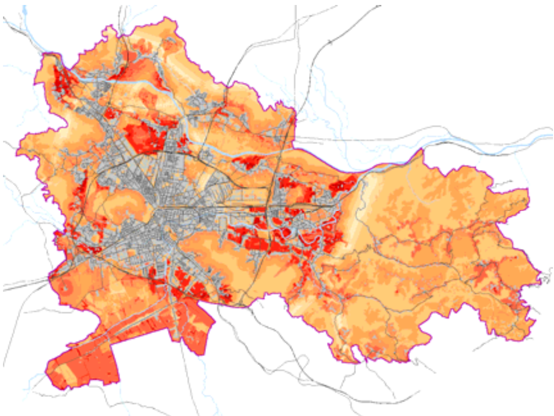
(2) Logic rules (sieve-mapping, adoption of minimum / maximum value, frequency of value class…). This is another simple and transparent option, but has limited sensitivity for differing among the levels of impacts severity. According to the precautionary principle in environmental protection, the rule of maximum is advisable (meaning that overall vulnerability score would comply with the most vulnerable component). This approach results in high vulnerability values across the area, which can be too limiting for the decision problem at hand. It also levels out areas where only one component is vulnerable with those of several vulnerable features.

(3) The issues of factor interdependence as well as limited comparability of the scales can be solved by using direct combination of

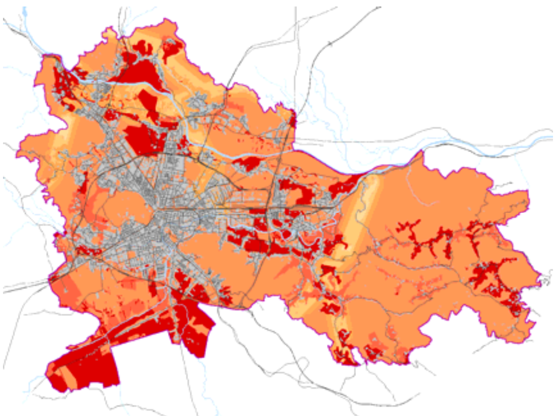
indicators. The final vulnerability score is determined based on expertly defined rules, defined in the reduction matrices. This approach enables to fit the evaluation model to the problem at hand and the results, which leave more decision space and flexibility. The problem is traceability and transparency of rules, especially in cases where many indicators have to be combined. The construction of the model is demanding and requires an experienced expert. Change of model parameters is difficult and requires a complete reconstruction of the model.

Different methods would normally bring different results. Therefore the choise of the method should be well argumented and should consider the following criteria:

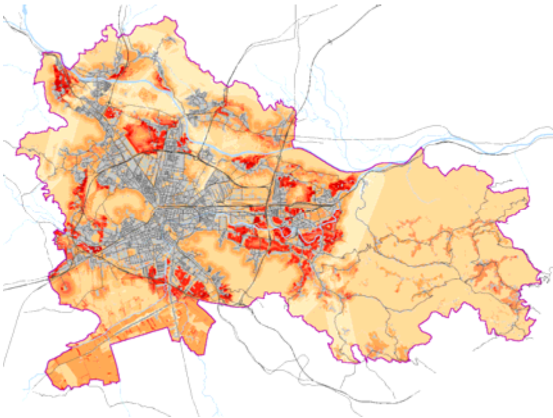
- type of problem to be resolved,
- technical, financial and time restrictions,
- available spatial data, and
- experience of the assessor.



(A) Linear model (normalized sum)



(B) Logic rules (adopting the maximum value)



(C) Combination of values using reduction matrices

Figure 14 (A, B, C): A comparison of different approaches for combination of indicators (vulnerability of landscape scenery due to new settlement for Ljubljana municipality, source: Marušič and Mlakar 2004)

In any case, no synthetic vulnerability should be taken for granted without careful interpretation and consideration of any partial result that has a bearing for the decision process. Use of multiple methods or sensitivity analysis is a way to check and to improve consistency and reliability of the aggregation.

III.2 Synthesis: aggregation of individual models

The analytical part of the vulnerability assessment results in a number of models, describing the relatively homogeneous and commendable parts of the problem. Use of the vulnerability assessment in decision making processes requires that information is provided in a more synthetic, ready to interpret way. Therefore, some kind of synthesis of the results is required. In case of complex problems (involving many sub-models) a step by step process is advisable. Aggregation by meaningful sub-models also contributes to better traceability and transparency of the modeling process (figure 15). For the purposes of spatial planning the models would be aggregated across the environmental components, so that the result is overall environmental vulnerability for a chosen activity (figure 16). It may be advisable to separately present the models according to the protection aim; i.e. nature conservation, protection of natural resources and protection of human environment; since these may reflect the difference of the intention also in spatial distribution of vulnerability classes (figure 17).

For the purposes of management of natural resources, the models can be aggregated across the activities, so that the result is an overall vulnerability of i.e. water resources. In this case, aggregation of activities in terms of their technological similarities may be useful (i.e. infrastructure, waste treatment, building).

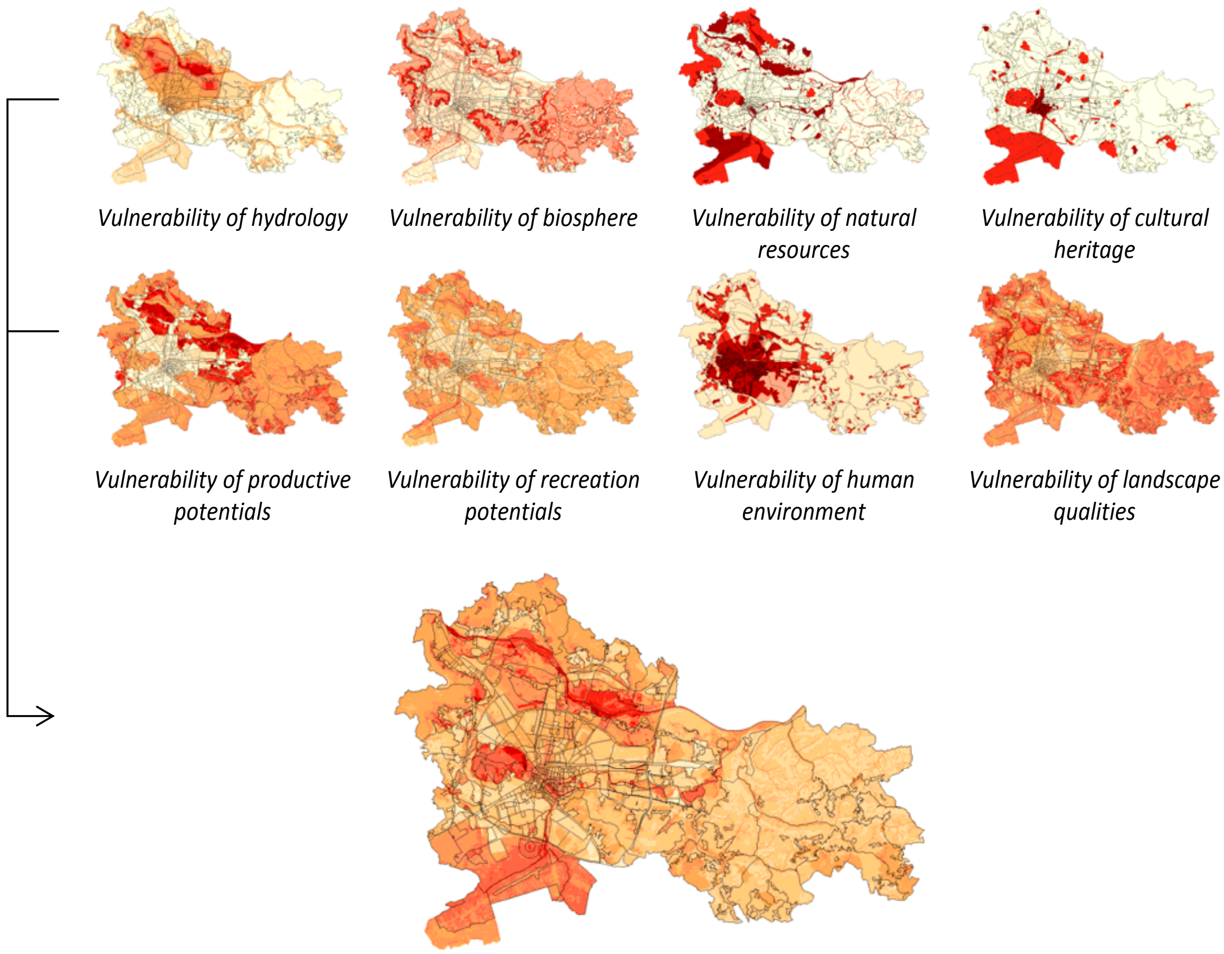


Figure 15: Aggregation in overall vulnerability should be done by meaningful submodels (example of vulnerability due to processing industry; source: Marušič and Mlakar 2004)

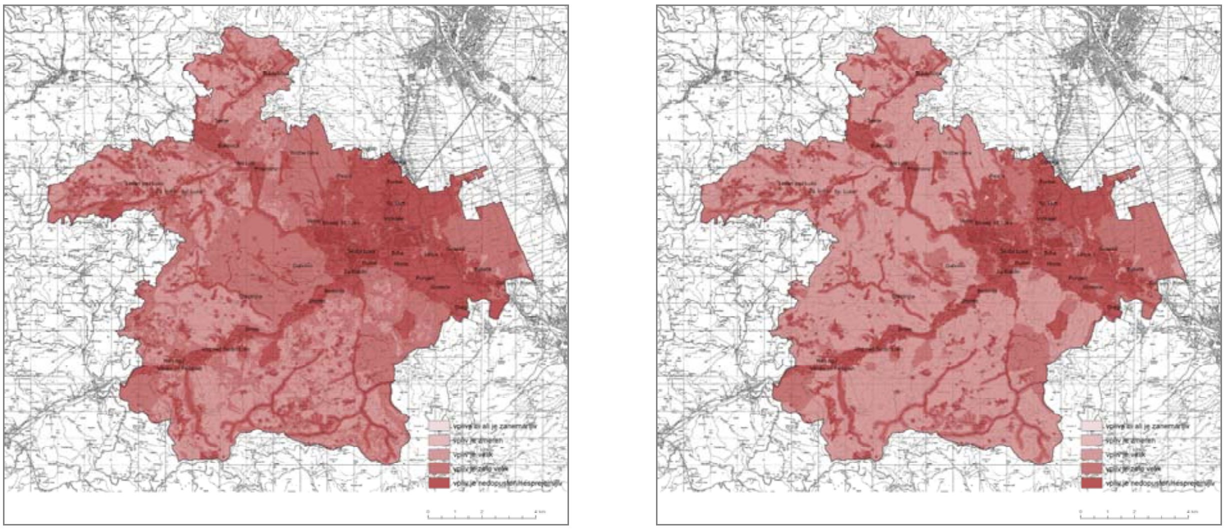
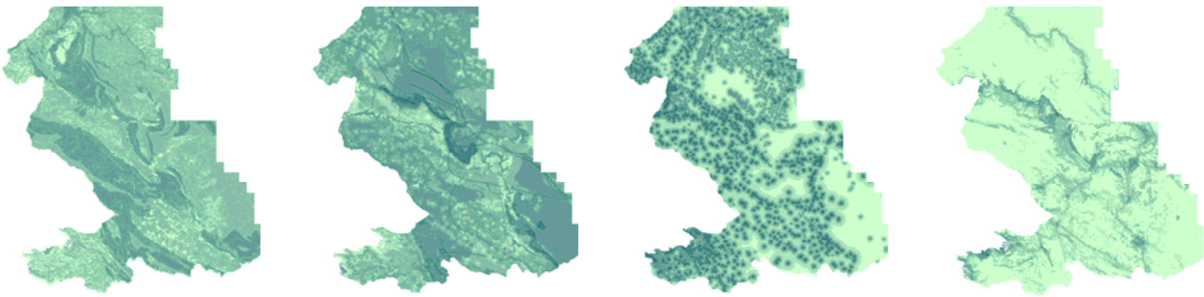


Figure 16: For the purposes of spatial planning, the overall vulnerabilities for each of different land uses should be presented (example of vulnerability for industrial zone and truck parking (source: Golobič et al. 2006)



Natural resources *Nature conservation* *Human environment* *Scenic values*

Figure 17: Aggregation of models according to the type of protection aim discloses differences in spatial distribution of vulnerability classes (example of vulnerability due to wind turbines; source: Brečević et al. 2001)

5 Integration of landscape planning concepts in formal planning procedures

The main concern of spatial planning is optimizing the use of territorial resources by distribution of land uses. In pursuing this aim, contemporary sustainable planning process must observe the requirements of environment protection as well as the requirements of good governance; i.e. openness and participation of concerned public. The following chapter will describe how vulnerability analysis can contribute to both aspects.

5.1 Environmental considerations in spatial planning process

Two main concepts of introducing environmental considerations in the frame of spatial planning are remediation of degraded area (ex-post, remedial approach) and prevention of potential degradations (ex-ante, preventive approach). Preventive approaches can further be divided into standardization and optimization (figure 18). Vulnerability assessment is a key approach of optimization-based environmental consideration. By simulating potential negative impacts of the planned activity on environment, it can inform the planning process where NOT to locate certain land use. This type of input supports development and choice among alternative planning options and optimization of site for individual land use/ facility. On more detailed planning levels vulnerability assessment can be used as a base for defining technological requirements and criteria for land use.

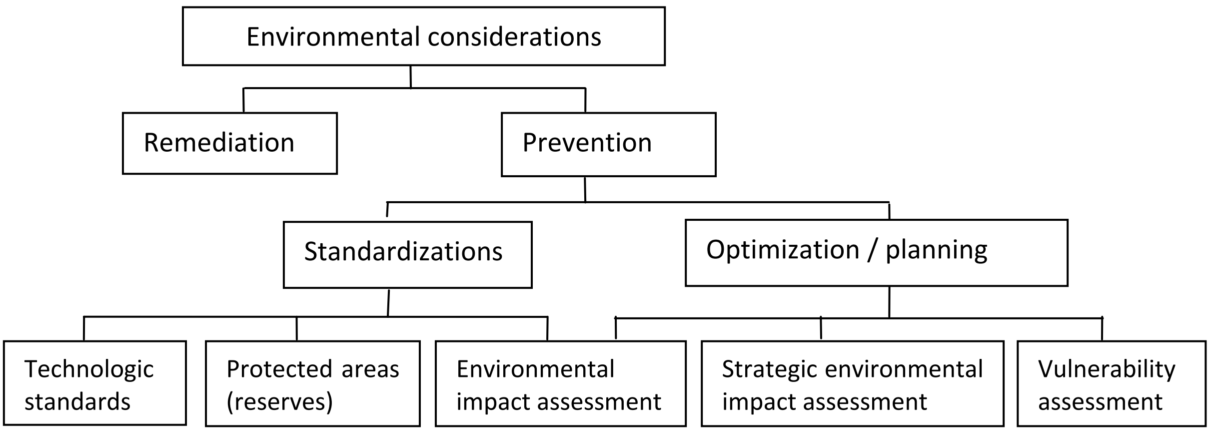


Figure 18: Ways of introducing environmental considerations in spatial planning framework (adapted from: Marušič 1999)

5.2 Applications of vulnerability assessment within the planning process

The main applications of vulnerability assessment are:

- identification of potential sites for proposed uses and their optimization in terms of environmental impacts (development models),
- identification of least vulnerable corridors for infrastructure,
- assessment of alternative proposals in terms of their environmental impacts,
- identification of areas of strategic importance for protection of natural resources and nature conservation (including ecologic networks),
- definition of criteria, regulations and guidelines for land uses,
- strategic environmental impact assessment (Dir. 42/01 EC).

Most of these applications are relevant at different levels of planning and for different types of planning tasks / documents. The overview is given in table 5.

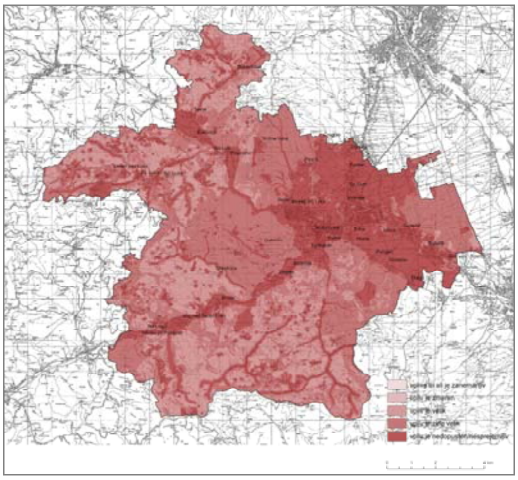
Table 5: Overview of applications of vulnerability assessment in spatial planning framework

Spatial planning documents	Relevant contents of plan	Application of vulnerability assessment
Municipal / regional plan (strategic level)	growth of settlement areas strategic areas for conservation infrastructure corridors distribution of services and industry definition of redevelopment /regeneration areas	identification of potential sites and their optimization in terms of environmental impacts of proposed uses (development models), identification of least vulnerable corridors for infrastructure assessment of alternative proposals in terms of their environmental impacts identification of areas of strategic importance for protection of natural resources, nature conservation (including ecologic networks) Strategic environmental impact assessment (Dir. 42/01 EC)
Municipal land use plan	boundary of built-up areas land use designation implementation criteria, regulations and guidelines urban regulations	identification of potential sites and their optimization in terms of environmental impacts of proposed uses (development models), definition of criteria, regulations and guidelines Strategic environmental impact assessment (Dir. 42/01 EC)
Detailed plan	sites for complex development (infrastructure, industrial zones, intensive settlement development) protected areas and regimes redevelopment/regeneration areas	identification and assessment of alternative proposals in terms of their environmental impacts definition of criteria, regulations and guidelines

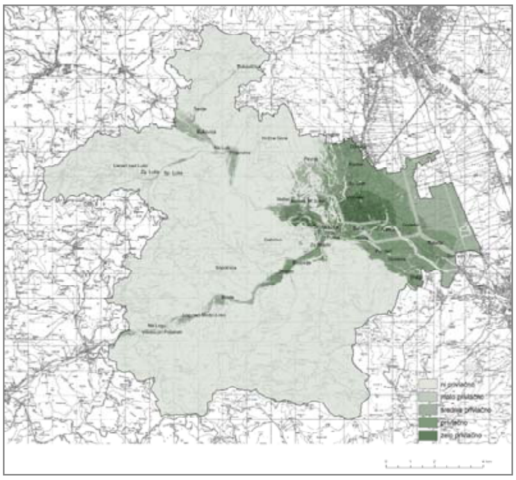
5.2.1 Identification of potential sites and their optimization in terms of environmental impacts of proposed uses

Vulnerability assessment differentiates the planning area according to the level of vulnerability of environment. It identifies very vulnerable areas, which should be avoided when an activity / land use is located. In the planning process vulnerability map is confronted with developmental demands or proposals. If these are not yet known, they can be simulated by evaluating spatial potentials (attractiveness analysis) or another type of spatial modelling. The areas with highest potentials, which are at the same time least vulnerable, may be considered optimal or most suitable for development. If such sites cannot be found then the demands of either development or environment protection may have to be redefined or another solution (for example technological) needs to be found.

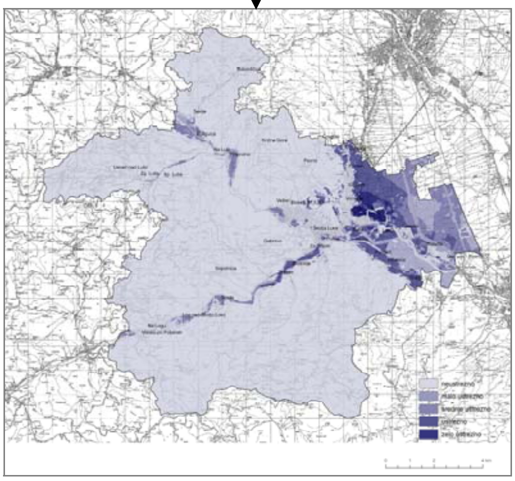
The identified most suitable areas are then subject of a detailed assessment in terms of criteria of site availability, ownership, and detailed site characteristics.



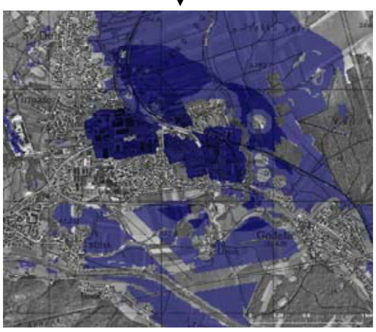
Vulnerability due to industry



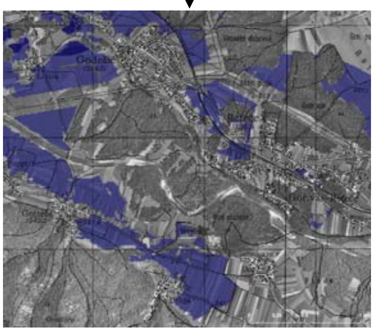
Attractiveness for industry



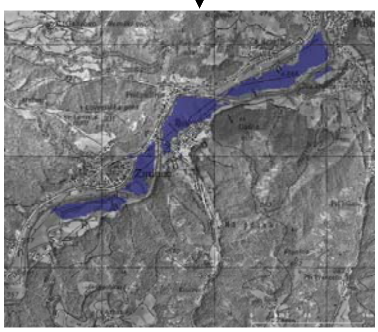
Suitability for industry



Suitability for industrial zone – site A



Suitability for industrial zone – site B



Suitability for industrial zone – site C

5.2.2 Identification of least vulnerable corridors for infrastructure

This is essentially the same way of applying the vulnerability assessment as above. The difference is in the way of synthesizing the results, which takes into account the topology of infrastructure. The aim is to identify a spatially contiguous belt of required width and lowest vulnerability. Most GIS enable this operation (least cost), requiring the following inputs: digital vulnerability map, starting and ending points, potentially required intermediate points (i.e. infrastructure nodes).

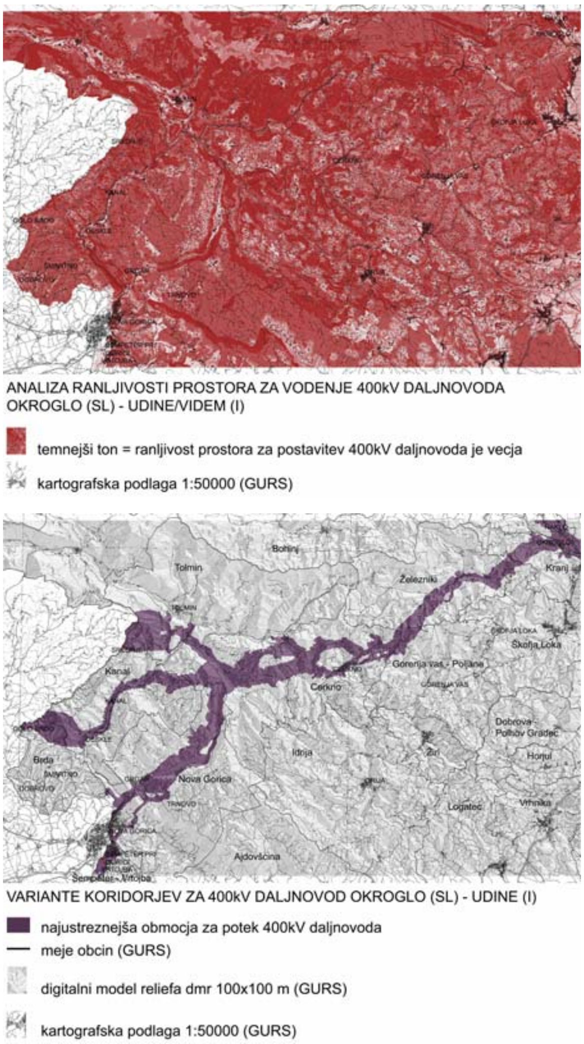


Figure 19: An example of least vulnerable corridor for electric power lines (right), computed on the base of vulnerability map (left) (source: Marušič and Cof 2007)

5.2.3 Assessment of alternative proposals in terms of their environmental impacts

Developing and comparative assessment of a set of alternative planning options in an increasingly accepted approach to ensure that the optimal solution is finally chosen. The criteria for assessment refer to different aspects of benefits and costs. They usually include economic effects, technological functionality and feasibility, impacts on development potential and use of resources, impact on society, equity, health, and environment. Evaluations are based on multicriteria assessment methods, since most of these effects cannot be measured in financial or other quantitative units. Vulnerability assessment can be used to evaluate the alternative proposals from environmental aspect.

For the assessment, the vulnerability map(s) are overlaid by mapped development proposals. The quickest method of evaluation is gestalt, by visual analysis. However, the method of vulnerability assessment also enables some level of quantification, which is usually required for the synthesis and decision-making. The performance of each alternative proposal can be computed as an average vulnerability of overlaid cells, or frequency distribution of different vulnerability classes. Because vulnerability maps covers the entire area of a set of considered alternatives it does not only identify the environmentally most acceptable option, but can also give proposals on how to further optimize it or even helps to disclose a new, potentially better option.

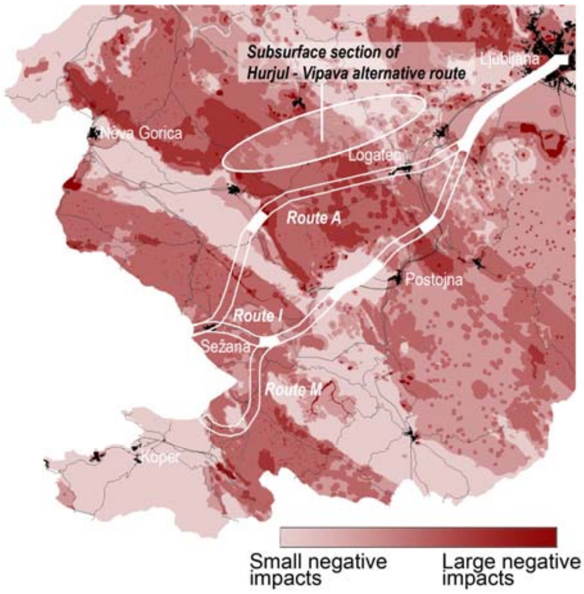


Figure 20: Assessment of alternative options of Trieste – Ljubljana high speed rail: Vulnerability map of underground environment was used to assess the subsurface sections and helped to identify alternative route (source: Kontič et al. 2005)

5.2.4 Identification of areas of strategic importance for protection of natural resources and nature conservation (including ecologic networks)

Decisions about which parts of territory will be dedicated to development and which should be excluded is a part of strategic planning for a region or local community. The areas of strategic importance for protection are those, which are recognized as endangered or valuable due to their role in ensuring healthy human environment or as a natural resource to be preserved for future generations. These areas are given a formal protection status with corresponding restrictions of use. Vulnerability assessment can be used to identify these areas by overlaying maps for different environmental components and land uses. The areas where several high scores accumulate should be given priority for strategic protection. Information on the types of most vulnerable environmental components and the types of most endangering land uses can be used for designation of protection regimes.

Definition of protected area based on vulnerability assessment should consider the following criteria:

- accumulation of highly vulnerable environmental components,
- high density of smaller highly vulnerable areas,
- potential for interconnectedness of highly vulnerable areas,
- territorial management issues: possibility to apply a common management framework or include it into existing management scheme.

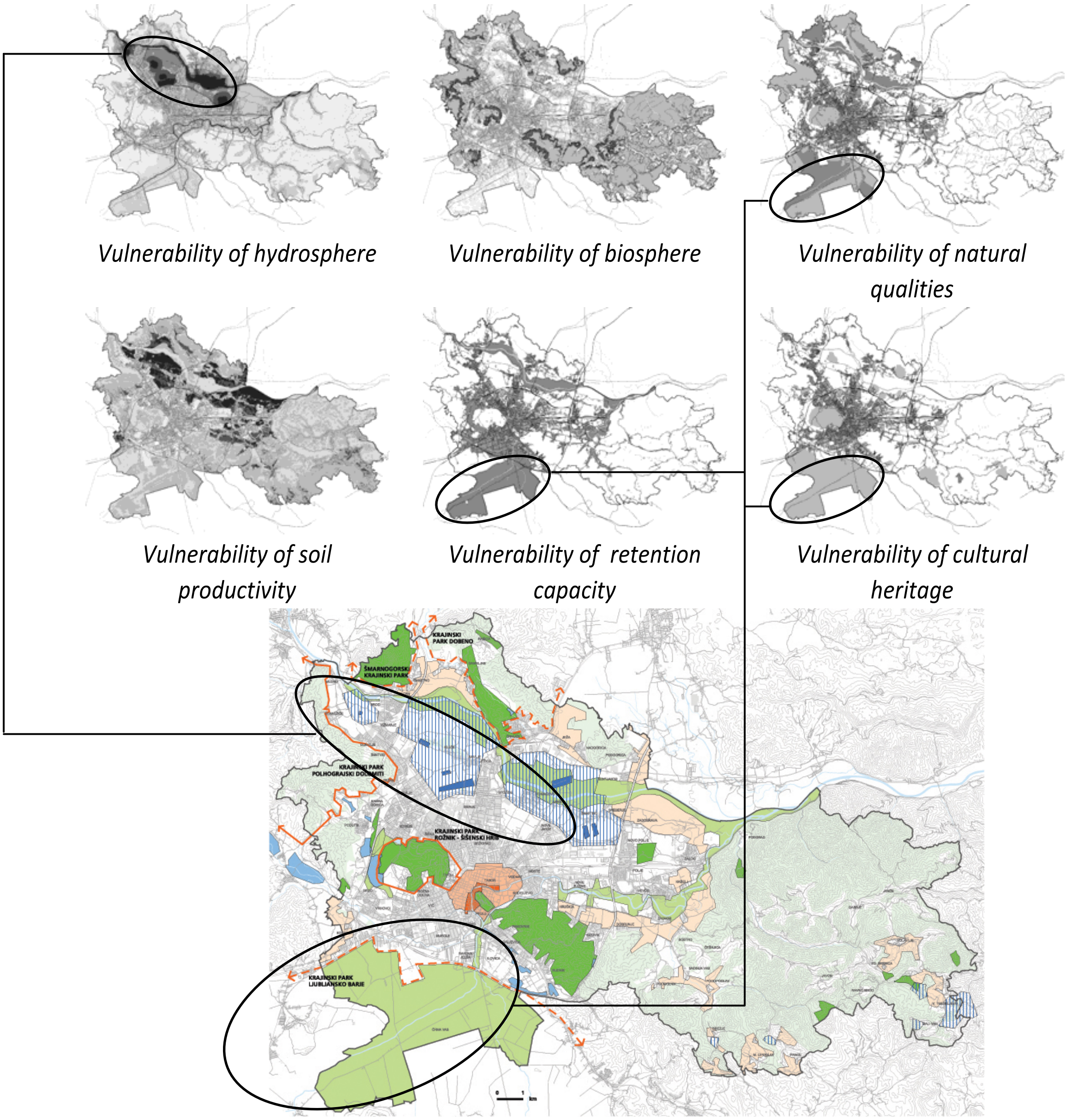


Figure 21: Designation of areas of strategic protection in municipal spatial plan (below), based on the results of vulnerability assessment (above) (source: Spatial plan for Ljubljana municipality, 2002; qtd in: Marušič and Mlakar 2004)

5.2.5 Baseline for definition of criteria, regulations and guidelines for land use

Technologic standards are most commonly used approach for securing environmental requirements. In spatial planning this means that different technology or design solutions can be applied for the same land use or activity, according to type of environment. Land use plans usually divide the planning area in planning units. Each unit has attributes of type of land use and a set of related criteria, regulations and guidelines for detailed planning. Vulnerability assessment can be used to determine the type of technology and minimum requirements that apply to certain land use in relation to the level of vulnerability and characteristic of most vulnerable environmental components.

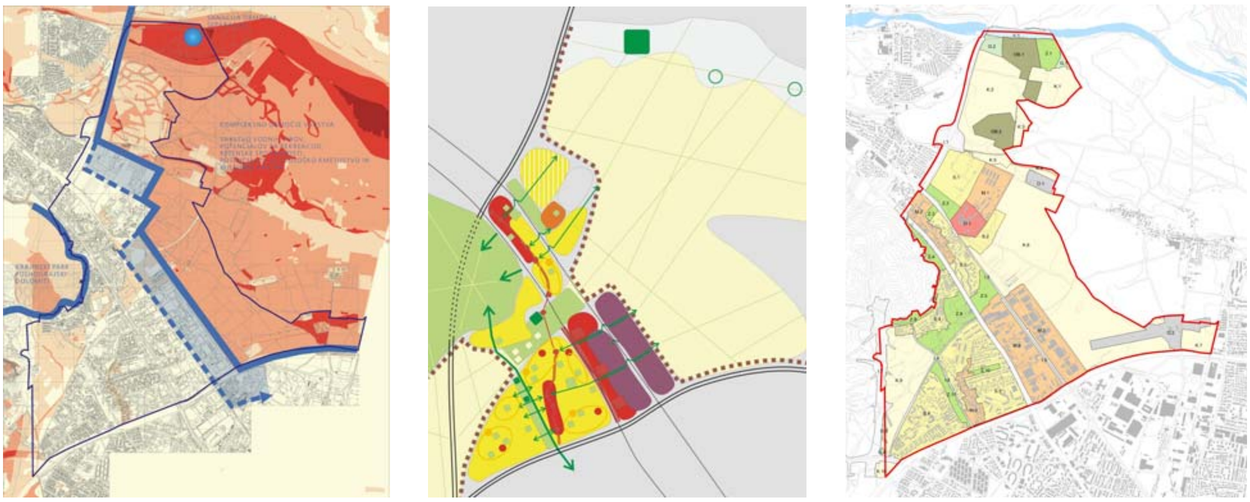


Figure 22: An example of the use of vulnerability assessment (left) for development of design concept (centre) and designation of spatial units with related regulations (right) (source: Mlakar et al. 2004)

5.2.6 Strategic environmental impact assessment

Strategic environmental assessment (SEA) Directive (2001/42/EC) requires that the effects of certain plans and programmers on the environment are assessed before they are being adopted. Directive includes "town and country planning or land use" among the documents that need to be assessed. The aim of this assessment is not just to give an environmental "clearance" for the document, but also to influence the process of its development in terms of its environmental impacts. Therefore, the assessment should begin and proceed in parallel to plan development. However, the general and vague designations of documents in their draft phases do not allow to relate the proposed actions to specific environment and to quantify the impacts. The majority of traditional environmental impact modelling is rather useless for this purpose, resulting in SEAs which are either very vague and indecisive or prepared ex-post, as a justification of already agreed upon plans. Another strengths in comparison to majority of their environmental impact methods is that they are territorially sensitive, which is important in case of assessing spatial plans. The use of vulnerability assessment in SEA can provide the inputs, which are useful for optimization of the plan.

Vulnerability assessment must consider the structure of the activities/land uses as given in the assessed document. The evaluation of impacts of the proposed land uses can simply be given with reference to the vulnerability class at the site of proposed intervention. In cases where environmental thresholds do not exist, the judgment about acceptability of the impact can be given based on comparison between the vulnerability of the proposed site with alternative sites. In case where vulnerability assessment indicates potentially very high impact of proposed action, the following steps can be proposed:

- Search for an alternative site with lower vulnerability, and accordingly a proposal for a change of plan.
- If no such site can be found, then the technical condition and mitigation measures are proposed to reduce the environmental damage.
- If neither of the two is possible, the proposed development might have to be cancelled or moved to entirely different location.

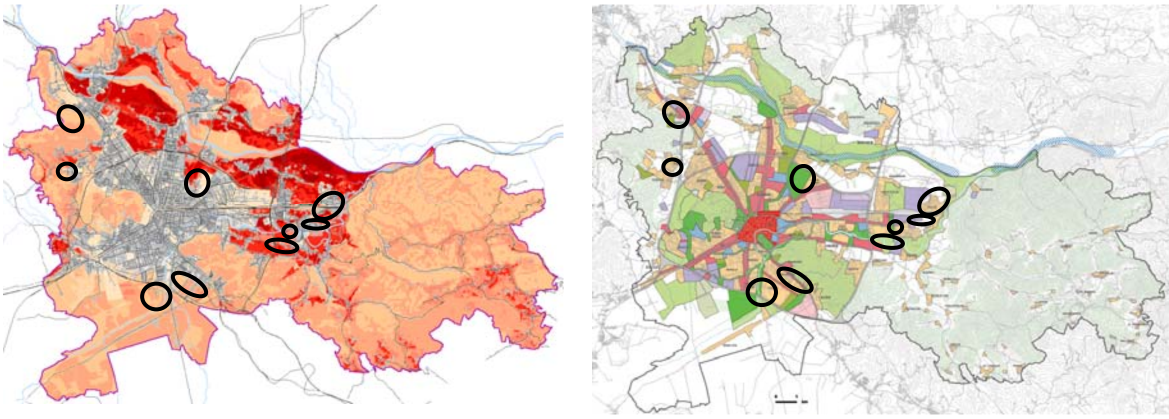


Figure 23: SEA for municipal plan (right; important projects are marked with black circles) based on vulnerability assessment (right; example for impact on soil productivity) (source: Spatial plan for Ljubljana municipality, 2002; qtd in: Marušič and Mlakar 2004)

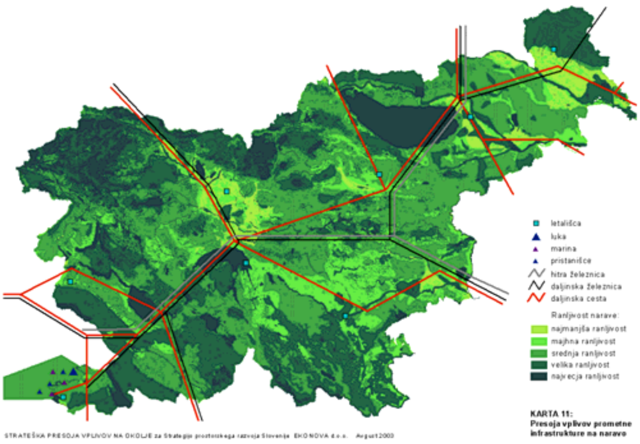


Figure 24: Example of SEA for national plan; example of infrastructure corridors; based on vulnerability assessment (source: Stojič et al. 2003)

APPENDICES
EXAMPLES OF VULNERABILITY ASSESSMENT APPLICATION

Appendix A
Application of vulnerability assessment in preparation of land use plan – the case of Piran municipality

Source: Knowledge base for preparation of Piran Municipality spatial plan; environment protection issues, Commissioned by Piran Municipality and prepared by Prostorsko načrtovanje Aleš Mlakar s.p. and Aquarius d.o.o. Ljubljana in September 2008

A.1 Background and scope of the study

A.1.1 Background

After 2007 local communities and municipalities in Slovenia started preparation of new generation of spatial plans following the requirements of new Spatial Planning Act (Zakon o prostorskem načrtovanju, Ur. l. RS, No. 33/2007). Municipality as a body responsible for plan preparation, commissioned several expert teams to prepare studies from diverse fields of expertise including environment protection. The expert input on environmental must follow the needs of strategic environmental impact assessment (SEA), which is required for land use plans by Environment Protection Act (Zakon o varstvu okolja, Ur. l. RS, No. 41/2004). The methods and contents of SEA are regulated in its bylaw (Uredba o okoljskem poročilu in podrobnejšem postopku celovite presoje vplivov izvedbe planov na okolje, Ur. l. RS, No. 73/2005). The aim of this study is therefore to provide the knowledge and method to ensure an early and effective consideration of environmental issues in planning process by optimization of planned land uses. This includes, but goes beyond sectoral contents and represents a common comprehensive environmental framework for developing the main planning document for municipality.

The study contains the following parts:

- Strategic planning guidelines: summary of existing strategic documents, referring to environment protection such as Strategy of spatial development of Slovenia (Ur. l. RS, No. 76/2004) and National environmental protection programme 2005 - 2012 (Ur. l. RS, No. 2/2006).
- Environmental vulnerability assessment for new settlements with aim to determine areas where new settlement should not be proposed (as an early warning measure).
- Designation of areas of different types of protection based on the existing regulation and detailed expert analysis. The municipal area is divided based on main spatial characteristics which need to be considered in developing the vision of sustainable development.
- Planning guidelines and operational recommendations for detailed planning.

The following chapters will mainly focus on presenting part (2) of the study: vulnerability assessment.

The Piran municipality area was also included in vulnerability assessment for Coastal Region, which was prepared in the framework of CAMP Slovenia project, by ACER (2006).

A.1.2 Definition and description of analyzed area

Municipality of Piran lies at the south-western part of Slovenia and covers 46.6 square kilometres (figure 25). It has close to 17 000 inhabitants and 17.9 km of coastline, which is about half of the total Slovenian coast. It is the most developed Slovenian municipality in tourism sector and one of the most important congress, spa, casino, and nautical tourism centres in the northern Mediterranean.

Settl**em**ents

At the end of the Piran peninsula, which gradually narrows between Strunjan and Piran Bay, lays the old seaport of Piran. The city has preserved the medieval layout with narrow streets and compact houses, which from the coastal plains rise to the top of the ridge and give the whole area a typical Mediterranean look. There are a number of other mainly touristic settlements along the seacoast among which it is important to mention Portorož with its Marina. Primarily in recent years ridge-stretched settlements emerge on the hill-ridges near the sea and dispersed form of settlements on the southern slopes near the sea. The traditional compact settlement structures are thus gradually disappearing. Extensive plains along the coast are not populated due to the lower bearing capacity of the soil and high ground water. The population in the coastal part of the municipality is increasing while it is declining elsewhere over the hills.

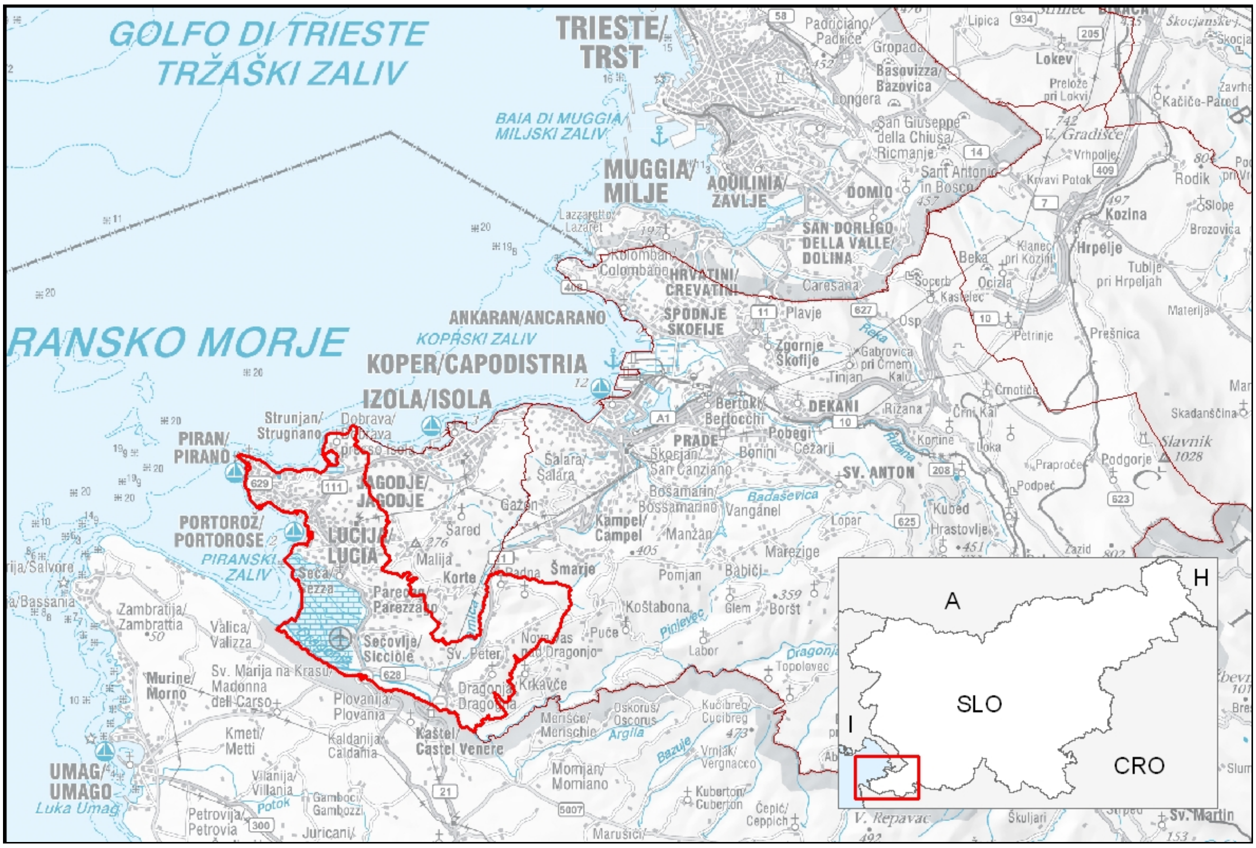


Figure 25: Piran Municipality

Landscape

The characteristic of the landscape is the transition from the narrow valleys, surrounded by relatively steep slopes and covered with forests to large and often marshy plains with a sea coast. In the past, marshy plains were ameliorated and cultivated (Bonifika). Also extensive salt-pans were created on such contacts of rivers and sea. Besides cliffs, salt-pans mark the image of the Slovene coastline. Most of the smaller salt-pans are now abandoned. Among larger ones, only Sečovlje salt-pans are still functioning. In the hilly part of the municipality, the northern steeper slopes appear in contrast with the less steep southern slopes. Northern slopes are mostly overgrown with forests. In accordance with the fact that forests were the most well preserved on steep slopes and in areas unsuitable for agriculture, they have mainly ecologic and erosion protective function while very few are intended for the production of wood. South slopes have been largely transformed into terraces with small land allotment and with mostly permanent crops (vineyards, orchards, olive groves) and mixed culture. Terraces with mixed crops have been gradually abandoned. The most recognizable landscape patterns in the municipality are: flysch cliffs, coast with historical settlement on peninsula, salt-pans, agricultural land on seaside plains, agricultural land on terraced slopes, urbanized terraced slopes and terraced slopes in overgrowing. So called "areas of national recognition" specified in the Spatial Planning Strategy of Slovenia are the areas of Strunjan and Šavrini. Among exceptional landscapes are also Sečovlje salt-pans, Strunjan salt-pans, and the area of the village Padna.

Air and climate

The area of municipality has coastal sub-mediterranean climate with rapid intrusions of cold north Bura wind. In accordance with Slovenian bylaws, the municipality belongs in area SI 4, which belongs to II. level of air pollution. This level indicates that one or more pollutants (nitrogen dioxide, PM10 particles and ozone) are higher than the limit value and lower than the sum of the limit values and tolerance values. The pollution is mainly related to unregulated traffic regime with traffic congestions (particularly during the tourist season) and also to the lack of large green areas along the coast and urban parks within large settlements.

Geomorphology

Flysch hills with elongated ridges run from east to west. Northern slopes are steeper in comparison with the southern. Streams and rivers cut numerous ravines and valleys in Šavrini hills and in the lower parts of valleys produced fairly wide and broad plains. The most extensive plain in the municipality represent Sečovlje salt-pans. Prominent transitions of land into the sea represent steep flysch walls – cliffs that occurred as a result of sea impacts on soft rock. Because of the flysch bedrock almost the whole area of the municipality is prone to erosion.

Hydrology

On heavy rain, most of the streams and rivers become torrents and flood. Larger flood areas are around the two largest rivers in the municipality, Dragonja and Drnica. At the estuaries of rivers, coastal wetlands have been created: Strunjan Laguna with Štjuža, two lakes in Fiesa, and salt-pans (Sečovlje and Strunjan). Sečovlje salt-pans are with 650 ha the largest coastal wetland. In 1993 they became the first Slovenian Ramsar locality. The sea is very shallow (maximum depth is 30 m) and is thus ecologically very sensitive. Sea water is moderately eutrophic. Mainly because of shipping and nautical tourism, as well as municipal sewage outfalls marine sediments are moderately polluted. Excessive intake of sewage to the sea through water treatment plants is causing occasional occurrence of algal blooms, hypoxia in the bottom layers and the growth of non-native species. One of the major problems of the municipality is the lack of water. Municipality of Piran doesn’t have its own drinking water sources. The vast majority of the population is supplied with drinking water from a regional network.

Nature

Slovenian Sea with its characteristics such as small depth and estuaries rich in nutrients is relatively rich home to marine plants and animals. Marine ecosystem is due to intense shipping constantly threatened, primarily because of the potential inputs of non-native species, and uncontrolled discharges from ships. There are nine Natura2000 sites and eight protected areas in the municipality. The later are:

- Sečovlje salt-pans landscape park as the most important ornithological and faunal site in Slovenia; Sečovlje salt-pans were the first Slovenian locality on the Ramsar List of Wetlands of International Importance (1993);
- Strunjan landscape park with 3 core protected areas: nature reserve Strunjan with 4 km long and up to 80 m high naturally preserved flysch cliff, nature reserve Strunjan-Stjuža with unique salt-water biotope and Pine avenue;
- natural monument the Fiesa lakes;
- natural monument cape Madona with extremely diverse underwater world; and
- Dragonja landscape park with naturally well-preserved area of river Dragonja.

Cultural heritage

There is a rich cultural heritage in the municipality, mainly due to the preservation of old cities and somewhere also cultural landscapes. There are also two areas of complex cultural heritage protection: (1) Strunjan peninsula with salt-pans and typical dispersed settlement with typical rural architecture and terraced cultural landscape and (2) Šavrini hills with many well-preserved forts, traditional settlements on the ridges, traditional architecture, and terraced cultural landscape around the settlements with typical mixed culture.

A.1.3 Definitions of concerned land uses / activities

Vulnerability assessment refers to a certain activity / land use. In our case, the chosen category of land use was »settlements«. Expansion of settlements is the most common initiative to be dealt with by planning documents and also the most general land use type, so that the findings are easiest to be transferred for other, more specific land uses.

A.1.4 Identification of impacts / vulnerability models

Identification of impacts is based on interaction matrix. The overview is presented in table 6.

Vulnerability models were prepared for the impacts of settlement expansion on:

- air and climate,
- soil and geomorphology,
- hydrology,
- flora, fauna and habitats,
- nature protection areas,
- noise,
- cultural heritage,
- landscape qualities,
- forests and forestry, and
- agriculture and agricultural land.

A.1.5 Definition of environmental unit for assessment

Grid cell of 10 x 10 m was used as a unit of analysis, meaning that values of indicators are determined for each cell, calculated according to the model and then attributed to the cell as a vulnerability class. The size of a cell is adapted to the basic unit of considered land use: a building as a part of a settlement area.

Table 6: Expected impacts of settlement expansion on the individual environmental components

Protection aim	Environmental systems	Environmental component	Impacts due to settlement expansion
nature conservation	atmosphere	physical properties	◨
		chemical properties	◨
		climate	□
	geosphere	bedrock	◨
		soils	■
		geomorphology	■
		natural qualities	■
	hydrosphere	ground water	◨
		surface waters	■
		sea	■
		natural qualities	■
	biosphere	flora	■
		fauna	◨
		sea flora	◨
		sea fauna	◨
		ecosystems and habitats	■
		natural qualities	■
protection of resources	natural and land use resources	production forest	◨
		agricultural land	■
		water resources	□
		mineral resources	□
		energy potential	□
		recreation potential	◨
		potential for housing	n/a
		potential for infrastructure	◨
protection of human environment	safe and healthy environment	clean air	◨
		clean water	◨
		clean soils	◨
		noise	■
	cultural and social qualities	landscape	■
		cultural heritage	■
		ownership	◨
		present use	◨
		other social qualities	◨

A.2 Vulnerability models

A.2.1 General description of the models

Each of the identified models is presented in the following subchapters by the following items:

- description of potential impacts of settlement expansion on environmental component concerned, based on identified properties of environment and land use,
- description of the model concept with definition of vulnerability criteria,
- presentation of model results on a vulnerability map,
- interpretation of the model results with special attention to extremely vulnerable areas,
- relation to other findings, relevant for planning, summarized as planning recommendations.

The data were selected from the following available spatial data banks:

- digital spatial data base of Piran Municipality,
- cultural heritage register, Ministry of Culture, Slovenia,
- on-line Nature Protection Atlas, Ministry of the Environment and Spatial Planning, Slovenia,
- on-line Environmental Atlas, Environmental Agency, Slovenia,
- data provided by the Ministry of Agriculture, Forestry and Food, Slovenia,
- data provided by Slovenia Forest Service, and
- digital elevation model.

Some additional data were prepared by mapping the required information or by inferring (modeling) from existing data.

Modelling was done by GIS software ProVal2000. Data-classes were ascribed values from 1 (no impact) to 10 (impact exceeding threshold). Parameters were combined either by matrix-rules or by normalized sum.

A.2.2 Air and climate

Potential impacts of settlement expansion on air and climate include changes of microclimate properties and increase of air pollution.

Vulnerability criteria are:

- green areas within settled areas are considered more vulnerable due to their microclimate regulative function,
- green corridors and »wedges«, which connect coast with natural hinterland are considered more vulnerable,
- belts along and around streams and lakes are considered more vulnerable.

Data used: settlement areas, forest areas, streams and rivers.

less more vulnerable

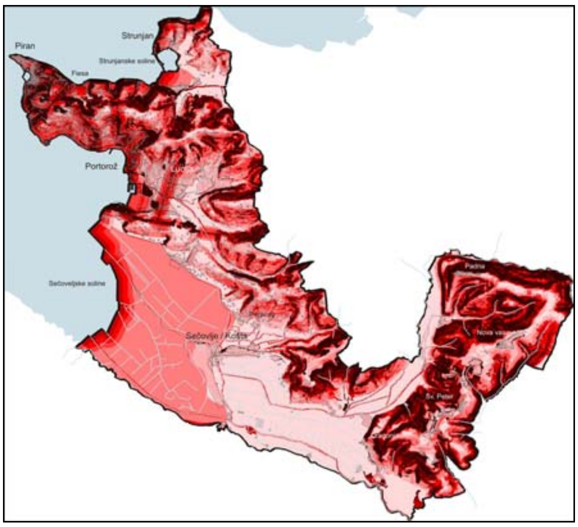


Figure 26: Vulnerability of air and climate due to settlement expansion

Green areas are disclosed as more vulnerable; especially forest patches within the dense settlements. Model also discloses connections between forested hinterlands and urbanized areas, such as steep slopes and gorges. Preserved natural areas as well as coast with background are more vulnerable. Areas of intensive agriculture in lowland are least vulnerable.

Planning recommendations:

Green areas within dense settlements should be retained as much as possible to preserve the microclimate role of existing open areas. This will contribute to the vitality and healthy environment of the existing settlements and improve the quality of life of their inhabitants. Building and management of construction areas must strictly adhere to air protection regulation, including monitoring and protection/mitigation measures if required. Energy supply should increase the share of renewables. Municipality should support the energy saving and passive building. Coastal areas in the municipality should be relieved form traffic. The underground garage along main road Izola-Portoroz-Secovlje should be considered, as well as construction of walking and biking ways to and along the coast. Public transport need to be better developed.

A.2.3 Soil and geomorphology

Potential impacts of settlement expansion on soil and geomorphology are:

- change of typical geomorphologic features,
- soil pollution,
- change of soil structure,
- loss of soil as resource,
- increase of erosion.

Vulnerability criteria are:

- preserved typical geomorphologic features are more vulnerable (ridges, terraces, gorges),
- outstanding geomorphologic features are more vulnerable (preserved coastal features; cliffs),
- soils of higher quality are more vulnerable,
- erodible areas are more vulnerable,
- existing settlement areas are least vulnerable.

Data used: DEM, altitude belts, geology map, soils map, land use.

The model discloses areas of preserved geomorphologic features (cliffs, some coastal areas, salt fields, lakes, ridges) as most vulnerable (figure 27). Prime soils on alluvial flatlands along some streams are also vulnerable. Less vulnerable are densely as well as dispersedly built-up areas.

Planning recommendations:

Outstanding geomorphologic features, which are important for identity of the municipality (above all cliffs and other parts of the coast), must be preserved. Any action that might change their qualities or increase erosion must be avoided. Their visual presence must also be protected. The traditional agricultural cultivation on terraces should be preserved. Areas that are already partly degraded due to dispersed settlement should be planned in detail in order to rationally use space for new housing by densification and simultaneous improvement of road and sanitary infrastructure. Alluvial plains along rivers are the most important soil resource and should be preserved. Agricultural measures can be maintained. Measures for areas requiring improvement or renaturation include removal of parking from between Frnaža and Bernardin along with reorganization of traffic and introduction of recreational and swimming area; improvement of communal piers in Sv Jernej canal, improvement of existing dike along cape Seca for recreational / swimming use.

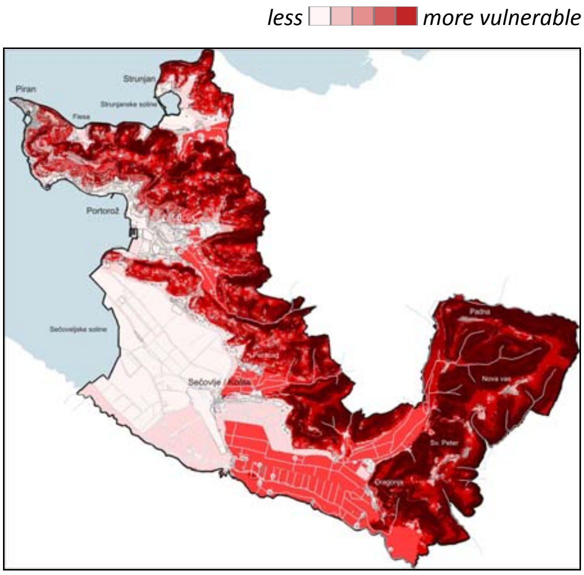


Figure 27: Vulnerability of soil and geomorphology due to settlement expansion

Figure 28: Environmental baselines: soil and geomorphology aspect

A.2.4 Hydrology

The potential impacts of settlement expansion on water are:

- pollution of rivers, sea and coastal areas,
- exposure of groundwater and water resources to pollution,
- degradation of streams and water sources due to technical measures,
- change of hydrological conditions.

Vulnerability criteria are:

- preserved natural streams are more vulnerable for pollution or physical interventions,
- preserved coastal areas and those, which are used for swimming are more vulnerable,
- areas along streams with important hydrological functions are more vulnerable,
- water protection areas, especially the strict ones, are more vulnerable,
- flooding areas are more vulnerable,
- areas prone to eutrofication are more vulnerable.

Data used: streams and rivers, flooding areas, classification of streams according to their natural state, acquifers, water protection areas, classification of swimming waters.

The result (figure 29) exposes as most vulnerable Strunjan and Secovlje salt fields and coastal sea between Strunjan and Piran. All swimming waters are also vulnerable. More vulnerable are plains and water contribution areas of streams; also the periodic ones in gorges.

Planning recommendations:

Coastal areas

Interventions in coastal areas[1] are only allowed for:

- public infrastructure and objects,
- measures for improvement of hydromorphologic and biologic properties of water
- nature conservation measures,
- necessary infrastructure for use of water; technical objects for flood protection and protection against pollution of water.

The whole coastal sea (2 km belt from the coast) is defined as sensitive area because of its swimming function as well as because of eutrofication processes.

The existing eco-morphological state of streams must be preserved. Close to nature options must be chosen in case of regulations.

less ▭▭▭▭▭ *more vulnerable*

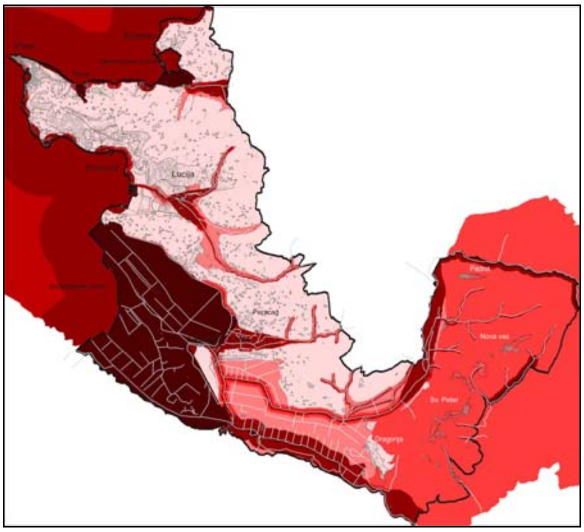


Figure 29: Vulnerability of water due to settlement expansion

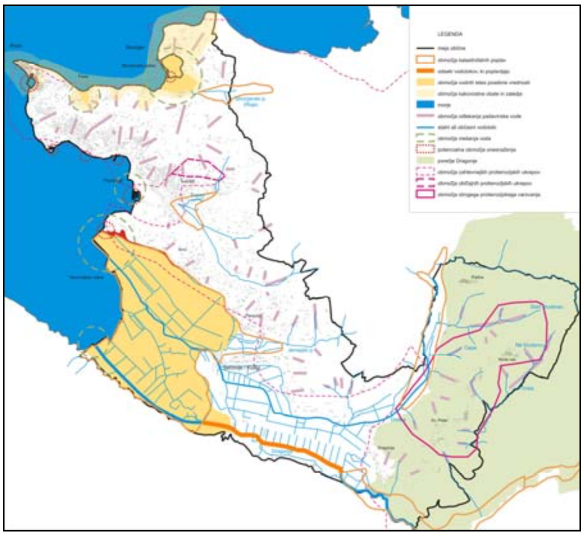


Figure 30: Environmental baselines: water protection aspect

[1] For Dragonja river the coastal belt is 15 meters form each river bank; for other rivers and streams 5 meters. Sea coastal area is defined with highest tidal level. By-coastal area is 25m from this line.

Endangered areas

According to the potentially detrimental processes related to water the following areas can be defined:

- catastrophic floods areas,
- regular flood areas,
- areas of regular anti-erosion measures,
- areas of complex anti-erosion measures,
- areas of strict anti-erosion measures.

Land uses and interventions in flooding areas, which may have harmful impact in case of flooding, are prohibited as well as those, which may increase danger of floods.

Interventions, which may increase danger of erosion, emergence of torrential streams, removal of green cover, filling up the water sources are prohibited in erosion prone areas and areas endangered from land sliding. Building in these areas should be avoided or done only after careful detailed geological analysis and planning.

Sea flooding and sea level rise due to global warming

Sea floods lower lying coastal areas when sea level exceeds average level for 85 cm. Beaches, salt fields and some piers road infrastructure and even some houses are flooded yearly. Extreme floods would affect large parts of old city centre of Piran, large parts of coastal infrastructure, many buildings in Lucija, parts of Sečovlje including Sečovlje airport and production facilities.

Due to global warming sea level along Slovenian coast would rise for 22 cm until 2050 and 50 cm until 2100. 50 cm rise means that the average sea level would be very close to flooding level, causing floods almost weekly. For extreme floods it would mean 1.5 m of water on lower coastal areas. This level would endanger 7,53 % of inhabitants and would cause serious troubles in retail, transport and other activities. The recommendations therefore include:

- new settlement in areas of yearly and extreme sea floods must be avoided,
- existing settlement in potentially endangered areas in the future should be strategically relocated,
- timely preparation of measures for adaptation and mitigation of damage caused by floods in the future (reservation of areas for housing relocating of endangered people).

A.2.5 Fauna, flora and habitats

Potential impacts of settlement expansion on fauna, flora and habitats are:

- destruction or change of properties of special habitats, diverse biotopes and areas of special protection interest due to their removal or change of physical conditions.

Vulnerability criteria are:

- more diverse biotopes are more vulnerable,
- areas of special natural qualities are more vulnerable (forest edge, preserve biotopes, hedges, forest patches, preserved coastal areas and sea ecosystems),
- streams and vegetation along the streams are more vulnerable.

Data used: land cover, hydrology, classification of forests, settlement areas.

The most vulnerable are the areas of special habitats in the salt field and preserved parts of the coast (figure 31). Also vulnerable are mainland areas covered with forest, especially along the streams and emergent streams, which contribute to biodiversity of the area. Also vulnerable are forest edge and patches between the settled and agricultural land. Less vulnerable are intensively managed agricultural lands, fields and gardens.

Planning recommendations:

Areas under special attention for protection are:

- Sečovelje salt fields (also protected under Ramsar convention)
- Strunjan salt field with Stjuža,
- Strunjan cliff
- Piran cliff, coastal sections: Pacug – Fiesa, Strunjan – Pacug
- Sea and sea shore
- Lakes in Fiesa
- Forests
- Areas along streams
- Dragonja river area

Land use of these areas should be maintained or rather improved in terms of their natural qualities (especially in Sečovlje and Strunjan salt fields, cliffs, lakes in Fiesi). Any intervention must be carefully assessed. Intensive touristic and recreational uses should not be placed along the shore and in sensitive habitats. More sustainable types of recreation should be promoted, which require minimal interventions (walking, biking, bird-watching, swimming). In newly planned settlements, sufficient land must be set aside for a network of green areas. Streams must be managed in sustainable and nature friendly way.

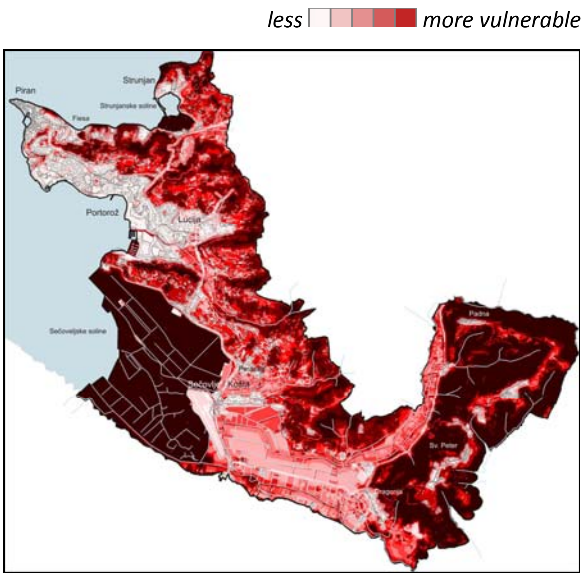


Figure 31: Vulnerability of flora, fauna and habitats due to settlement expansion

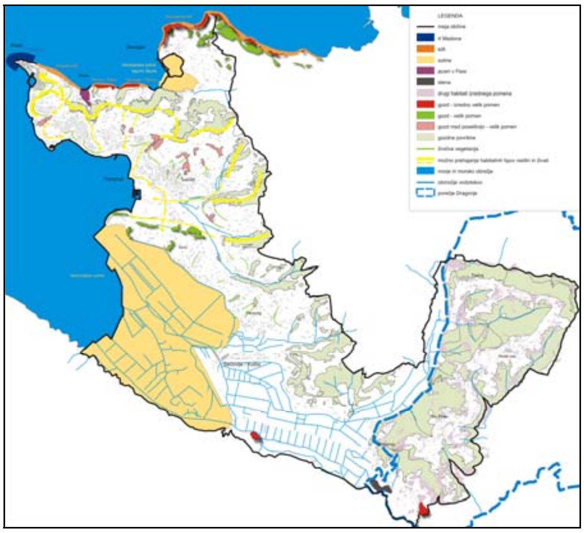


Figure 32: Environmental baselines: flora, fauna and habitats aspect

Interventions in sea shore that may endanger biodiversity must be avoided. Marines can only be planned on already degraded shore. Forests should be maintained, especially those covering steep slopes and cliffs.

A.2.6 Nature protection areas

Potential impacts of settlement expansion on nature protection areas are:

- destruction or change of properties which are reason for protection,
- impacts on protection regimes.

Vulnerability criteria are:

- small protected areas (natural monument, strict nature reserve and nature reserve) are more vulnerable,
- point and line natural features are more vulnerable,
- large protected areas (national, regional and landscape park), ecologically important areas, areas Natura2000 are relatively less vulnerable,
- areas proposed for protection are relatively less vulnerable,
- areas where different protection statuses overlap are more vulnerable.

Data used: nature protection areas.

The most vulnerable are areas with overlapping protection statuses such as areas of Strunjan and Sečovlje salt fields and hilly eastern part of the municipality. These areas are protected as valuable natural feature, ecological important area, Natura2000 or landscape park. More vulnerable are also individual (point) valuable natural features in northern part of Piran peninsula.

Planning recommendations:

Land use and intervention in these areas must follow the guidelines and regimes, provided by relevant document of nature conservation sector[2].

less *more vulnerable*

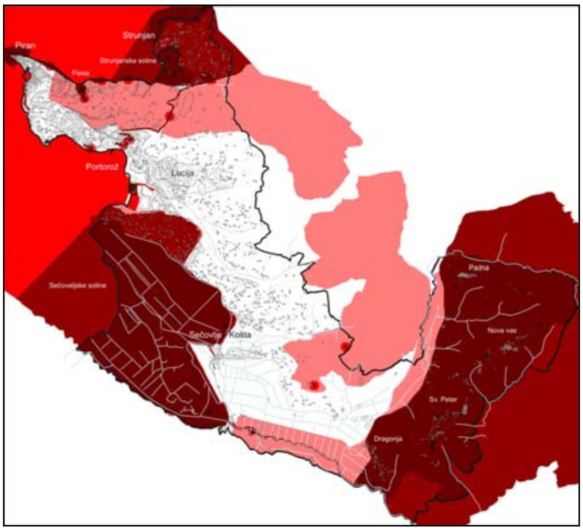


Figure 33: Vulnerability of nature protection areas due to settlement expansion

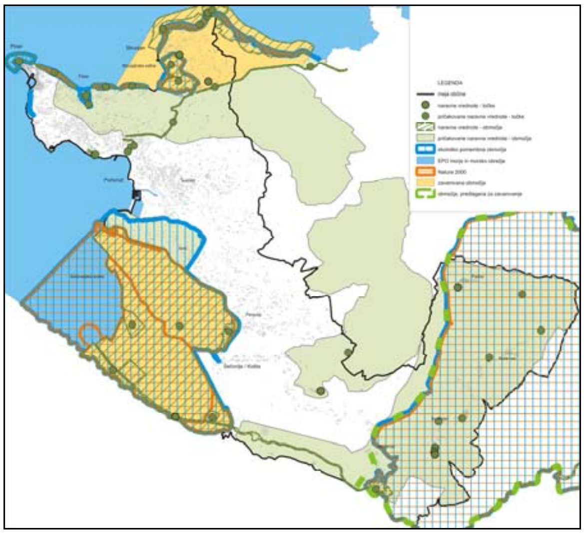


Figure 34: Environmental baselines: nature protection areas

[2] These were also summarized in the study

A.2.7 Noise

Potential impacts of settlement expansion include:

- increase of noise in settled areas and nature protected areas,
- quality of life reduction and potential impact on human health.

Vulnerability criteria are:

- most vulnerable are areas of exclusive housing, health services, tourism and nature protection areas,
- less vulnerable are areas of central services, dispersed settlements and green and water areas,
- least vulnerable are production areas, infrastructure, agricultural areas and forests.

Data used: planned land use, settlements, road classification according traffic frequency.

Most vulnerable are densely settled and touristic areas in Portorož, Piran and Lucija as well as some smaller settlements in the municipality (figure 35). Especially vulnerable are areas along important roads. Less vulnerable are city centers in Piran, Portorož and Lucija as well as dispersedly settled areas. Vulnerable parts of open landscape include nature protection areas Sečovlje and Strunjan salt fields and green areas within settlements. Least vulnerable to noise are industrial areas of Liminjan and Dragonja, all transport areas as well as land for agricultural and forestry production.

Planning recommendations:

Expansion of settlement should be planned in suitable distance from main roads, airport, industrial areas and sites for sports and other public events. For each source of potential considerable noise (i.e. industrial facility) a noise simulation study must be conducted. Coastal areas should be relieved of noise by building underground parking facilities along the inner main road, by building biking and hiking ways to and along the coast and promoting public transport.

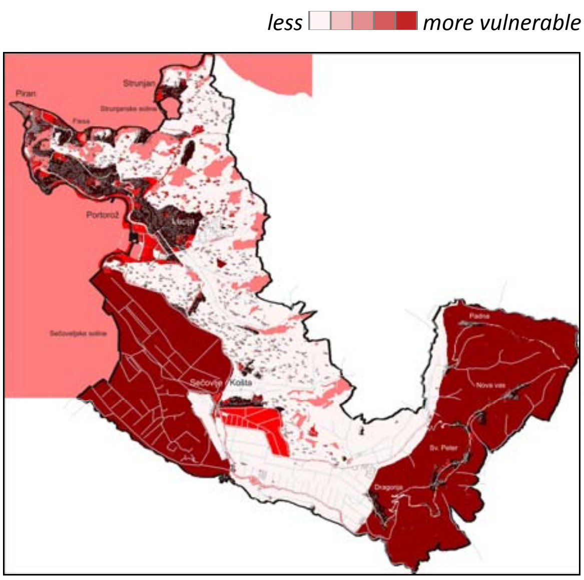


Figure 35: Vulnerability to noise due to settlement expansion

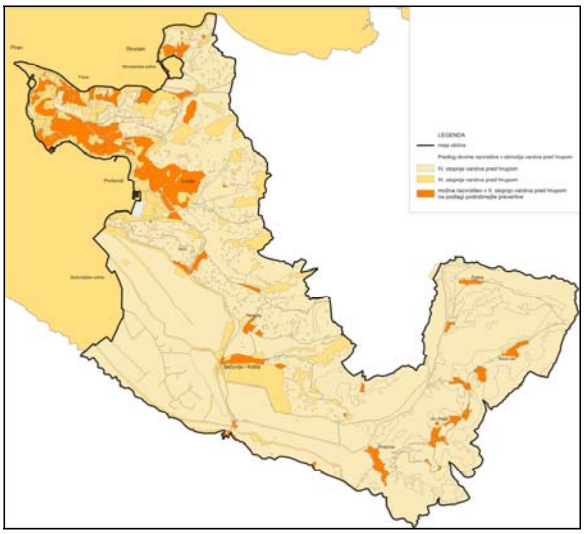


Figure 36: Environmental baselines: proposed categories of noise protection

A.2.8 Cultural heritage

Potential impacts of settlement expansion on cultural heritage are:

- destruction or damaging of cultural heritage areas and buildings,
- diminishing the complex value of cultural heritage areas.

Vulnerability criteria are:

- cultural heritage objects are more vulnerable, as well as their impact areas,
- relatively less vulnerable are areas of complex protection,
- more vulnerable are areas where different types of cultural heritage overlap.

Data used: areas and objects of cultural heritage.

less ▢▢▢▢▢ *more vulnerable*

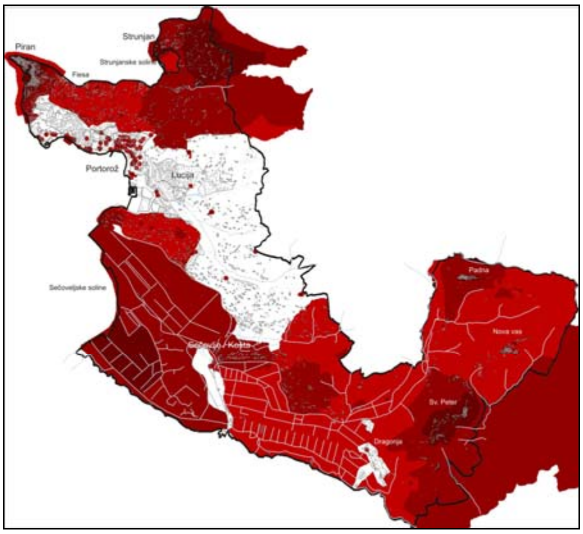


Figure 37: Vulnerability of cultural heritage due to settlement expansion

Areas of protected cultural heritage are around cape Strunjan, Piran, Seča and villages Padna and Sv. Peter. Their impact areas include Piran, old salt fields in Sečovlje, Košta, Sv. Nedelja, Sv. Peter and Padna. Majority of cultural heritage objects are in towns of Piran, Bernardin, Portoroz and Lucija.

Planning recommendations:

Land use and intervention in these areas must follow the guidelines and regimes, provided by relevant document of cultural heritage protection sector[3].

[3] These were also summarized in the study

A.2.9 Landscape qualities

Potential impacts of settlement expansion are:
- change of typical views,
- concealment of visually attractive parts of landscape and landmarks,
- change of typical landscape structure,
- reduction of landscape diversity.

Vulnerability criteria are:
- visually more exposed areas are more vulnerable,
- areas of high landscape diversity and identity are more vulnerable,
- less vulnerable are infrastructural corridors and other degraded landscapes.

Data used: land use / cover, hydrology.

Most vulnerable are areas of preserved cultural landscape, intertwined with natural elements: cultivated terraces, olive groves, vineyards and orchards together with traditional settlement patterns (figure 38). Also vulnerable are areas of homogeneous land use such as compact parts of forests, especially on visually exposed slopes. Very vulnerable are areas of Strunjan and Sečovlje salt fields and other coastal areas.

Planning recommendations:

Based on the analysis of the existing landscape patterns and landscape typology the area of municipality was divided into the following landscape quality areas:
- areas of exceptional landscape on national level, where all activities must be submitted to the natural and cultural landscape values;
- areas of preserved cultural landscapes of high value, where new settlement should be avoided, especially on geomorphologically prominent sites;
- areas of preserved cultural landscape, where traditional settlement and other land use patterns should be preserved; new settlement is only allowed in selected parts;
- areas of transformed cultural landscape, where typical agricultural pattern and parcelation should be preserved;
- degraded landscapes, where existing density of settlement should be preserved or increased in selected areas. Green areas within the settlements must be preserved or improved. Parts along the shore need common design approach; car traffic should be reduced and a »promenade« established. Specific degraded areas must be reconstructed according to detailed plans.

less ▢ *more vulnerable*

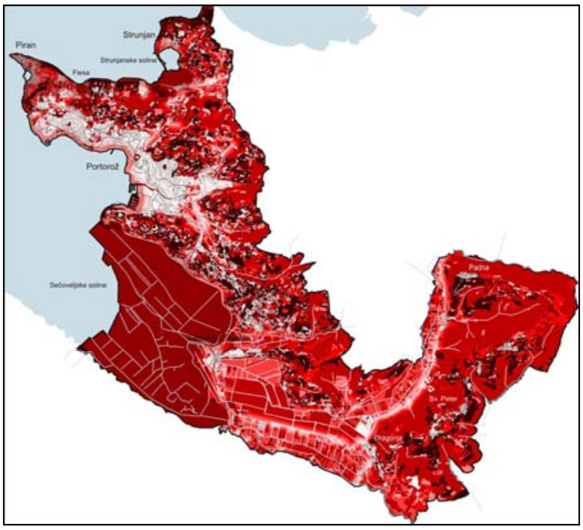


Figure 38: Vulnerability of landscape qualities due to settlement expansion

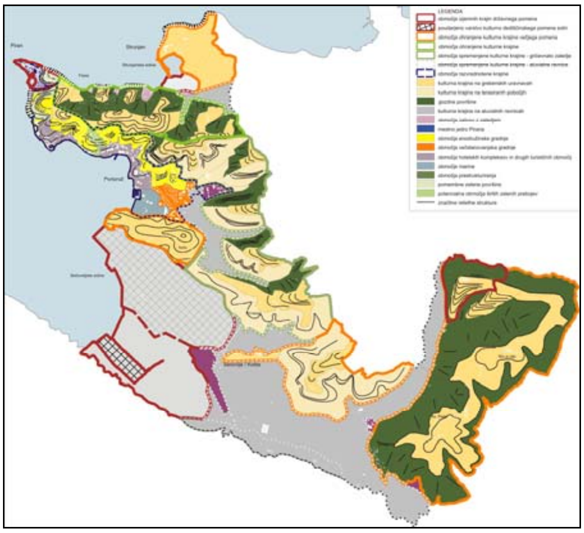


Figure 39: Environmental baselines: aspect of landscape qualities

A.2.10 Forests and forestry

Potential impacts of settlement expansion on forests and forestry are:

- loss of forest lands,
- diminishing value of certain forests' functions.

Vulnerability criteria are:

- most vulnerable are protective forests,
- more vulnerable are forest with special function,
- vulnerable are forests with multiple functions.

Data used: land use, protective forests, forests with special function.

Widest areas suitable for forestry production and so more vulnerable are along the eastern edges of the municipality (figure 40). Most vulnerable are forests on steep and erosion-prone slopes. Vulnerable are also forests with strong ecologic function, especially biotope and climate on ridges in north and north east parts of the municipality as well as forests around touristic areas with important recreational and aesthetic value.

Planning recommendations:

Special attention must be given to »green wedges«: connections between forested hinterland and urban areas. They should retain or increase prevailingly green character. Recreation in forests must be nature close and sustainable, restricted to hiking and biking paths. Building should be avoided. Additional reforestation within the settlements should be considered to improve living quality. Forests along the coast must be preserved to retain their anti-erosion, climate and biotope functions.

New infrastructure must be planned so as to avoid impacts on forests and to enable migration of animals.

less *more vulnerable*

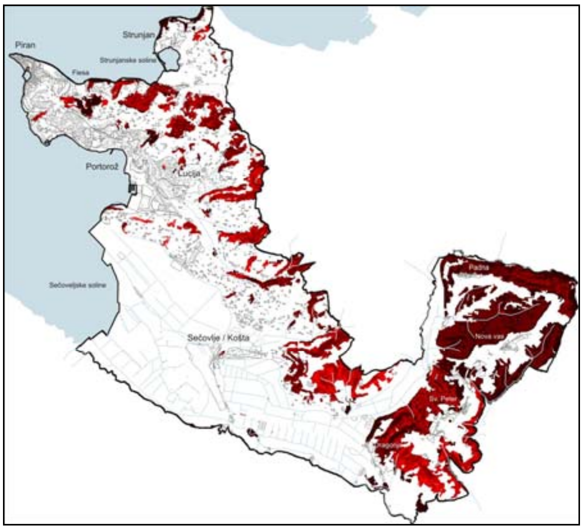


Figure 40: Vulnerability of forests and forestry due to settlement expansion

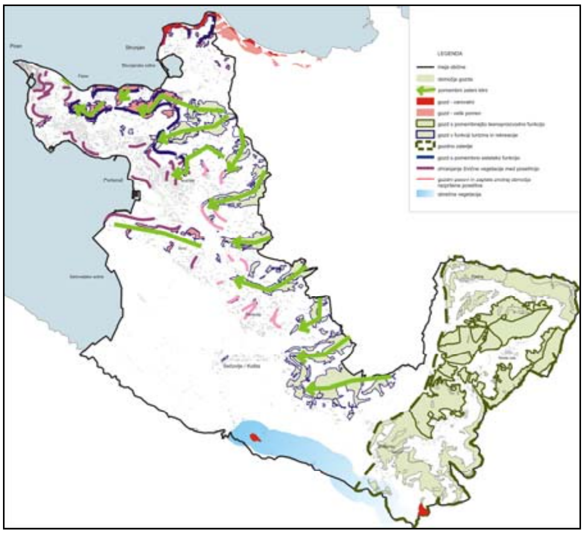


Figure 41: Environmental baselines: forests and forestry aspect

A.2.11 Agriculture and agricultural land

Potential impacts of settlement expansion on agriculture and agricultural land are:

- physical loss of agricultural land
- division of arable complexes into smaller parts,
- soil contamination.

Vulnerability criteria are:

- more vulnerable are areas with more fertile soils – soils with higher production potential
- more vulnerable are areas which facilitate the agriculture production – flat areas and slope shelves with southern exposition in higher areas.

Data used: soil number[4], slope and exposition to sun.

Flat areas with high quality soils are the most vulnerable (figure 42). The widest among them is the alluvial plain of the river Dragonja in the southern part of the Municipality. Vulnerable are also wide and flat hill-ridges with quality soils. Areas unsuitable for cultivation due to northern exposition and larger slopes are least vulnerable.

Planning recommendations are given according to:

- classification of agricultural land into "best-" and "other agricultural land",
- overall features of individual agricult. areas.

The classification is in accordance with Agricultural Land Act (Ur. l. RS, No. 59/1996) while recommendations are in accordance with Spatial Planning Act (Ur. l. RS, No. 33/2007).

Planning recommendations for "best-" and "other agricultural land":

Provided that it is not possible to use "other agricultural land" that is less suitable for agricultural production, following interventions are allowed to be implemented on "best agricultural land":

- those who directly serve the agricultural, forestry or tourism activities,
- those intended for the general use (local built public good),
- for the implementation of environmental protection, nature conservation and cultural heritage protection as well as of recognizable landscape features protection,

less *more vulnerable*

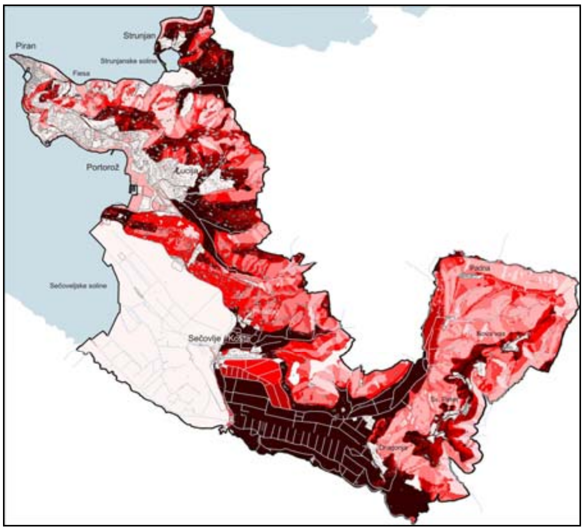


Figure 42: Vulnerability of agricultural production potential due to settlement expansion

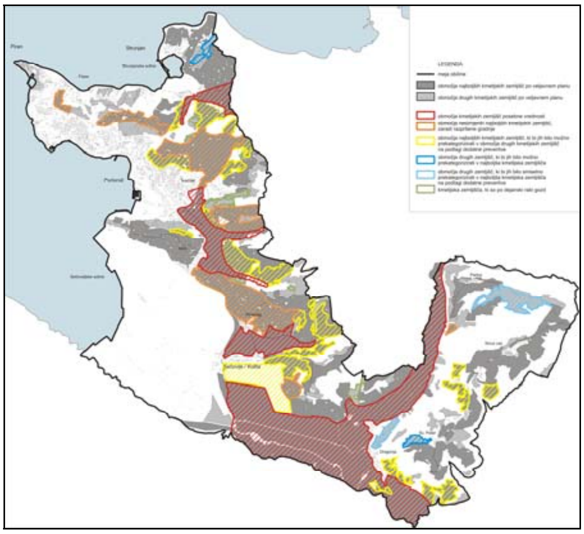


Figure 43: Environmental baselines: agriculture and agricultural land aspect / possible reclassification of the best and other agricultural land

[4] Data on soil number give the information about the suitability or potential for agricultural use based on pedologic characteristics.

- for the purpose of sport and recreation,
- for the use of natural assets and remediation of abandoned areas of exploitation,
- for the purpose of defence and protection against natural and other disasters.

Planning recommendations for typical agricultural areas:

Based on the analysis of the agricultural land features and potential for development of agriculture the area of municipality was divided into the following agricultural areas:
- areas of agricultural land of special value on alluvial plain, where settlement expansion is prohibited;
- areas of agriculture development due to emphasized conservation of cultural landscape, especially terraces, where agricultural land should be maintained and the development of agriculture promoted in order to maintain the cultural landscape;
- areas of agricultural land with good production potential, where it is reasonable to preserve agricultural land and to restrain settlement expansion (only concentration within settlement areas is allowed);
- areas of dense agricultural area on flat hill-ridges, where agricultural land should be preserved and settlement expansion restrained (only concentration within settlement areas is allowed);
- areas of agricultural land with moderate production potential;
- fragmented agricultural land due to dispersed building; where existing settlement is too dense agricultural land may be allocated to settlement.

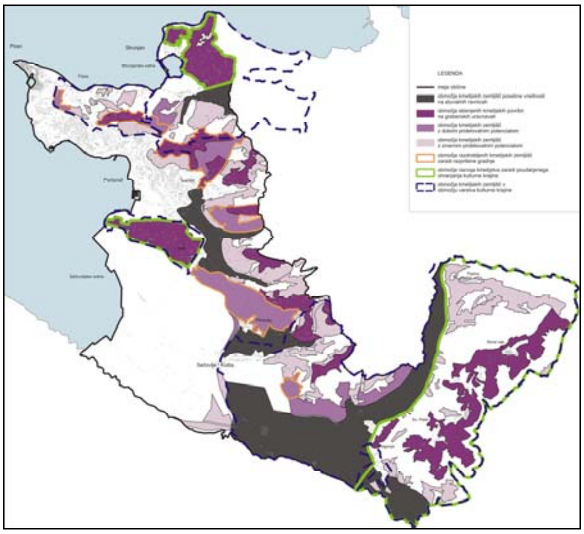


Figure 44: Environmental baselines: agriculture and agricultural land aspect / classification of typical agricultural areas

Additional recommendations:

- potential water resources should be explored together with potential water accumulations for irrigation,
- in areas of permanent crops soil surveys should be done; based on their findings appropriate measures for production optimization should be identified;
- in a truly development-oriented agricultural areas, land consolidation and land improvement should be carried out;

A.3 Joint vulnerability

Series of maps showing vulnerability of individual environmental components due to settlement expansion were combined into a joint spatial vulnerability in two ways:

- average value rule: a map of joint vulnerability shows an average degree of vulnerability considering individual models;
- maximum rule: a map of joint vulnerability for each part of the area shows the highest value of vulnerability from any of the individual models.

Joint vulnerability according to the maximum rule (figure 45) shows the entire municipal area as highly vulnerable. To joint vulnerability contribute vulnerabilities of the individual environmental components which refer to different parts of the municipal area.

Joint vulnerability according to the average value rule (figure 46) is more structured and enables the identification of relative differences between areas.

The results of both shows as more vulnerable in particular:

- naturally preserved areas of the coast and ridges,
- areas of preserved cultural landscape, particularly terraced southern slopes,
- dense forest areas,
- areas of special value (salt-pans).

Less vulnerable are due to existing settlement degraded ridges and urbanized coast with the hinterland.

less *more vulnerable*

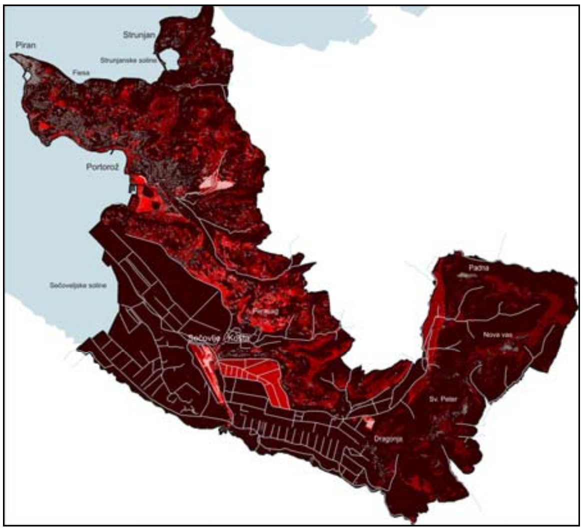


Figure 45: Joint vulnerability – maximum values

less *more vulnerable*

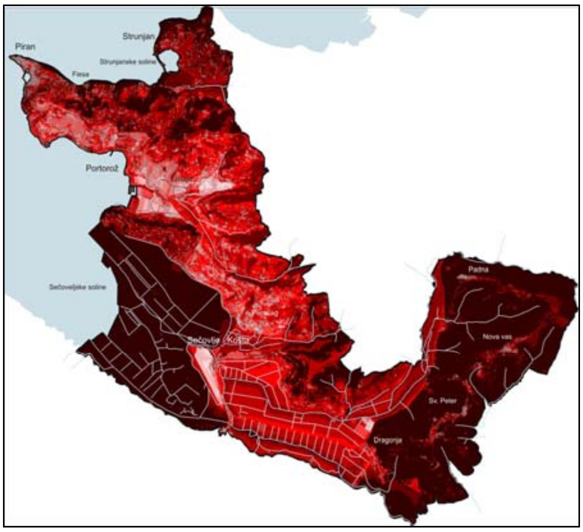


Figure 46: Joint vulnerability – average values

A.4 General environmental baselines

In the context of comprehensive spatial planning and proceeding from identified environmental baselines general guidelines for environmentally acceptable spatial development are given as well as planning guidelines for specific environmentally significant areas in the municipality.

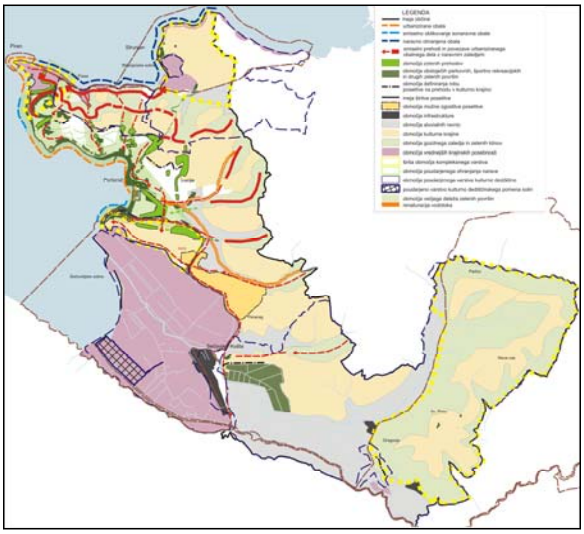


Figure 47: General environmental baselines

A.4.1 General guidelines

General guidelines for environmentally acceptable spatial development can be summarized into following points:

Consistent prevention of further dispersed construction

New building should be directed into existing settlement areas. This is a precondition for maintaining an attractive image of the cultural landscape, recreational and tourism potential, for reducing emissions from individual sources of pollution and for economical distribution of public infrastructure. The concentration of existing settlements should strictly consider and respect the areas of protection and restraints, the accessibility to public transport and should be directed into already degraded areas.

Provision of suitable living environment and health care of the residents

A suitable living environment can be ensured by a set of interrelated measures which relate mainly to ensuring an adequate supply of drinking water, discharging of rainwater and cleaning of water, maintaining of green area system, and reducing of traffic emissions with the establishment of an attractive system of public passenger transport and stimulation of its use, with administrative measures, and with the concept of traffic which would ease the burden on the coastal strip - notably the construction of underground garages along the main road in the hinterland with the access routes and public transport systems to the coast.

Protection of agricultural land

In the agricultural areas with high quality any interventions should be restricted. Areas of alluvial plains should be given special protection with strict prohibition of settlement expansion. Potential water resources for irrigation should be explored. In areas of permanent crops soil surveys should be done. Based on their findings appropriate measures for production optimization should be identified. In truly development-oriented agricultural areas, land consolidation and land improvement should be carried out.

Cultural heritage protection

Formulation of detailed spatial development conditions or active urban policy is required for settlements defined as urban heritage. Special attention should be given to the conservation of heritage landscapes as important elements of municipal identity, whose existence is largely dependent on the promotion of the continued existence of agriculture.

Disencumberment and comprehensive regulation of coastline

Building in the coastal area must be prevented. The coast must be comprehensively planned with reconciliation of developmental needs with protection baselines and with a clear idea of what to do with a particular part of the coast.

Sea floods and sea level rise

Due to the high sea flood risk throughout the coastal area of the municipality immediate appropriate measures are required. These relate mainly to (1) strict avoidance of new interventions in the flood-prone areas, and (2) planning and implementation of flood protection measures along the coast, where they are possible and meaningful. Reasonable is also timely preparation of measures to adapt to the global sea level rise and to reduce its impacts (eg strategic protection of areas suitable for new or alternative urban development, planning of protection measures along the coast).

Regulation of public transport and stationary traffic

Effective system of public transport should be ensured. Parking places should be arranged in the hinterland of the coast along the main road (preferably underground garages) and thus replacing current less environmentally acceptable unbridled parking.

Integrating the principles of landscape ecology in urban planning solutions

New conceptions of urban development should include the system of green areas and green belts for recreation, separation of incompatible land uses, reduction of the effects of emissions, crossing of animals, and improvement of microclimate conditions. Particular attention should be paid to the so-called urban drainage, especially retention of clean rainwater for watering and irrigation needs.

Definition of planning units with regard to environmental baselines

Planning units or land use areas to which specific spatial planning and development measures are applied should be most consistent with environmental baselines or with areas of environmental protection, human health, nature protection, and cultural heritage protection regimes.

Integration of environmental protection doctrine in the instruments for the implementation of a plan

Environmental baselines must be integrated also in various implementation and management instruments, such as education, research, monitoring, system of financing, maintenance programs etc.

A.4.2 Areas with planning guidelines

Significant areas of environmental protection were defined based on vulnerability analysis and on spatial division according to individual environmental components. Planning guidelines were ascribed to each of them. Presenting all defined areas and guidelines related to them would be too extensive. Therefore, only sea and sea coast area with planning guidelines is presented, mainly for purposes of illustration.

Figure 48: Naturally preserved Piran peninsula coast

Sea and sea coast

Slovenian sea is an area of great biodiversity and a wide range of well-preserved habitat types. Underwater world should be thus taken into account in planning the coast. Great importance of the coast and high pressure of users require comprehensive and integrated planning of the coast that should reconcile developmental needs and protection interests in detail and ensure an attractive image of the coast. Detailed spatial arrangements should be obtained by an open competition for the entire coast of the municipality.

For individual parts of the sea coast, the following applies:

- The coast along the bay Strunjan should be maintained in its natural state; appropriate footpaths to parking areas in the hinterland should be planned and conducted.
- The coast in the area of Piran should be maintained in its existing state; a network of small parks should be established that would increase the proportion of green areas in densely built structure of the city.
- Central parking area in Piran is an important potential swimming location in Slovenia. It should be converted in a sustainable way into a swimmer friendly coast (eg Le Mourillona in Toulon) Parking for residents should be settled in an underground garage and for visitors in the hinterland.
- The area between Marina Portorož and Bernardin should maintain the characteristics of “urban coast”; special attention should be paid to the redevelopment of the industrial buildings area Droga Kolinska; walking and cycling connections should be conducted in terms of better access to existing park areas. Heavy traffic and parking around hotels should be redirected and relocated to the hinterland.
- Potential increase in capacity of Marina Portorož should be reached primarily by regulations of sea gulfs in the Interior of the coast. Expansion of the Marina to the sea is less acceptable because it would affect the underwater habitats and morphology of cape Seča. Multifunctionality and landscape architectural arrangements of this part of the coast must be ensured.
- The fill between Marina Portorož and channel Sv. Jernej is inappropriate. Swimmer friendly coast and longitudinal cycling and walking paths should be

arranged; trees between the coast and cliffs should be planted while cliffs must be fully retained.

Figure 49: Inappropriate fill of cape Seča

- The channel Sv. Jernej should be restored and berths arranged. Additional berths arrangement would represent an alternative to the possible extension of the Marina Portorož. At the same time supporting infrastructure (access road, sanitary facilities etc.) should be arranged.

Figure 50: Disordered berths and the coast along the channel Sv. Jernej

Appendix B
Application of vulnerability assessment in a site selection process – the case of wind turbines

Source: Analysis of the Primorska region potentials for wind farms – attractiveness and vulnerability of space, commissioned by Elektro Primorska d.d., coordinated by IREET, d.o.o. et al., Attractiveness and vulnerability analysis prepared by Urban Planning Institute of RS, Ljubljana, 2001

B.1 Background and scope of the study

B.1.1 Background

The Energy Act of the Republic of Slovenia (Ur. l. RS No. 79/99) provides that the energy policy shall, through appropriate measures, give priority to the use of renewable types of energy and to replacing energy resources, which accelerate the greenhouse effect (CO2) and generate nitric oxide (NO) into the atmosphere. This goal is consistent with the energy policy of European Union (Energy for the future: renewable sources of energy - White Paper for a Community strategy and action plan). Elektro Primorska d.d., a Slovenian distribution company took the first important steps in the field of wind power exploitation. The study "Analysis of the Primorska region's potentials for wind farms – attractiveness and vulnerability of space" served as an expert base for this project.

8 sites in the Primorska region were proposed for wind farms: Bate, Trstelj, Sinji vrh, Nanos, Golič, Kokoš, Volovja Reber, and Slatna (figure 51). The main aim of the analysis was thus to evaluate the suitability of the proposed sites for wind farms and to give the proposal for the selection of the best site.

However, the analysis covered the entire area of Primorska region, including areas that were already known in advance that they are less suitable for wind farms. One of the key reasons is that rejection of certain parts of the area before any analysis of the entire area is performed is not justified. It cannot be known in advance whether suitable sites can really be identified in allegedly relevant areas. Another reason is that with multi-criteria evaluation of proposed and potential new sites based on non-quantifiable values, the suitability of a site can be determined only relatively. Acceptability of the site, therefore, depends on how well or bad is the evaluated site in relation to other possible choices.

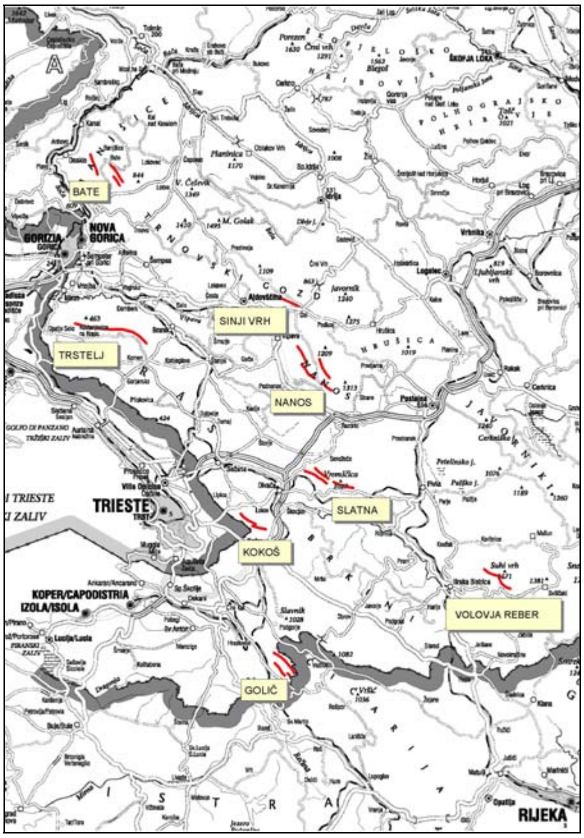


Figure 51: Proposed sites for wind farms in the Primorska region

The study first examined potential impacts of wind farms on reducing greenhouse gas emissions. According to the estimations, a wind field with 86 wind turbines would prevent the emission of 1.6 tons of CO_2 into the atmosphere within its life-time and thus save 10 million Euros. In addition to this mitigating effect on climate changes, one can also expect positive effects on local and regional environment by reducing the concentration of NO_X and resulting in less ground-level ozone. The study than examined integration of wind farms into the energy system of Slovenia and the impact that wind farms might have on the future Slovenian electricity market. According to the simulations the wind farms' integration into the energy system would not cause problems. The second part of the study is the suitability analysis of the Primorska region for wind farms. The analysis helped to identify the most suitable sites for the future wind farm in the region. The basic idea was to find the right balance between space characteristics, as required by the specific technology of the wind farms, and space restrictions, imposed in order to safeguard the environment. For this purpose, attractiveness and vulnerability analyses were performed. This presentation of the study will focus mainly on the vulnerability analysis as a part of the process of locating wind farms within the Primorska region.

B.1.2 Suitability analysis - working method

In the suitability analysis, the aspects of attractiveness and vulnerability of space are treated separately. Aspect of the benefits or the appropriateness of space depending on the investor's requests is evaluated by attractiveness analysis. This is to identify those spatial conditions, which reveal the locations where the project is the most profitable. For wind farms the far most important spatial condition is windiness, which was modeled separately by meteorological models and later included in the analysis. Vulnerability analysis enables the second aspect of the spatial assessment - integration of negative impacts. The basis for evaluation of spatial vulnerability was a model of potential impacts on the environment.

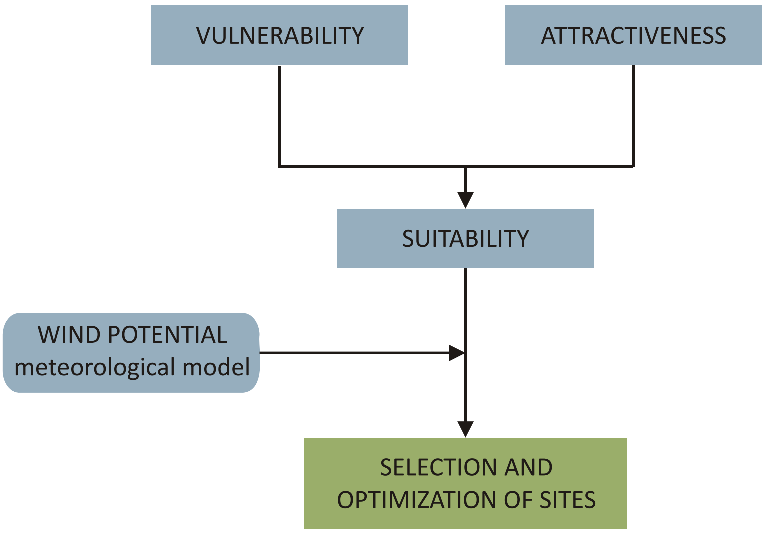


Figure 52: Components of suitability analysis

Such approach to the suitability analysis enables different types of assessments and analyses in the process of site selection:

- Optimization of the general-approximate position of structures in the space
- Checking the compliance of the proposed sites with technological requirements of the planned activity
- Checking the compliance of the proposed sites with environment-safeguarding restrictions
- Assessment of proposed sites in respect of several criteria

The work process consists of the following steps:

- Definition of analyzed area
- Description of activity and interventions in physical environment
- Space requirement of activity as a basis for attractiveness models' definition
- Potential environmental impacts as a basis for vulnerability models' definition
- Interaction matrix
- Selection and processing of spatial data
- Definition of attractiveness models
- Definition of vulnerability models

- Implementation of models and display of results on maps
- Proposed sites' assessment based on vulnerability and attractiveness models

B.1.3 Definition of activity

The reasons for an increased interest in wind energy are the relatively simple technology of wind farms, and in particular its negligible emissions to the environment. The main elements that make up a wind turbine are a pillar and a rotor. The proposed technology involves a pillar of between 43 and 48 m and a rotor consisting of three approximately 24 m long blades and a carrier cap. Rotor as well as generator and a system for the deflection are bound to the basic element of a wind farm - an integrated speed transmission, which is fastened on top of a central pillar.

A wind turbine requires a small area of land - a foundation usually takes approximately 11x11 m of surface. A wind farm requires also space for access roads. Distance between two wind turbines is somewhat dependent on the configuration of the terrain and is about 70 m. Tall buildings or forests must be removed from their immediate vicinity; grassland, pasture or shrubs are most appropriate land cover. Dependence on wind required that locations for wind farms are on exposed positions. In Slovenia such sites are located primarily on ridges and peaks at a relatively high altitude (700 - 1100 m above sea level). Wind farms will be connected to the existing electric power system. If no power line is in the vicinity, the construction of power line infrastructure must be considered as a part of planned intervention. Appropriate transport infrastructure is required to enable construction of facilities and their maintenance. Service road is required to each particular wind turbine. Service life of a wind turbine is 20 – 25 years.

Figure 53: Wind farm (photomontage) (Brečevič et al. 2001)

B.1.4 Definition and description of analyzed area

The area of Primorska region comprises 22 municipalities on surface of 4.335 km2: Koper, Izola, Piran, Pivka, Postojna, Ilirska Bistrica, Nova Gorica, Brda, Kanal, Miren-Kostanjevica, Šempeter-Vrtojba, Divača, Hrpelje- Kozina, Sežana, Komen, Ajdovščina, Vipava, Bovec, Tolmin, Kobarid, Cerkno, and Idrija.

Figure 54: Analyzed area - 22 Slovene municipalities

Landscapes of the Primorska region encompass Slovene coastal area and its hinterland as well as Karst area and interior Primorska all the way to where reaches the impact of the sub-Mediterranean climate. Climate is also the most determining factor of the Primorska landscapes. This is the climate of northern peripheral areas of the Mediterranean, which is characterized by higher temperatures, strong wind, rare snow and frost, drought, more sunny days etc. that is reflected also in the typical vegetation. The climate becomes harsh closer to the eastern border of Primorska region, which is shown in a change of vegetation, agricultural use and relief. The coast is characterized by coastal plains, some remains of salt-pans and terraced slopes. The coastal hinterland is hilly, with the streams along the bottom of valleys. Coastal part of the region is parted from the internal karst with Karst edge, which is a prominent feature of the Primorska landscape and, in the past, an important dividing line between cultures. In the north part of the region is a dry karst, plateau world with specific forms of village architecture.

An intensive use of agricultural land is characteristic for the Primorska region. Cultural landscapes are largely marked by vineyards and fruit trees. In the past, agricultural land use was intense also in the less fertile soil, the Karst rendzina and steep slopes of the coast. Today, such land is spontaneously overgrowing with forests, while some of its parts were reforested with non-indigenous tree species already in the past (eg. karst – with black pine). Bare rocky karst has almost disappeared, except in some small-scale patches and lowland scree slopes on the edge of Trnovska plateau. Alluvial plains in the valleys are swampy especially in areas of soft rock.

Traditional settlements were located in the landscape with regard to weather conditions. In the karst area and in Slovenian Istria, which are characterized by strong wind burja, settlements were mainly located in areas that were not exposed to the wind. Goriška brda is a northwestern part of the region in similar geologic and relief, but in different climate conditions, with settlements on ridges. Settlements are, especially near cities, losing their traditional patterns, and are becoming more dispersed and generally less controlled.

B.1.5 Selection and processing of spatial data

The selection and use of spatial data follow the spatial vulnerability criteria. Majority of the data were obtained from existing databases. Interpretation of data and definition of models were expertly performed while the evaluation of individual models was performed in the interdisciplinary expert workshops.

Vulnerability modeling was done on a raster grid of 25 x 25 m. Selected cell size corresponds to the criterion of planned intervention, the precision of most of the data used and the extent of the area. Geoinformation software application ProVal was used for modeling.

B.2 Identification of impacts

Wind farms have impacts on the environment in the time of their construction and during their operation. At the time of construction, interventions that affect the environment are mainly related to the preparation of land while constructed facilities cause impacts already by the mare presence but above all with the operation.

Table 7: Identification of interventions

activity	*group of interventions*	*intervention*	*task*
wind farm	preparing land for construction and installation of facilities	modifying relief	surface leveling filling depressions construction of terraces
		changing land cover	removing of vegetation
		changing water and waterside area	regulation of watercourses changing coastlines drying out wet land
		transporting material	transporting surplus material transporting material for filling
	presence of wind farms	presence of facilities	presence of facilities
	operation of wind farms	producing noise	rotation of rotor

Construction and operation of wind farms cause impacts on environment directly by occupying physical space and indirectly by their proximity. They cause impacts on all environmental components – on nature, space as natural resource, and above all on human environment.

Table 8: Identification of impacts (■ small or negligible, ■■ medium, ■■■ considerable expected impact)

interventions: *environment:* *systems, use, potentials*	preparing land for construction and installation of facilities	presence of facilities	operation of wind farms
protection of nature			
atmosphere			
physical properties			■
chemical properties	■		
climate			
geosphere			
bedrock	■		
soil	■		
relief, geomorphology	■■		
hydrosphere			
groundwater	■		■
surface water, sea	■		
biosphere			
terrestrial flora	■		■
terrestrial fauna	■■	■	■■■
biotopes	■■	■	■
protection of natural resources			
timber forest	■■	■■	
agricultural land	■	■	
water resources		■	
mineral resources		■	
protection of human environment			
unpolluted atmosphere	■		
noise free environment	■		■■
landscape scenery	■	■■■	■

B.2.1 Impacts on nature

Atmosphere

Wind turbines do not affect the chemical characteristics of the atmosphere. This effect is caused by emissions from traffic, which are produced during the construction and installation of facilities, but they are negligible.

Geosphere

Subsoil, soil and relief can be affected during preparation of land for the installation of wind turbines by:
- surface leveling and filling depressions,
- removing rocks and stones,
- changing the soil characteristics due to removing top layer of soil, and
- changing the soil characteristics due to the use of heavy machinery.

The consequences of interventions are:
- changing physical and chemical characteristics of soil,
- erosion and removal of soil and
- changing natural geomorphologic forms.

For wind turbines flat and exposed areas are the most appropriate. All the steeper areas need to be leveled, filled or otherwise transformed. Therefore, the steepest areas are the most vulnerable. Vulnerable are also areas with low soil stability and erosion prone areas, where additional interventions and measures are needed in the stage of construction. Areas with rare or quality soil or soil, whose creation has lasted a long time, are vulnerable as well.

Hydrosphere

Interventions, which can affect the water and the aquatic environment in the stage of preparing the land for wind turbine installation, are:
- regulation of watercourses,
- drying out wet land and
- machinery – discharges of petroleum products and machinery oils.

The consequences of interventions are:
- surface water pollution and
- ground water pollution

Wind turbines can affect the hydrosphere also in the stage of their construction and installation. With building foundations, transport and interventions required for construction or reconstruction of access roads, they can pollute waters, change the watercourses or the water regime.

Very vulnerable are ground waters located in permeable aquifers due to the discharges of petroleum products and machinery oils. Due to potential pollution, surface waters are also vulnerable among which are more vulnerable clean and naturally preserved ones as well as completely degraded waters, that, if we want them return to life may not be even more polluted. Completely naturally preserved watercourses are very vulnerable due to potential regulations as well as flood areas, which need to be properly regulated.

Biosphere

Construction, installation and operation of wind turbines may affect the biosphere with the following interventions:
- land cover change,
- changes – barriers in the atmosphere.

Less likely are the affects due to regulating watercourses or land drying.

The consequences of those interventions are:
- direct destruction of plants,
- deterioration of the species' living environment - barriers for birds in the air, disruptions for other animals,
- destruction of or damage to habitats (modified soil conditions, microclimate characteristics, changes in land cover, increased noise).

Vulnerability of the biosphere in the stage of construction depends on the frequency of individual species' occurrence and the number of species which occur in the affected area. More vulnerable are areas with rare species (including exceptional, typical...), areas with species, specialized to a specific living environment, and naturally preserved areas. Indirect affects on the biosphere are caused by construction and presence of facilities and traffic. From this perspective, more vulnerable biotopes are those that are rarer (also exceptional, typical…), more adapted to specific environmental conditions and are naturally preserved.

Impacts of wind turbines are most prominent on birds and large mammals.

Birds

Researches show that the mortality of birds due to wind turbines is generally low (the victims are often larger birds, which are typically highly threatened), while in areas of a lot of birds along their migration routes or corridors is significantly higher and contribute to reduction of birds' populations. Wind farms also affect the birds by habitat loss usually in the territory of the radius of approximately 250 to 500 m around a wind turbine.

The entire analyzed area is an important habitat for many rare and endangered bird species and also an area of the traditional migratory routes and wintering and resting places for birds. The largest impact is likely on birds of prey and owls, which are all on the list of endangered species in Slovenia, among which are of particular importance: Griffon Vulture Gyps fulvus, Golden Eagle Aquila chrysaetos, Short-toed Eagle Circaetus gallicus, and Eurasian Eagle-owl Bubo bubo.

Figure 55: Griffon Vulture

Large mammals

The impacts of wind turbines on other animals has not been studied yet but one can expect the impacts on large mammals, particularly on wolf and lynx, which are most sensitive to disturbances in an environment, and possibly on bear, deer and other animals. Expected impacts are mainly due to reduction or destruction of habitats and migration routes of these species. Other disturbances (mainly noise) are also expected due to allocating the facilities in naturally preserved areas. The whole western part of Slovenia is an important area of brown bear Ursus arctos, wolf Canis lupus and lynx Lynx lynx, which are all on the red list of endangered mammals in Slovenia, and at the same time an area of important migratory routes of animals.

Figure 56: Golden Eagle

B.2.2 Impacts on space as natural resource

The interventions needed for construction, installation and operation of wind turbines can destroy or only limit the use of natural resource. One can speak of partial destruction, since after the removal of facilities, the land can be returned to its original state.

Forest

The consequences of installing and operating (maintenance of corridor) of wind turbines are:

- removal of trees in the area of wind turbines and for a width of approx. 30 m around it,
- changing tree species composition due to establishment of different forest edge.

More vulnerable are forests with high growing stock and slower restoration of growing stock.

Agricultural land

Wind turbines effect the agricultural land mainly in the stage of construction, namely by destruction of agricultural land or by temporal use restrictions. Vulnerability of agricultural land depends in their potential for agricultural production.

Water resources

Water resources can be affected by emissions from traffic during the installation of facilities and by possible discharges of large quantities of oils, which can contaminate them. Vulnerable are all water resources, among them the most drinking water catchments.

Mineral resources

In the case of mineral resources wind turbines represent only temporary restriction on the potential for exploitation of mineral resources. The installation of wind turbines in principle doesn't affect bedrock.

B.2.3 Impacts on human environment

Visual qualities (landscape scenery)

Landscape scenery can be affected by several types of interventions: changing terrain, changing land cover and especially by mare presence of facilities. Wind turbines are most perceivable in a completely flat area or on hill ridges on fringes of larger plain areas. Vulnerability of landscape scenery depends on its visibility (from settlements, major roads) as well as on its cultural and social values. The more is an area visible, a higher cultural and other social value it has, the more vulnerable it is.

Cultural qualities

Wind turbines can affect the cultural qualities of areas (the affect is larger if there is a recognized cultural heritage category), its identity and symbolic and other values of areas. These effects are somewhat dependent on the visibility of facilities, but they can be also related to merely knowing about the presence of facilities. Areas with greater symbolic and cultural-heritage values are more vulnerable.

Noise

Noise is caused by rotation of blades, causing high frequencies, movement of blades past the tower, causing low frequencies, and by mechanism, especially cogwheels. Produced noise can be particularly disturbing for housing and other accommodation objects (hospitals, nursing homes) and educational institutions. Noise acceptability thresholds are usually attained at a distance of about 250 m from a wind turbine. More vulnerable are areas near existing settlements. Slovenian Decree on noise in the natural and living environment (Ur. L. RS, No. 45/1995) defines 4 levels of protection against noise as well as noise thresholds. Levels are defined according to the sensitivity of a particular area of natural or living environment for noise effects. The most vulnerable are areas of 1st level of protection against noise. These are natural areas intended for tourism and recreation, immediate surrounding of hospitals, areas of health resorts and areas of national parks or nature reserves. The higher is the level, the lower is vulnerability.

B.3 Vulnerability models

Vulnerability criteria are derived from the identified potential impacts on environment. Separate models were prepared for each of the 3 basic protection aims (nature protection, protection of natural resources and protection of human environment). Since the issue of landscape scenery change was considered to be highly relevant, a separate model for vulnerability of visual and cultural qualities was prepared.

B.3.1 Vulnerability of human environment

With the model of human environment vulnerability, impacts due to increase of noise, traffic, and electromagnetic radiation, as well as danger of ruination of constructions were assessed. Noise and electromagnetic radiation are considered most relevant. On the basis of data on emissions, caused by wind turbines, and regulations that determine acceptable levels of noise and EM radiation in the living environment, distance zones from dwellings have been determined.

data	*category*	*eval.*
cultural monuments		
	cultural monument + up to 25 m	5
	25 – 50 m	4
	50 – 100 m	3
	above 100 m	1
outstanding landscapes		
	outstanding landscape	3
	no feature	1
landscape parks		
	landscape park	3
	no feature	1

$\text{Vulnerability}_{visqual}$ =
Visibility (roads + settlements + viewpoints) * WEIGHT

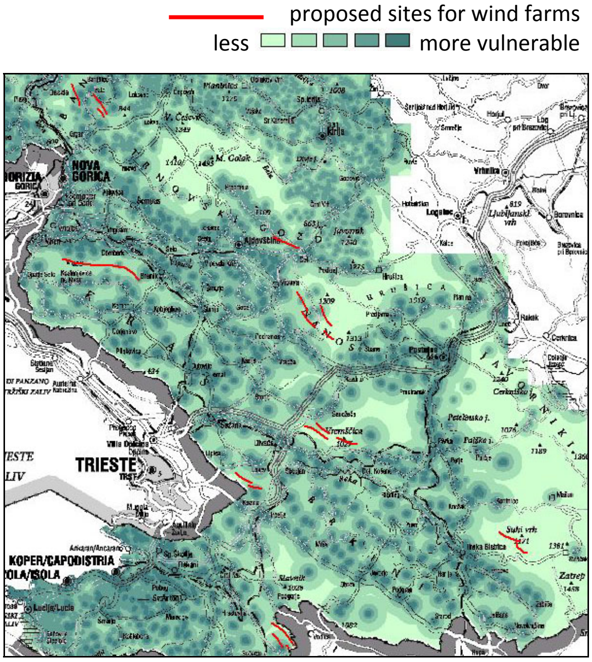


Figure 57: Human environment vulnerability due to wind turbines

More vulnerable areas are densely populated, low-lying parts of the Primorska, which are also less attractive for locating wind farms (figure 57). The proposed sites for wind turbines are located in remote and uninhabited areas, where the vulnerability of human environment is low.

It can be assumed that there will be no serious conflicts due to noise, the possibility of ruination and other direct disturbances to the human environment in the phase of the wind turbines operation. Charging of local roads during the construction and installation of wind turbines, the potential noise, the presence of workers and different machines will be of limited duration so they are also not likely to cause conflicts.

B.3.2 Vulnerability of visual qualities

With the model of vulnerability of visual and cultural qualities, impairment of visual qualities of the landscape and impacts on its cultural-, symbolic-, and identity qualities were assessed. The impacts of wind turbines on the visual qualities of an area are directly related to its visual exposure. A computer program was used to calculate visibility, which tells from how many points / pixels of the selected observation sites (such as major roads, settlements and viewpoints) the individual point / pixel is visible. Another parameter concerns visual priority, whereby the areas, designated as exceptional landscape, landscape park, cultural monument and its surrounding have been given priority. Most visible areas, which are at the same time of high visual quality, are considered most vulnerable.

data	*category*	*eval.*
cultural monuments		
	cultural monument + up to 25 m	5
	25 – 50 m	4
	50 – 100 m	3
	above 100 m	1
outstanding landscapes		
	outstanding landscape	3
	no feature	1
landscape parks		
	landscape park	3
	no feature	1

$\text{Vulnerability}_{\text{visqual}}$ =
Visibility (roads + settlements + viewpoints) * WEIGHT

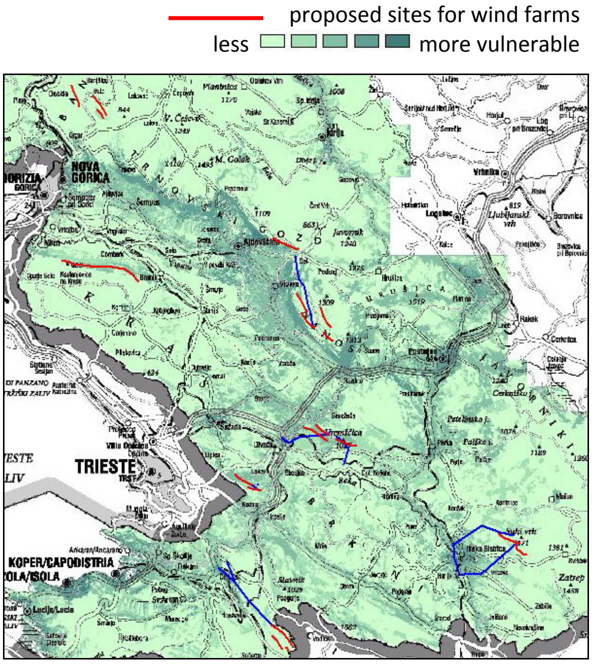


Figure 58: Visual qualities vulnerability due to wind turbines (and overhead lines)

The vulnerability map of visual qualities (figure 58) shows that the areas around the proposed sites are relatively highly vulnerable, because they are visibly exposed and the landscape is of high quality. Nevertheless, due to fragmented spatial vulnerability obtained, there is still enough room for maneuvers left; namely, by paying enough attention when planning the sites in detail, it should be possible to further optimize the proposed sites. As can be seen from the map, most of the proposed sites have already been optimized to a significant extent in this respect.

B.3.3 Vulnerability of natural resources

With the model of natural resources vulnerability, we assess impact on agricultural land, forest, and water sources.

Agricultural land is in principle not very vulnerable, because only small area is directly affected (100 m^2 per pillar). The remaining area may be left in the regular agricultural use. Impacts on agriculture are also caused by access and service roads.

Constructing a wind farm in a forest, this would require large scale deforestation and forest vulnerability would therefore be very high. Because we had no detailed data on quality of forests' timber potential, we evaluated general vulnerability as medium.

Major impacts on the water resources are not expected, however, it is necessary to take into account the risk of oil discharge that could have significant impact primarily on permeable soils. Vulnerability of groundwater aquifers was obtained by combining data on the soil permeability with the data on the presence of aquifers.

data	*category*	*eval.*
agricultural land		
	land is not suitable for agric.	1
	less suitable land for agric.	1
	medium suitable land for agric.	2
	suitable land for agric.	3
	very suitable land for agric.	4
forests		
	timber forest	3
	special purpose forest	3
	protective forest	3
	no forest	1
vulnerability of groundwater aquifers		
	very high vulnerability	3
	high vulnerability	2
	medium vulnerability	2
	low vulnerability	1
	no aquifer	1

In the model, individual vulnerabilities are grouped by following logical rules:
forest + agricultural land: maximum value rule
(forest + agricultural land) + water resource: see matrix below

	forest + agr. land			
water res.	1	2	3	4
1	1	2	3	3
2	2	2	3	3
3	3	3	4	4

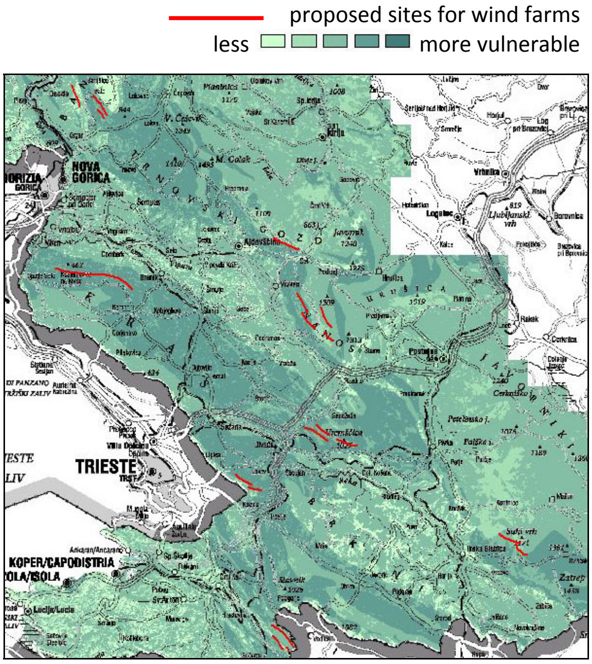


Figure 59: Natural resources vulnerability due to wind turbines

The proposed sites are on the areas with medium to low vulnerability of natural resources (figure 59). The effects of wind turbines on natural resources are generally not big and moreover, they might be mitigated through technical and technological solutions. The vulnerability model points out above all the necessity of such measures in the sites with natural resources of greater quality, for example:

- to prevent polluting substances run-off into the subsoil, water traps shall be constructed in potentially affected areas;
- on agricultural land, the micro location of wind turbines shall be determined in a way that the pillars will not hinder the cultivation, communications within the agricultural lots and similar.

B.3.4 Vulnerability of nature

The model of nature vulnerability includes the following components of the natural environment: geosphere, hydrosphere and biosphere, while major impacts on atmosphere are not expected. All the components are considered to be primarily vulnerable due to potential changes in their natural (conservation) values and to a lesser extent also due to complete destruction of particular parts of the area. Transition zones (buffers) have also been taken into consideration. Data on permanent or frequent stay of animals and on migration corridors was used to asses the impacts on animals' habitats (birds and large mammals). Areas, which are exceptionally naturally preserved, were given higher priority, since the installation of wind turbines would there lead to a greater disturbance of a habitat's natural state.

data	*category*	*eval.*
geomorphologic features		
	peak	3
	ridge	3
	passé	2
	channel	3
	cavity, sinkhole, gorge	3
	no feature	1
erosion areas		
	erosion area of Ist category	1
	erosion area of 2nd category	2
	erosion area of 3th category	3
	erosion area of 4th category	4
	no feature	1
springs		
	spring	5
	distance up to 50 m	4
	distance from 50 to 100 m	3
	no feature	1
flood lands		
	flood land	4
	no feature	1
naturally preserved watercourses		
	entirely naturally preserved w.	5
	distance up to 50 m	4
	distance from 50 to 100 m	3
	partially naturally preserved w.	4
	distance up to 50 m	3
	distance from 50 to 100 m	2
	regulated watercourses	3
	distance up to 50 m	2
	distance from 50 to 100 m	1
	no feature	1
natural preservation		
	largest natural preservation	5
	large natural preservation	4
	medium natural preservation	3
	small natural preservation	2
	smallest natural preservation	1
stagnant waters		
	stagnant water	5
	distance up to 50 m	4
	distance from 50 to 100 m	3
	no feature	1
natural monuments and reserves		
	natural monument or reserve	5
	distance up to 50 m	4
	distance from 50 to 100 m	3
	distance above 100 m	1
nature protection areas		
	regional or landscape park	4
forests		
	timber forest	3
	protective forest	5
	special purpose forest	4
	no feature	1
settlements, highways		
	settlement	1
	highway	1
birds areas		
	most important birds areas	4
	important birds areas	3
	other features	1
migratory corridors of animals		
	migratory corridor of wolf (50m)	5
	zone up to 100 m from corridor	4
	zone up to 250 m from corridor	3
	other areas	1
	migratory corridor of bear	4
	zone up to 100 m from corridor	3
	zone up to 250 m from corridor	2
	other areas	1
	migratory corridor of deer	3
	zone up to 100 m from corridor	2
	other areas	1

The model was calculated by the maximum value rule.

The most vulnerable areas are those where habitats and corridors of different species coincide with well preserved natural areas (figure 60). These areas include the sites, which are according to previous researches important on national or international level as nesting sites or corridors of threatened bird species: the south-west edge of Trnovo plateau, Nanos, the western edge of Snežnik highlands, and a vast part of Kras.

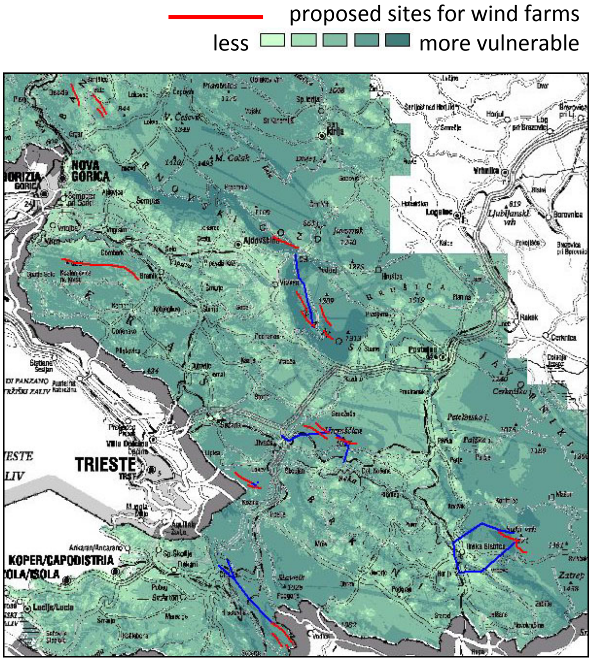


Figure 60: Nature vulnerability due to wind turbines (and overhead lines)

High vulnerability is also shown in the karst areas of dry grasslands on the southern slopes of the Primorska peaks, which are among the most valuable habitats also on the European level. These specific conditions enable the creation of endemic flora and fauna, among which is a large number of very rare and endangered species of meadow plants and insects, including many butterflies. Most vulnerable parts of nature largely coincide with areas that have already been declared a nature protected area or are proposed for it. The importance of this model in relation to protected areas is in hierarchical and spatial fragmentation of actual values.

The map shows that practically all proposed sites lie within the most vulnerable areas.

B.4 Assessment of proposed sites based on vulnerability models

The assessment of proposed sites was based on the presented vulnerability maps as well as on the maps of spatial attractiveness for wind turbines. Maps below show attractiveness of the Primorska region for wind turbines in respect of the two most important types of wind: burja (strong north-east wind) (figure 61) and south-west wind (figure 62). Besides windiness, distance from roads, distance from the existing energy network, and slope were also considered as attractiveness criteria.

proposed sites for wind farms
least attractive most attractive

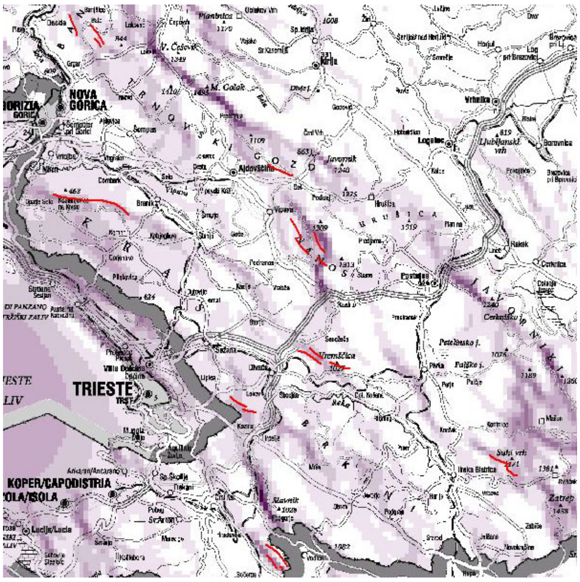


Figure 61: Attractiveness of the Primorska region for wind turbines: burja (strong north-east wind)

Assessment was also based on modeled spatial vulnerability and attractiveness for overhead lines.

The criteria of functionality (i.e. windiness) excluded 3 proposed sites (Bate, Trstelj, and Sinji vrh) at the very beginning of the assessment. The remaining 5 sites that were assessed for their suitability for wind farms are: Nanos, Golič, Kokoš, Volovja Reber, and Slatna (Vremščica).

proposed sites for wind farms
least attractive most attractive

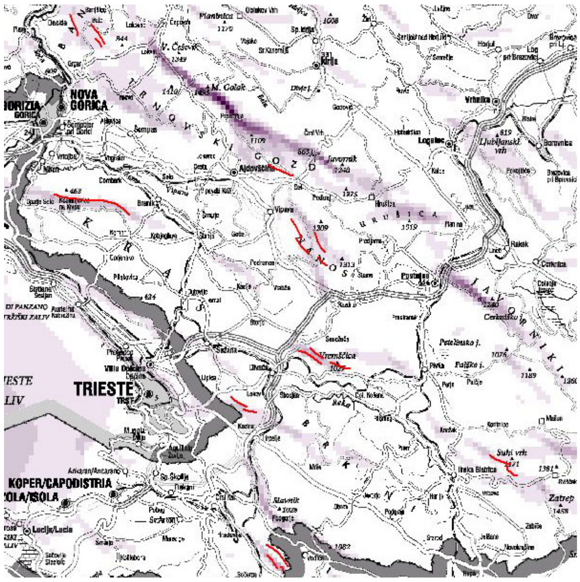


Figure 62: Attractiveness of the Primorska region for wind turbines: south-west wind

B.4.1 Results of proposed sites' assessment

This chapter presents the results of sites' vulnerability assessment according to the individual vulnerability models and (synthetic) results of multicriteria assessment considering the results of vulnerability as well as of attractiveness aspects of the assessment. Each aspect was represented by 4 criteria; attractiveness by infrastructure availability, electro-energetic potential, windiness, availability of space; vulnerability presented by impact on nature, natural resources, human environment and visual qualities (in figure 64 and the following). Each criteria was given a mark on a common 1-10 scale; "1" meaning extremely unsuitable site; exceeding legal thresholds and "10" extraordinary suitable; ideal site with no detrimental impacts.

Nanos

Vulnerability of nature

In terms of nature vulnerability the site Nanos is bad (2). In particular, this applies to both east lines, passing by the steep, naturally preserved areas and close to the border of the regional park. Bad is in particular from the view of the impacts on animals, as it lies in the area of vital importance for bird protection and in migratory corridors. It is also the location of karst dry grasslands with rare and special plant and animal species. Slightly less of a concern is only the extreme eastern line.

Vulnerability of natural resources

The site is assessed as slightly above average (6) in terms of natural resource vulnerability. Significant impacts on forest and agricultural land are not expected since there are only low quality forests and bushes as well as low quality agricultural land on the site. Vulnerability is slightly higher in the areas above the most vulnerable aquifers in the south-western part.

Vulnerability of human environment

Due to its remoteness from human habitation the site was rated favourably (8) in terms of human environment vulnerability.

Figure 63: Wind turbines at Nanos site (photomontage)

Vulnerability of visual qualities

Although the main part of the proposed wind turbines' site is properly withdrawn behind the edge and therefore less visible, some parts of south-eastern line are still very clearly exposed. To withdraw them from the view, they should be moved a bit more inside. Wind turbines would be visible also in both eastern lines. The site was given a medium score (5).

Figure 64: Wind turbines at Nanos site (photomontage)

Joint assessment

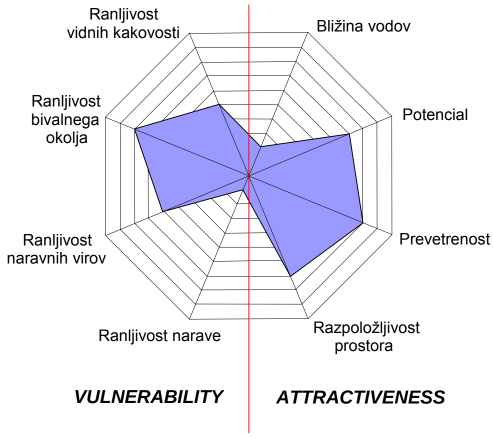


Figure 65: Star chart for Nanos site: right side of the "star" presenting attractiveness criteria: infrastructure availability, energetic potential, windiness, availability of space; vulnerability presented on the left side of the star by: impact on nature, natural resources, human environment and visual qualities (clock-wise).

The attractiveness of the Nanos site is medium. The wind potential is not the best and it would be very difficult to construct access roads and overhead lines without a major effect on the environment. Taking into account also safety restrictions, only a very limited space is then available. In respect of effects on the intact natural environment and on some populations of animals, wolves, bears, and especially birds, the site was assessed as unacceptable.

Golič

Vulnerability of nature

In terms of vulnerability of nature, the site is bad mainly due to its high nature conservation value. The site is also bad in term of the impacts on birds as it is positioned in the core area of the Karst edge, which is of outmost importance for the bird protection. The site is also within the proposed Karst regional park. Overall the site is rated low (3 out of 10) in terms of impact on nature.

Vulnerability of natural resources

In terms of vulnerability of natural resources, the site is not very problematic (7), since it does not involve intervention in either the forests or the high-quality agricultural land. Vulnerability is slightly higher because of the position above the very vulnerable aquifers.

Figure 66: Wind turbines at Golič site (photomontage)

Vulnerability of human environment

Due to its remoteness from human habitation the site was rated favourably (8) in terms of human environment vulnerability.

Vulnerability of visual qualities

On a general level of assessment, the site is favourable in terms of visual qualities (8).

Joint assessment

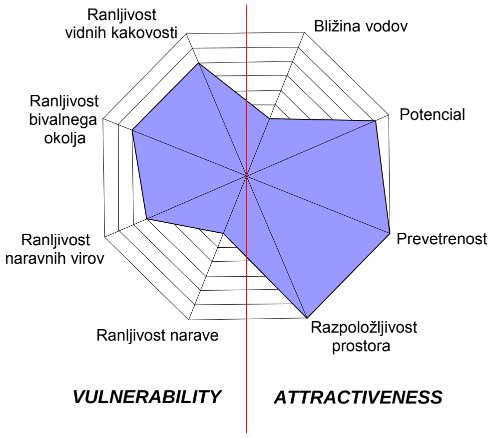


Figure 67: Star chart for Golič site

The Golič site is the best among all sites in respect of attractiveness. It has a lot of energetic potential, good ventilation, and relatively large space available. The only limitation is the difficulty of overhead lines' construction. Regarding vulnerability, the site is less favorable, especially so because the impacts on nature would be big. Namely, the intervention would take place in a very well preserved natural environment with specific and sensitive habitats, shaped by the dynamics of natural processes. Impacts on birds would be noticeable, too. We must also point out the possible effects of overhead lines on visual and cultural qualities of the space; these are otherwise not affected by wind turbines.

Figure 68: Wind turbines at Golič site (photomontage)

Kokoš

Vulnerability of nature

Kokoš is in view of the nature vulnerability least problematic (5 out of 10). Although the vulnerability is high across the area, it does not reach the highest values. The site is not extremely naturally preserved and not very important for birds.

Vulnerability of natural resources

Vulnerability of natural resources is quite high especially in the eastern part of the proposed site. The reasons are primarily the existing forest and a position above very vulnerable (Karst) aquifers. Having regard to the appropriate safeguard measures against oil discharges and considering the lower quality forests, the impacts may be assessed as medium (5).

Vulnerability of human environment

Although the settled areas are closer to this site than to the others, we can expect no significant impacts on human environment. The site can be assumed suitable (mark 7 out of 10).

Vulnerability of visual qualities

Proposed site is at the edge of very visibly exposed area. By moving the wind turbines a bit more south, smaller visible exposure would be reached. This may improve acceptability and score (5) of the site in terms of the impacts on visual qualities.

Figure 69: Wind turbines at Kokoš site (photomontage)

Joint assessment

The Kokoš site is one of the worst in view of energy (small wind potential and poor ventilation, and especially limited space available), but its attractiveness is increased by the facility of connecting to the current network. Moreover, the site is relatively acceptable in respect of space vulnerability, as the intervention would not be big and the effects on environment consequently smaller. Effects on the state of natural preservation and on birds, as well as visible effects and effects on natural resources (especially forest) would be noticeable, but still within the boundaries of acceptability.

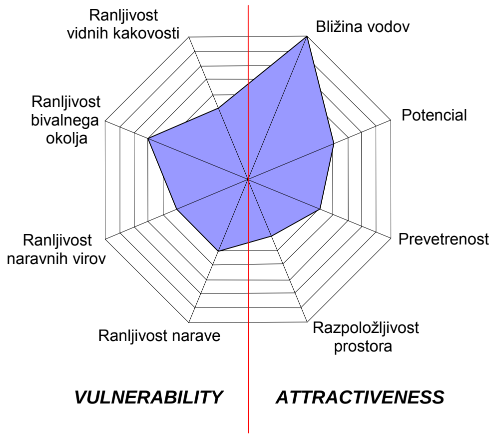


Figure 70: Star chart for Kokoš site

Volovja Reber

Vulnerability of nature

Volovja Reber lies in one of the largest areas of relatively preserved nature in Slovenia, dominated by dry grasslands and forest, which are very important natural habitats of many plant and animal species. The area is of utmost importance for the bird protection and an important corridor for large mammals and has been proposed for nature protection area (Regional Park). The location is therefore bad in terms of the nature vulnerability (2). Shift to the east would make the site more acceptable.

Figure 71: Wind turbines at Volovja Reber site (photomontage)

Vulnerability of natural resources

The proposed site for wind turbines is middle vulnerable (5). The site is mostly outside the forest and the agricultural land is of low quality. The vulnerability is bigger in the southern area, which lies above very vulnerable aquifers.

Vulnerability of human environment

Due to its remoteness from human habitation the site was rated as preferable among the proposed sites (9 out of 10) in terms of human environment vulnerability.

Vulnerability of visual qualities

The southern part of the proposed site is not visible from the major observation points. More problematic is the northern part of the site, which is quite visible. Overall the site was given a rather good mark (7).

Joint **asses**sment

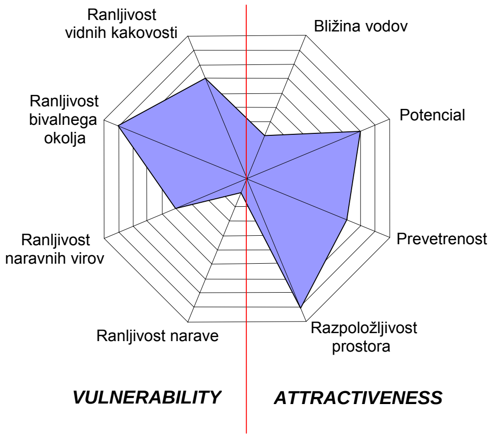


Figure 72: Star chart for Volovja Reber site

Good energy potential and ventilation, together with large space available, make the Volovja Reber a rather attractive site. The difficulty of overhead lines' construction slightly reduces the attractiveness; but, in view of vulnerability criteria, the site performs much worse. Impact is big especially in terms of natural environment including birds.

Figure 73: Wind turbines at Volovja Reber site (photomontage)

Slatna

Vulnerability of nature

The site Slatna is in terms of the nature vulnerability hardly suitable (2). Vulnerability is very high across the whole area; at some points it reaches the highest value. Slatna is naturally well preserved, is an important habitat of flora and fauna, is of great importance for birds and is a part of an important deer migration corridor.

Vulnerability of natural resources

Vulnerability is middle (6). Most of the construction will be on agricultural land, appropriate for extensive cultivation. Vulnerability of the site is higher due to its location over very vulnerable aquifers.

Vulnerability of human environment

The site is not very vulnerable in terms of human environment (8). It can only conflict with the current rather intensive recreational use of the area.

Vulnerability of visual qualities

Of all the proposed sites, wind turbines on Slatna would certainly be the most visible especially the line running over the hill-top. Visible is also the south-west line. The latter could be withdrawn from the most vulnerable position with a shift a bit more north. Both northern parts are slightly less visible. In terms of visual vulnerability, the site scored low (3).

Joint assessment

The Slatna site has got a lot of energy potential, but is less attractive in respect of windiness and space available. Construction of overhead lines would be a very difficult task here. Moreover, the site is vulnerable in respect of impacts on the environment, especially its natural component. Wind turbines would affect animals, especially birds. Among all sites, this one is rated as worst in terms of impacts on visual qualities, as wind turbines, together with the overhead lines, would be very exposed and visible.

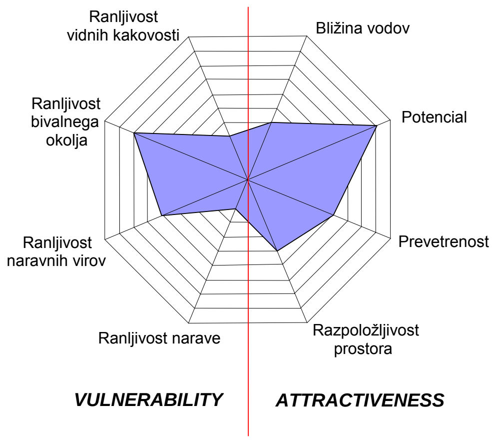


Figure 74: Star chart for Slatna site

Figure 75: Wind turbines at Slatna site (photomontage)

B.4.2 Selected sites

None of the proposed sites performs equally well in terms of attractiveness and vulnerability criteria. Majority are worst in terms of their impact on nature. Out of the proposed sites, Golič and Kokoš sites were found as the most suitable. The Golič site was selected mainly due to its attractiveness for wind farms, while the Kokoš site was selected as acceptable mainly in respect of environmental vulnerability.

Figure 76: Wind turbines at Golič site (photomontage)

Golič

Recommendations:

- On the basis of a more detailed examination (especially botanical), it is necessary to find micro locations that avoid areas with rare plant species.
- It is necessary to review the overhead lines' route in respect of effect on cultural heritage and visual quality of space and, if necessary, change it.
- It is necessary to study in detail the visible exposure of wind turbines and of the overhead lines from the local roads and nearby settlements, and optimize the location if necessary.

Kokoš

Recommendations:

- It is necessary to study in detail the visible exposure of wind turbines and optimize the location if necessary. By shifting wind turbines to the south, the site would become more acceptable in respect of visual quality of the space.
- It is necessary to eliminate the possibility of oil discharge, as the proposed site is above very vulnerable karstic water supplies.
- It is necessary to reduce the effect of (re)construction of roads by carefully planning access roads (change of timberline, excavation works, dump material, felling).

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