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3 Methods And Techniques In Landscape Impact Assessment

3.1 Introduction

Many years of EIA and SEA practice have resulted in the development of a wide range of methods that can also be used in landscape impact assessment. These range from methods and techniques that are applied frequently (such as analogs, checklists, expert opinions, mass balances, matrices and interaction diagrams, overlay mapping, photographs/photomontages or qualitative models), to those that are used moderately (such as decision-focused checklists, indices or indicators, laboratory testing, literature reviews, networks, quantitative models) and to those that are used sometimes only (such as environmental cost-benefit analysis, expert systems, baseline monitoring and field studies monitoring, risk assessment, scenario building, trend extrapolation, etc.).

Given the multidisciplinary nature and understanding of landscape, a lot of professionals including ecologists, geographers, environmental experts, planners and architects, artists, psychologists, economists and others are engaging in studies of landscape assessment and perception. As a result, they have introduced and explored the application of different sets of methods representing their own disciplinary perspectives, contributing to making the literature in this area, extensive and vast.

This chapter introduces and briefly explains the most commonly used methods and techniques in landscape impact assessment. An overview of moderately used methods and techniques is also provided. The type method and technique to use is determined based on the stage of the assessment process, geographical scale, the hierarchical level or the specifics of the assessed development proposal.

The most commonly used methods and techniques in landscape impact assessment include:

- *baseline description, surveys and analysis methods*, which include baseline data and field surveys which allow for the subsequent landscape evaluation and generation of follow-up data for monitoring purposes,
- *impact identification and prediction methods*, which include checklists, visual quality models, integrated landscape management models, landscape-ecology based models and scenarios, multi-criteria evaluation method and landscape ecological stability methodology. These methods also serve as a reference basis for assessing the significance of impacts,
- *impact assessment and monitoring methods* which include matrices and interaction diagrams, criteria, thresholds and indicators,

- *presentation techniques* which have become important in recent practice and are now considered an integral part of landscape impact assessment procedures.

In this chapter, special attention is given to the application of geographic information systems (GIS) as a technique used in all steps of EIA and SEA procedures and at all decision-making levels. GIS as a tool in itself, or as a basis for the application of other tools, can be helpful for analysing, predicting and/or assessing impacts on the landscape. GIS can in effect support the application of visual quality models, overlay mapping, landscape environment management models, landscape ecology-based models, scenario development and other spatially relevant methods. At the same time, GIS can be a very efficient method for presenting the results of a landscape impact assessment process, along with other presentation tools such as maps, photographs, photomontage, videomontage and/or 3D visualization. As a method therefore, it can be considered instrumental for baseline analysis, impact identification and prediction, impact assessment and monitoring, and for presenting information and findings. As such, it makes sense to explore GIS separately, prior to reviewing the other classifications of methods and techniques.

3.2 Geographic Information Systems And Their Assistance In Landscape Impact Assessment

Geographic information systems (GIS) represent a very common tool used in various approaches of landscape impact assessment. Using functionalities of GIS software, it is possible to interpret landscape features and determine real or potential qualitative characteristics of a landscape. Nowadays, GIS can be considered as a carrier of information about landscape, society and their cross interactions. Simultaneously, GIS is also a tool for generating new information, knowledge and approaches for decision - making.

The application of GIS in landscape assessment allows faster and more exact elaboration of outputs and detects interrelations and interconnections between particular landscape units or phenomenon and processes. From a cartographical aspect, GIS technology allows more efficient data processing and visual interpretation.

In GIS the majority of data is related to spatially located objects, patterns, phenomena or processes (Maguire et al., 1991), and are presented in the form of maps, digital images and tables of geocoded data items (Bonham-Carter, 1994). According to Kolář (1997), the term “geographic information systems” is the most often used term indicating a wide spectrum of systems processing the data of a spatial character. Defining GIS requires a systematic and integrative approach. It implies the relation of spatial elements (entities) to the Earth’s surface (geo), their visual (graphic) expression using computer graphics and work with data and

information. It produces a complex, spatially oriented system serving to collect, store, manage, analyse and present spatial data in order to describe and model (simulate) surrounding space as well as to gain new information for the rational utilization of this world.

The most important components of GIS are unequivocally graphic and non-graphic (attribute) data. Other authors also acknowledge the “organizational context” or infrastructure for GIS, which refers to the set of users, supporting elements.

3.2.1 Graphic Components Of GIS

Dynamic objects on the Earth’s surface are expressed in geoinformation systems in the form of static graphic entities. In general, two types of data models can be distinguished, namely vector and raster (see Box 3.1). Within the vector model, three basic types of spatial data are distinguished which are point, line and polygon; within the grid model spatial data is referred to as a grid cell (spatial unit). Grid models (maps) are primarily used to show the area data (continuous fields) expressing dynamic phenomena taking place on the Earth’s surface.

Box 3.1: Raster and vector models of GIS. Source: Authors.

Raster model

The raster model is based on the principle that space is a regular grid divided into single parts – cells (pixels) – representing the smallest, usually indivisible spatial units. Raster is thus a set of cells defined as a matrix or field in n-dimensional place. In order to illustrate geographic objects on the Earth’s surface, we most frequently use the 2- dimensional grid where each cell is defined by a rectangular unit, often by a square. Grids can also have an irregular mosaic of cells, which have various dimensions and geometry, continuously changing in space. A basic cell in a 3-dimensional grid, often used in geology and meteorology, is called a voxel (i.e. 3-dimensional pixel); it may be of a cube or a rectangular parallelepiped shape.

Vector model

Vector data models can illustrate any objects on the Earth’s surface with the help of simplified geometric shapes. Besides the three essential types of graphic entities, some software also uses other geometric shapes – for example, ArcInfo uses, among others, a polyline, arc, circle, ellipse, rectangular object, rectangular object with round corners and so on. The following terms in vector graphics are significant – vertex – representing an inflexion point of a polyline or a polygon; and node – representing an intersection point or a contact point of two entities.

Every vector entity is defined in GIS by its geographic position, geometry and typology. Geographic position is one of the most important attributes in the GIS structure. In a strict sense, it is impossible to consider as GIS what is not unequivocally defined by geographic coordinates.

3.2.2 Attribute (Non-Graphic) Component Of GIS

Every GIS should aim to ensure the interconnectedness of its graphics and non-graphic components. In the majority of vector-oriented GISs, it is possible to join the graphic entities with the tables through mutual relations; this is known as a relational database. When inputting records into the relational database, various attributes (or descriptive data) are attached to the graphic entities. In the grid data structure, numerical values to the smallest allocable units – grid cells, are normally inputted. Numerical values are determined to perform analytical operations within spatial data, and not to archive or manage data on spatially located objects. This is why relational databases are not referred to within the context of a grid data model.

3.2.3 Application Of GIS To Landscape Impact Assessment

The introduction of GIS in impact assessment was driven by the wider introduction and application of computer-based techniques in scientific procedures and practices during the 1970s and 1980s. It is during that time that the first commercially accessible software were put on the market. Since then, specialized software products have been developed, serving among other things, to create information systems utilizable also for the needs of planning and design.

It is possible to use GIS in planning and landscape assessment processes for cartographic presentations, production of geographic databases or as a tool for comprehensive area based analyses and modeling (Goodchild, 2002; Clarke, Parks and Crane, 2000). When elaborating on cartographic outputs to analyze, select, model and assess landscape elements and their interrelations in any structure of landscape, it is advantageous, in terms of efficiency and accuracy, to create a geographic information system as a spatial data model. In this context, the application of GIS to land use planning may be conceived as a projection of map elements with all their characteristics into a spatial information system.

With planning and project design procedures, the whole team of experts from diverse branches, departments or institutions work together. GIS is a platform to which all involved specialists can contribute, share existing databases and interpret information.

When adopting GIS as a method, Chapin and Kaiser (1985) also point out the importance of determining a work programme with individual steps to pursue. They recommend the following steps:

1. to identify the key data to include into a future spatial information system. Such data can be data on land use (recreational areas, industrial zones, residential areas, etc.), environmental data (geological substratum, pedological characteristics, data on inundated territories, types of vegetation growths,

- climatic characteristics etc.), data on the communication and transport systems, demographic data, economic indicators,
2. to determine specific data of particular significance for building an information system (e.g. plots, addresses etc.),
 3. collection of data (primary or secondary),
 4. archiving and updating of data,
 5. conversion of data, database operations and analyses,
 6. presentation of outputs.

The so called Land Information System (LIS) is one of the application possibilities with current GIS, which is utilizable in the processes of area-based comprehensive planning. Another application of information systems is the so-called city information systems (CIS), which is de facto a variation of an LIS. The specificity of a CIS is the object of interest, which is an urban organism, formed by a digital map of the city (DMC) – however this is not merely one map, but a whole set of maps or information layers. The map should be set up in such a way so that it is possible to add descriptive (attribute) data from other subsystems.

The application of GIS to the processes of landscape impact assessment at both project and planning or more strategic levels has increased the possibilities for more effective, accomplished and precise work. The comprehensive information system on the territory represents a strong tool for practical managing, decision-making and planning activities: a territory may be presented in a detailed way from diverse thematic viewpoints; changes in a territory can be monitored and tracked through time, shedding light on potential interdependencies and relations among single phenomena, processes and factors. Owing to that, the quality of research on the spatial structure of territorial units becomes higher.

One of the main GIS functions for landscape impact assessment is to gather data that will result in the creation of a database, where the data can be subsequently manipulated and analysed (Gontier et al., 2010; Majorošová, 2016). Such databases are useful for elaborating land cover maps, topographical maps (digital elevation model or digital model of relief), conservation or protected – areas maps, soil maps, geology maps, climate maps, erosion-accumulation models, models of various natural dynamic phenomena demonstrated in the form of continuous physical fields obtained by the interpolation of input points. In addition, GIS can be used to produce more advanced analysis of outputs, such as connectivity or fragmentation analysis at different scale levels as well as the production of ecosystem and biodiversity maps (Mörtberg, 2004).

Collecting data of different character through an information system can provide a range of advantages. For instance, if one was looking for data about a specific concrete lot, it would be sufficient to input the lots' details, with GIS then providing information about the zone in which the lots are included, the lots' proprietors, the planned utilizations etc. The created database may be always updated, allowing

for the continuity of works into the future, and into future planning exercises. An inseparable part of GIS is formed also by the production of prognostic models serving to evaluate expected situations in the future.

In the context of planning and design, landscape visual quality assessments are sometimes considered not important because they lack substantial evidence or because of the level of subjectivity inherent in this type of assessment. In this context, a GIS-based land use map or 3D landscape model might be used to emphasise the aesthetic changes in an environment or landscape, strengthening therefore the evidence-basis of a visual quality assessment. Moreover, land use maps and 3D landscape models can be used to measure landscape quality, replacing to a certain extent, the need to use real images.

A GIS system can be used for landscape evaluation and advanced geographic analysis (geo- processing) as well as for the creation of thematic maps such as gradient of relief, micro-catchment – contributing areas, length of the slopes, vulnerability to water erosion, etc... (see Fig.3.1 and 3.2).

Figure 3.1: Slope orientation – important characteristic for assessment of visibility objects in landscape. Source: Pauditšová (2007).

The development of information technology makes it possible to continuously improve the models created. Using them we can better express and describe certain phenomena, relationships, structures, systems and/or components of the real world. Models are transformed from a 2D plane into a three-dimensional understanding, thus increasing human imagination and consequently, the level of decision-making in a landscape-based environmental assessment. 3D modelling has over the past 15 years advanced from a purely visualization tool into a multipurpose tool that is being used in land use planning. At present, landscape models in 3D are understood to be intelligent tools with an enormous database of information. The standardization of 3D geographic information systems highlights the importance of sharing information

as well as the use of semantic information in the creation of a representation of environmental objects such as buildings, greenery, water elements and others (Aien et al., 2013; Gröger and Plümer, 2012; Zhu et al., 2011; Macura et al., 2016; Ivan et al., 2016).

Moreover, 3D visualisation technologies offer the potential for comparing impacts between different development scenarios or alternatives as required in landscape impact assessment processes. They are powerful tools that can be helpful for consultation and communication purposes in assessment processes (LI and IEMA, 2013).

Figure 3.2: Micro-catchment areas – an example of an analytic map for landscape impact assessment within EIA/SEA processes. Source: Pauditšová (2007).

3.3 Baseline Description, Surveys And Analysis

In landscape impact assessment the actual (existing) condition of nature and the landscape is determined and assessed based on legal and functional objectives and standards. In order to do so, a lot of data and information about landscape is necessary and surveys are therefore undertaken.

The aim of a baseline description is to identify the current state of a landscape; the data collected will then form the basis against which the landscape and visual impacts are assessed and monitored (Thérivel and Partidário, 1996). The level of detail should be appropriate to the scale of the proposed project or plan and to the stage of the assessment process. Furthermore, the baseline description will vary according to the planning tier and the availability of appropriate data (LI and IEMA, 2013; Thérivel and Partidário, 1996).

The risks of getting lost in the endless options available to acquire information and collect baseline data, therefore spending unnecessary time and resources, are quite real. What information is needed as well as by when and by whom are useful “check” questions to address before embarking on data acquisition. Another aspect

to consider is that the process of collecting baseline data needs to take into account the uniqueness of each landscape, and it should facilitate the identification of those features that give a locality its “sense of place”.

Experience to date has shown that baseline data commonly included in statements and more generally, taken into account in assessment exercises, aim to describe the performance and function natural resources and the balance and relationship between nature and landscape. Examples of datasets commonly adopted in landscape baseline studies are presented in Box 3.2.

Box. 3.2: Example of a data set useful for landscape baseline studies. Source: Authors.

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- a) relevant legal and planning framework** – this is an essential starting point for most landscape management activities
 - b) landscape framework documentation** such as Landscape Character Areas (LCA), Landscape Heritage Assessment (LHA) or landscape plans at all planning levels – these provide the framework reference based on which the analysis and prediction of landscape and visual impacts can be easier
 - c) functional characteristics of the territory** – location components (siting, accessibility, geographical context); geo-morphological components (relief structure, hydrological system, topography, geology); bio-physical components (soil, climate, vegetation and associated habitats, wildlife and ecosystems); socio-economic components (settlements, infrastructure networks, land use, demographics, economic activities and flows); historical and cultural components (built and land-based heritage, land ownership, land custodians)
 - d) perceptual dimensions** – visual and other sensory aspects (patterns of landform, lines, structures, colours), perceptual aspects (scales of perception, points of observation), values (involvement of local communities); specific potential receptors of landscape and visual impact (important components of landscape, visitors, residents, travellers through the area, other groups and viewers)
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Baseline information is often available and provided by environmental authorities, nature conservation organisations and planning authorities; it is normally based on pre-existing data and field work, and collected and analysed via desk-study exercises. Additional data is collected through specific field surveys, with the data then collected made available in both text and map formats (see Fig.3.3).

Figure 3.3: An example of biotope map. Source: Belčáková (2011).

3.4 Impact Identification And Prediction Methods

3.4.1 Checklists

Checklists have been described as an ad-hoc method (Sadar, 2006), within which, prescribed lists of parameters are used. The potential benefits of checklists are (Sadar, 2006):

- to apply a simple method for identifying relevant environmental factors for consideration in both, EIA and SEA,
- to encourage discussion during early stages of the assessment process.

Checklists may range from a simple list of environmental factors (see Tab. 3.1) to a list that incorporates mathematical modeling. An exhaustive approach should be followed to ensure that the list of factors included is as comprehensive as possible. Different types of checklists exist that fulfil different purposes, from those that aim to describe and identify impacts to those that aim to support decision-making. Decision-focused checklists represent lists of environmental factors, including information on measurement, impact prediction and assessment. They are useful for the comparative evaluation of alternatives, and can be used for ranking environmental factors and associated impacts in order of importance. They provide a basis for selecting the preferred course of action.

The checklist presented in Table 3.1 represents the outcomes of expert judgement on the hierarchy of objectives under SAPARD Plan. The actual environmental assessment has been conducted at two levels: a) the general objectives and the specific objectives of SAPARD Plan b) the specific objectives and the measures of SAPARD Plan. From the table below it is evident that priorities of SAPARD Plan and appropriate measures are drafted in a cohesive and coordinated way as far as concerns the environmental factors.

There are also limitations when using checklists. For example, checklists are unable to discover interdependencies, connectivities or synergisms between interacting environmental components, nor are they able to describe variations in environmental conditions. Furthermore, they do not provide information on specific data needs (Belčáková, 2008), and are highly subjective.

Table 3.1: A simple checklist example taken from the SEA of Slovak National Plan for Agriculture and Rural Development under SAPARD. Source: Belčáková (2000).

1. Correspondence between the general and specific objectives of the Slovak National Plan for Agriculture and Rural Development		
General objectives	1. To help the creation of competitive agrifood sector, capable of full integration and operation in the EU area in a developed multifunctional agriculture.	2. The improvement of the quality of life of the rural population, provision of a sufficient number of jobs and adequate income even for agricultural less favoured regions (need for ecological approach and sustainable development of rural areas).
Specific Objectives		
Priority No.1		
1. By supporting investment in technologies, to achieve restructuring and enhance efficiency in agricultural production	+++	
2. To ensure further development of individual branches of the food industry with conditions valid in EU	+++	++
3. To support the establishment, formation and simplification of administrative operations for producer groups	++	+
Priority No.2		
4. Preserve and improve the balance of economic opportunity and social conditions for the rural population	+++	+++
5. Development of economic and environmental functions of forest management in rural areas	++	+++
6. to acquire sufficient experience to be able to prepare an agri-environmental programme and to deliver management training through five pilot projects	+++	+++
7. Development and implementation of land consolidation projects	+	+++

General objectives	1. To help the creation of competitive agrifood sector, capable of full integration and operation in the EU area in a developed multifunctional agriculture.	2. The improvement of the quality of life of the rural population, provision of a sufficient number of jobs and adequate income even for agricultural less favoured regions (need for ecological approach and sustainable development of rural areas).
Specific Objectives		
Priority No.3		
8.To provide farmers with and others with necessary skill by training in different spheres relevant to agricultural and rural development	+++	
9.To support the process of alignment of the farming sector and rural areas, interactive programming and planning including territorial planning and preparation of studies for farmers and rural areas	+++	

Level of correspondence: +++: High ++: Medium +: Low

1. Correspondence between the specific objectives and the measures of Priority 1			
Specific Objectives Measures	1. By supporting investment in technologies, to achieve restructuring and enhance efficiency in agricultural production	2. To ensure further development of individual branches of the food industry with conditions valid in EU	3. To support the establishment , formation and simplification of administrative operations for producer groups
Measure .1.	+++	++	
Measure .2.	+++	+++	+++
Measure .3.	+	++	+++

2. Correspondence between the specific objectives and the measures of Priority 2

Specific Objectives Measures	1. Preserve and improve the balance of economic opportunity and social conditions for the rural population	2. Development of economic and environmental functions of forest management in rural areas	3. to acquire sufficient experience4. to be able to prepare an agri- environmental programme and to deliver management training through five pilot projects	4. Development and implemen- tation of land consolidation projects
Measure 4	+++	+		
Measure 5		+++		
Measure 6			+++	++
Measure 7	+++	+	+	+++

3. Correspondence between the specific objectives and the measures of Priority 3

Specific Objectives Measures	1. To provide farmers with and others with necessary skills by training in different spheres relevant to agricultural and rural development	2. To support the process of alignment of the farming sector and rural areas, interactive programming and planning including territo- rial planning and preparation of studies for farmers and rural areas
Measure 8	+++	
Measure 9		+++

Level of correspondence: +++: High ++: Medium +: Low

3.4.2 Visual Quality Models

Numerous models have been developed to evaluate visual landscape quality. Visual landscape quality assessment are conducted by professionals from many disciplines, and as a result, different models have emerged (Daniel and Vinning, 1983), which can be classified in different ways. For example, Briggs and France (1980) make reference to *direct and indirect* methods. *Direct* landscape evaluation consists of analyzing and describing a set of landscape features, in order to obtain a value representing the total scenic quality, obtained by the sum of the parts. Regardless of the skills and knowledge of each observer, it is commonly accepted that landscape quality derives from the interaction between a landscape's biophysical characteristics, the perceptive processes and the experiences and knowledge of the observer (Loures et al., 2015; Canter, 1996). According to Mazure and Burley (2005), integrated landscape assessments, which take into account aesthetic, economic and ecological variables, show that there is a direct relationship between the different characteristics and components of a landscape. In *indirect* landscape evaluations, the demand for and use value of a specific environmental amenity is used to assess the quality of a landscape, giving landscape an economic value which in turn informs the development of effective management policies.

Arthur (1977) split models into *descriptive inventories and public preference models*, with both categories being further split into non-quantitative and quantitative models. In this context, non-quantitative models refer to descriptive models where relevant information is utilised to address the implications of actions that can result in changes to environmental components. Quantitative models are represented by mathematical models that are used specifically for addressing expected changes in environmental media or resources. They range from simplified to very complicated models (for example three dimensional computer-based models) that may require extensive data input. In most cases, models are used for the description or prediction of changes in properties of the system over a time period. Quantitative modeling is most effective when environmental factors are easily quantifiable, so that they can easily be assigned a mathematical value.

Descriptive inventories include ecological and formal aesthetic models, which are mostly applied by experts in an objective manner. *Public preference models*, such as psychological and phenomenological, are often undertaken using questionnaires, and are unavoidably linked to seeking consensus among the public. Quantitative holistic techniques use a mixture of subjective and objective methods and include psychophysical and surrogate component models.

It is important to examine the reliability and validity of visual quality assessment models and to identify any assumptions central to the models. Internal and external validity are of concern in the development of any landscape visual assessment system. External validity reflects, in part, how well the system-generated assessments correspond to other known measures of visual quality. Internal validity reflects how

well the system's internal logic withstands testing and violation of assumptions (Buhyoff et al., 1995).

Arthur (1977) and others (Jacques, 1980; Hamill, 1985) have summarized the following methodological problems when using the above mentioned models:

- numerical ratings of landscape beauty represent people's preferences for a landscape and/or people's judgements of scenic beauty of a landscape. While public preferences tend to give a measure of "value" of a landscape, "quality" is discerned through judgement. When asked to indicate their preference for various landscapes, observers tend to apply criteria for use of those areas (recreation, residence, etc.) rather than for the landscapes' inherent beauty,
- some persistent errors in the evaluation of landscape: incorrect use of numbers derived from place in a classification; incorrect use of numbers to stand for words; use of spurious numbers in simple mathematical operations; use of incorrect data in complex mathematical and statistical operations; use of data that does not satisfy requirements of the model; use of numbers to support, derive, or demonstrate meaningless, spurious or useless concepts; and use of concepts without adequate operational definitions.

3.4.3 Integrated Landscape Management Models

Integrated landscape management models identify how land and natural resources are used, and the demands for future land and resource use. They aim to help ensure the protection of the landscape (environment) and the fulfilment of developmental needs. This implies that all possible land use options must be considered. An example of integrated landscape management model is LANDEP, i.e. the landscape ecological planning model, recommended by *Chapter 10 of Agenda 21*. LANDEP aims to facilitate the integration of environmental components such as air, water, land and other natural resources (UNCED, 1992), into plan-making, so that the conservation of valuable habitats in defined areas is ensured and appropriate nature management activities can be established for these sites. LANDEP's essential objective is to propose an ecologically optimal spatial organisation of territory, utilisation and protection of landscape.

The LANDEP methodological procedure consists of the following steps (Miklós, 1995):

1. Landscape-ecological analyses

The principal objective of analyses is to select, quantify and describe the main properties of abiotic, biotic and socio-economic complexes determining the landscape-ecology basis and spatial organisation of existing land uses. These include conducting analyses of:

- geomorphologic, geological, hydrological, soil and climatic conditions, thus of properties of the abiotic complex of a territory,

- fauna and flora and of their respective conditions, thus of properties of the biotic complex of a territory,
- socio-economic activities, including their positive and negative influences, thus of properties of the socio-economic complex of a territory.

The outcome of this step is the elaboration of a set of cartographic representations concerning the characteristics of the of abiotic and biotic properties and of the socio-economic elements in a given territory.

II. Landscape-ecological syntheses

Landscape and ecological syntheses are based on the superimposition of selected indicators regarding abiotic and biotic properties and socio-economic complexes in the territory. The aim of the syntheses is to create homogeneous areas characterised by various combinations of abiotic, biotic and socio-economic indicators, known as integral geosystems.

III. Landscape-ecological interpretations

The outcome of this step is the creation of functional landscape indexes, which can be divided into four fundamental groups:

- localisational (technological-abiotic) indexes – resulting from the interpretation of physical conditions for the realisation of different activities,
- selective (ecological-biotic) indexes – resulting from the interpretation of different aspects for the maintenance of ecological stability and biodiversity of a landscape, and for the maintenance of nature and natural resources,
- realisational (socio-economical) indexes – resulting from the interpretation of aspects expressing the active influence of human activities on the environment and various aspects of environmental care,
- indexes of human requirements, including different priority categories – resulting from the interpretation of society's demands on the use of a territory.

IV. Landscape-ecological evaluations

This step represents a comparison between the values of landscape indexes and the requirements of and for human activities. The process of ecological evaluations consist of the following steps:

- determination of the functional suitability values (especially ecologically limited and determined values) of individual indexes for each human activity,
- determination of the weighted coefficients of individual indexes for each human activity,
- determination of the total suitability value of each geosystem for each human activity.

V. Landscape-ecological propositions

This step aims to propose a landscape-ecologically-optimum of the spatial organisation and utilisation of landscape. The ecological propositions cover two aspects: aspect of spatial organisation expressing an optimum land use; and the technological aspect expressing the application of landscape-ecology technologies used in a landscape. The result is a proposal for the spatial and functional optimization of a given area and the determination of measures ensuring the appropriate utilisation of territory from a landscape-ecological viewpoint.

In addition to the methodological steps, LANDEP is typically complemented by a series of maps:

- map of landscape-ecological complexes i.e. homogeneous landscape-ecological units of spatial and functional land use,
- map of environmental problems i.e. specification and identification of environmental problems resulting from stress factor effects on nature, on natural resources and on the environment,
- map of alternative ecological selection. A set of feasible activities is defined for each area, i.e. of activities that are not limited by landscape-forming components,
- map of ecologically optimal land use, representing the ideal activities for a given area including the ecostabilizing measures.

Figure 3.4 below expands on these points and provides a simplified and general flow chart of LANDEP

Overall, LANDEP is considered an essential tool for sustainable land use because it regulates socioeconomic development with natural, human, cultural and historical landscape potential. Based on an analysis of territorial conditions, it proposes the best possible ways for territorial exploitation/land use; it secures a respectful use of nature, of natural resources, and the conservation of biodiversity and the support for ecological stability. The decision-making process informed by LANDEP is based on matching the offer of resources within a given territory with the demand for growth and development expressed by communities. Any discrepancies between an offer and demand, signify not only a lack of respect for landscape resources, including their properties, but also the rise of both, environmental and human problems.

Figure 3.4: LANDEP Sheme. Source: Miklós (1995).

3.4.4 Landscape Ecology-Based Models And Scenarios

A number of landscape-ecology based models have been developed and are applied in landscape impact assessment. Though not exclusive to GIS applications, when combined with GIS, landscape ecology based models and scenarios have opened up new possibilities for qualitative and quantitative predictions for analysing and predicting impacts on biodiversity, habitat loss and other ecosystem services. Their practical application “translates into practice certain concepts of landscape ecology related to ecological dynamic or spatial and temporal scales” (Gontier, 2006, p. 345-346). Gontier further argued that landscape ecology based models can serve as a platform for integrating other spatial landscape components, including recreational and cultural components.

When applied within the context of a GIS, landscape ecology models can be used for analysing land change, including vegetation growth and land uses changes (Izakovičová et al., 2017). Further, these models can be used for analysing habitats, including the prioritisation of biodiversity components taking into account aspects of habitat suitability and landscape connectivity (e.g. Gontier et al., 2006; Hepinstall et al., 2008). They can also be used for analysing neighbourhoods or specific localities, by taking into account different types of human activities within landscape, such as recreational local uses.

The development of landscape ecology-based models, such as habitat distribution models and biodiversity assessment models, are relevant for landscape impact assessment (Guisan and Zimmermann, 2000; Lehmann, Overton and Austin, 2002) because they are precise, ecologically sensible, interpretable, generalisable and fully data defined, and can be expressed in a spatial framework. According to (Mörtberg, 2004), their predictive nature establishes a relation between species occurrences and environmental variables in an attempt to characterize habitats suitable for specific species. In more detail, following Gontier’s (2006) review, Habitat Suitability (HS) models are applied mainly to individual species but can also be applied at the community level (US Fish and Wildlife Service, 1981). Other habitat-suitability methods includes the Generalized Linear Model (GLM) and the Ecological Niche Factor Analysis (ENFA) (Hirzel, Helfer and Metral, 2001) using empirical data. Verboom et al (2001) have introduced an approach combining species-distribution data, population-viability analysis and landscape indices using the Landscape Ecological Analysis and Rules for the Configuration of Habitat (LARCH) decision-support system. Another type of expert based ecological model is represented by the Landscape Ecological Decision and Evaluation Support System (LEDESS), developed for the evaluation of development scenarios at the landscape level (Knol and Verwilt, 1999).

Problems and limitations to the implementation of ecological modeling, whether with GIS assistance or not, are associated with issues of data accessibility. It is in response to this limitation that Gontier (2006) advocates for more open and technically easier access to existing data as well as for the harmonization of databases at the

national and international levels. Another obstacle relates to the reproducibility and robustness of ecological modeling for its further implementation in planning and assessment procedures (Goodchild, 2002).

3.4.5 Multi-Criteria Evaluation Method

GIS-based impact prediction models and techniques allow not only the integration of scientific knowledge of the planning process, but facilitate also a priority setting of development proposals for planners and stakeholders. For this purpose, a suitable tool is represented by *spatial multi-criteria analysis (SMCE)*, which includes a family of techniques to identify and compare solutions to a spatial problem based on the combination of multiple factors that can be represented by maps (Malczewski, 1999). This method takes advantage of both the capability of GIS to manage and process spatial information and the flexibility of SMCE to combine factual information (e.g. fragmentation, indicators) with value-based information (e.g. expert opinion, quality standards, participatory surveys). Taking into account both factual elements and people's values and perceptions is essential to identify options for building consensus around a decision and for reducing conflicts.

Geneletti (2005) noted that there are limitations on the practical use of multi-criteria evaluation methods because they focus on description, discussion and measurement of indicators but rarely link to a value judgement that can be directly utilised by planners and decision-makers. In this context, the author suggests making better use of expert opinions so that once collected they can be formally linked to the output of the spatial analysis. The author further suggests that indicators and scientific knowledge should be intelligible to strengthen the evidence-basis and potential impact of landscape ecological assessment (ibid).

3.4.6 Landscape-Ecological Stability Method

The ecological stability of a landscape as a whole, is one of the key concerns of landscape ecology-based impact assessment. It is generally agreed and accepted that species and/or communities of species can become threatened and their ecological functions impaired or rendered impossible if their living conditions are unfavourable or if they are *spatially isolated* (e.g. Odum, 1975). It is therefore paramount that suitable living conditions and *spatial interconnectivity* between ecological systems is maintained.

To survive, humans need a variety of ecosystems, which include stable, insufficiently stable and unstable man-made, modified agro-ecosystems, as well as newly created systems with settlements, transport and industry. These are present in specific areas of the landscape in the form of elements of landscape structure

(land cover) resulting from the exploitation of territory (hereinafter “the elements of current landscape structure – CLS”). The goal is to preserve the ecological stability of the landscape as a whole, despite the presence of differently stable - including unstable - elements of land cover. The prerequisite for maintaining such “stability”, in addition to the *internal ecological quality* (stability) of the most stable elements of the CLS, is maintaining the *interconnectivity* across territories (as a whole). Naveh and Liebermann (1993, p.8) argue that “we want to achieve a landscape which could be locally unstable, but globally stable”. It is clear that this goal cannot be achieved by simply protecting isolated ecosystems, but it can be achieved by instituting a spatial system of interconnected, ecologically stable elements of the CLS.

The starting point and basic criterion for assessing the spatial stability of a landscape is the *internal ecological quality – stability of ecosystems*. Ecological stability is defined differently by different authors. One acceptable definition is “the ability of ecosystems to persist during the action of disturbance, to keep and reproduce their essential characteristics under conditions of interference from the outside” (Míchal, 1992, p.26). This ability expresses *resistance*, i.e. minimal changes during the operation of disturbance or resilience, including the ability to return to the baseline condition. *Spatial ecological stability of a landscape* is therefore a dynamic measure of the ability to maintain the current landscape structure, of both vertical and horizontal ecological relations, at an acceptable conventional (model) level, even if the landscape is formed by various ecosystems with low levels of ecological stability. Preserving the spatial ecological stability of the landscape is *the purpose of creating ecological networks*.

Spatial ecological structure is often considered the core scope of landscape ecology. Many authors have conducted research into spatial relations of ecosystems, including the spatial arrangement and spatial impact of ecosystems on their surroundings. These investigations strive to demonstrate the significance of ecologically stable landscape elements and their spatial influence. Spatially interconnected, ecologically stable landscape elements are generally referred to as *ecological networks*. The theory of island biogeography (MacArthur and Wilson, 1967) later developed by Opdam et al. (1995) and Hanski (1999) in the metapopulation theory, provides a theoretical basis for forming views addressing the issue of habitat fragmentation and the concept of ecological networks.

The metapopulation theory deals with the behaviour of the populations in the landscape with fragmented habitats inhabited also by smaller subpopulations. It treats basic demographic trends (natality, mortality, migrality, etc.) as indicative monitoring characteristics of each population. Furthermore, it emphasises the importance of communication between subpopulations and considers the possibility of replacing locally extinct subpopulations. Metapopulation theory also addresses the necessity of preserving or restoring interconnectivity of landscape elements in the anthropogenic landscape.

The fragmentation of habitats affects various types of organisms differently. The metapopulation theory explains the impact of fragmentation on different populations. Increasing anthropogenic pressure in fragmented agricultural landscapes, for example, can result in reduced size and quality of patches and increased resistance to the colonisation of new species (eliminating of hedgerows), which consequently upsets the balance between the rate of extinction and recolonisation, to the extent where, on average, fewer patches are colonised. As the proportion of empty patches grows, the probability of species subsistence decreases. Current trends and research confirms the relevance of the theoretical basis for the concept of ecological networks in the landscape.

Forest fragments in farmland or isolated wetlands may be considered pseudo-islands, as they are governed by rules that are similar to those that govern true islands. In addition, the size of a natural element, shape or even distance from the nearest similar habitat and species diversity contribute to likening forest fragments in farmland or isolated wetlands to true islands. The surrounding landscape also plays an important role as it is prone to change induced by anthropogenic activities. The theory of island biogeography aims to quantify these relations. One of the major factors affecting species diversity of true and pseudo-islands is the size of the habitat fragment (direct correlation) and the degree of isolation (inverse correlation). Ecological networks are designed to preserve the minimum area required for survival of natural communities or target vulnerable populations and mitigate the isolation effects resulting from the isolation of landscape elements in the anthropogenic landscape, for example, by means of designating biocorridors, and, in extreme cases, by technical solutions, such as ecoducts.

Evaluating the stability of landscape structure elements (land cover) means taking into account the variety and arrangement of elements and the strengths of their internal links. The higher intrinsic environmental quality an element of the CLS has based on its biological, ecological, as well as other utilitarian functions, the higher is its ecological quality, and the larger is its positive influence on the area, for example having higher water-retention, anti-erosion, filter capacity, higher protective, hygienic, aesthetic functions. In order to express landscape ecological stability, several methodological approaches are used in practice (e.g. Löw., 1995; Míchal, 1992). Most of these approaches are based on *calculating the coefficient of ecological stability (CES) as a numerical indicator using a specific formula*. According to this formula, landscape elements can be classified into five different degrees of ecological stability (Pauditšová and Reháčková, 2007):

- 1st degree: without importance (e.g. built-upon areas and roads with asphalt or concrete surface),
- 2nd degree: minor importance (e.g. large-block fields, intensive vineyards, hop-growing, etc.),
- 3rd degree: medium importance (this is attributed to intensified meadows, extensive use of permanent crops, etc.),

- 4th degree: high importance (e.g. extensively used grassland, mixed forests, etc.),
- 5th degree: very high importance (especially indigenous and natural forests, natural herbaceous communities, wetlands, peat bogs, rivers and areas with natural bottom and sides characteristic of the aquatic and riparian communities).

By processing the classification of the ecological quality of each component of the area's CLS, ecologically important segments of the landscape can be identified. Subsequently, the overall ecological stability can be calculated to establish the coefficient of ecological stability (quality) of the territory (Pauditšová and Reháčková, 2007):

$$C_{ES} = \sum_{i=1}^n \frac{a_i \cdot D_{CLS_i}}{a}$$

where: C_{ES} – coefficient of ecological stability of the area of interest,
 a_i – total area of individual types of elements of landscape structure (ha),
 D_{CLS_i} – degree of ecological quality of the i-th element of CLS,
 a – total area of the area of interest (ha),
 n – number of elements of landscape structure in the area of interest.

An example of areas of individually mapped elements of the CLS, their degree of ecological quality (D_{CLS_i}) and the coefficient of ecological stability of the territory (C_{ES}) are presented in Table 3.2. The presented figures come from a case study in Myjava in Slovakia and they represent the coefficient of ecological stability calculation based on the above presented formula.

Table 3.2: Areas of individual elements of CLS in the study area and the relevant values of CES.
Source: Pauditšová and Reháčková (2007).

Elements of CLS	Area [ha]	Ci	CES
Forests	0.3315	3	0.002
Arable land	564.9226	1	0.912
Permanent grassland areas	22.2802	3	0.108
Gardens	0.3409	2	0.001
Water areas	4.5126	2	0.015
Built-up areas	4.4822	1	0.007
Other areas	22.525	2	0.073
Total	619.395	-	1.117

Based on the above, the value of C_{ES} , was calculated which in the example provided in Table 3.2 had a value of 1.117. According to Table 3.3, this corresponds to a landscape *with very low ecological stability* (see Tab. 3.3). In the case of the example provided, this value is caused by a high proportion of arable land and a small proportion of eco-stabilizing elements in the area of interest. What might be the implication of this, is that management measures aimed at improving the quality of the area should be recommended.

Table 3.3: Interpretation of C_{ES} and degrees of ecological stability. Source: Pudítšová and Reháčková (2007).

Assessment of landscape	Coefficient of ecological stability	Degree of ecological stability	Ecological measures
Landscape with very low ecological stability	1.00 – 1.49	1	high need to implement new eco-stabilizing elements and eco-stabilizing management measures
Landscape with low ecological stability	1.5 – 2.49	2	need to implement new eco-stabilizing elements and eco-stabilizing management measures
Landscape with medium ecological stability	2.5 – 3.49	3	conditional necessity to implement new eco-stabilizing elements, or application of appropriate management measures
Landscape with high ecological stability	3.5 – 4.49	4	implementation of appropriate management measures
Landscape with very high ecological stability	4.5 – 5.00	5	implementation of maintenance management

As illustrated in Table 3.3, when the particular degree of ecological stability is attributed to individual elements of the current landscape structure, it is always necessary to take into account the actual species composition of the vegetation, which reflects the quality of vegetation cover. Then, a proposal of general measures to increase or maintain the ecological stability of landscape can be determined.

Generally speaking, this approach for determining the coefficient of ecological stability is similar to that developed by other authors, albeit with some differences. For example, Löw (1995) follow the same principles but their five degrees of ecological stability are 1) degraded; 2) disturbed; 3) balanced; 4) landscape with predominant natural components; and 5) natural landscape. Michal (1992) evaluates the ecological stability of a landscape according to the ratio of relatively stable and unstable areas, with four categories of ecological stability being defined according to the level of disruption of landscape natural components. Jurko (1985) and Miklós (1990) use the landscape-ecological significance of landscape components for evaluating the ecological quality of a landscape. The input data for calculating the coefficient of ecological stability are the data on components of the CLS and the coefficients of landscape ecological significance of components of the CLS. The calculation of the

coefficient of ecological stability is based on four degrees, illustrating a low, average, high or very high landscape ecological quality.

3.5 Impact Assessment Methods

3.5.1 Matrices And Interaction Diagrams

Matrices usually take the form of a grid diagram or of a two-dimensional table for cross-referencing a list of actions with environmental impact parameters. Activities associated with various phases of a project or strategic action can be listed along one axis, with environmental components listed on the other. Inputs into a matrix can either be qualitative or quantitative. The simplest matrices indicate only the occurrence of an impact without any references to magnitude or significance (see Fig. 3.5). In more sophisticated matrices, quantitative estimates of impact magnitude and significance can be combined with a weighting scheme, leading to an “impact score”. The advantages of using matrices have been described by Sadar (1996), and include:

- a visual description of the relationship between two sets of the proposal being assessed,
- an identification of the impacts of different phases of a project or strategic action,
- an identification of separate site-specific impacts affecting a region as a whole (even though it may be better to describe different aspects of a proposal, using separate matrices).

	A1	A2	A3	B1	B2	B3	E1	E2	E3
A1	X	X	X						
A2	X	X	X						
A3	X	X	X						
B1				X	X	X			
B2				X	X	X			
B3				X	X	X			
E1							X	X	X
E2							X	X	X
E3							X	X	X

Explanations:

stable landscape	A1..., B1..., C1....
conditionally stable landscape	X – non assessed combination
Non stable landscape	

Figure 3.5: An example of a landscape stability matrix expressed through double combination of partial landscape stability. Source: Paudišová (2014).

Several types of matrices have been used in environmental assessment practice, e.g. Leopold matrix, Peterson matrix, Component Interaction Matrix. Leopold matrix is probably the best known example. This matrix was designed for the assessment of impacts associated with most types of construction projects, listing 100 different project actions along one axis and 88 environmental characteristics and conditions along the other, including aspects of both, the biophysical and socio-economic environments. Also, it involves qualitative as well as quantitative information about cause and effect relationships.

3.5.2 Criteria, Thresholds And Indicators (Indices)

Indicators comprise selected features or parameters of environmental media or resources, representing broader measures of the quality/quantity of such media or resources. Indicators may specifically refer to either, numerical or categorized information which can be used in describing the affected environment and impact prediction and assessment (Canter, 1998).

Indicators, criteria and thresholds are used also for landscape visual and amenity assessment. Important information can be aggregated into overall scores. Landscape impacts include direct and indirect impacts of actions upon landscape elements and features, as well as impacts on the general landscape, character and quality of surrounding area.

Landscape indicators need to be targeted on measurable attributes. In this context, it is possible to define landscape characteristics that are measurable in a qualitative if not quantitative way. Landscape is taken to include both countryside and townscapes. Indicators need to provide a good indicator of change in landscape structure or character, have resonance (capture public attention), be capable of measurements and use meaningful data. The setting of objectives, targets and indicators should take place as part of the scoping stage of an EIA or SEA before baseline surveys are completed.

Landscape indicators that are based on a pressure–state–response framework have been quite often used within the framework of the so-called Landscape Heritage Assessment (LHA) and Landscape Character Assessment (LCA), especially in England, Scotland, Wales and Northern Ireland.

Figure 3.6 provides an example of transnationally approved indicators for a regional plan case study in Germany and Table 3.4 presents an example of agri-environmental indicators used in a Rural Development Plan in Slovakia.

Figure 3.6: An example of transnationally approved indicators for a regional plan case study in Germany. Source: Helbron (2005).

Table 3.4: Agri-environmental indicators for project assessment. Source: Belčáková (2000).

Driving-Forces: Agricultural Investment Activities	Pressure: Indicators of Environmental Pressure	Pressure: Quantification of Indicators for Environmental Pressure
New agricultural buildings	Direct Impacts - Soil quality on the building site - Groundwater quantity on the building site - Atmospheric pollution - Landscape composition - Living conditions Indirect impacts - Water quality - Protected and planned protected areas - Other valuable areas - Endangered species	- removal of soil in m ³ - decrease in water level in m ¹ - production NH ₄ in kg/yr - reduction of openness in m ¹ - number of related persons - eutrophication of ground- and surface waters by N and P mg/l - reduction in areas with high natural values in ha - idem - reduction of species in nr.of species
Land improvement, incl. reparation of land	Direct impacts - Water quantity - Soil quality - Protected and planned protected areas - Other valuable areas - Endangered species - Landscape - Living conditions Indirect impacts - Water quality - Soil erosion	- decrease in water level in m ¹ - loss of valuable soils in m ³ - loss in areas with high natural values in ha - idem - reduction of species in nr - scale of landscape in m ¹ - number of related persons - eutrophication of ground- and surface waters by N and P in mg/l - loss of soil materials in m ³
Irrigation/drainage sector	Direct impact - Water quantity - Water quality - Soil quality Indirect impacts - Protected and planned protected areas - Other valuable areas - Endangered species	- loss of surface water in irrigated areas in m ³ - eutrophication and chemicals in ground- and surface waters in mg/l for N, P and pesticides - total salt accumulation in kg/ha - loss in areas with high natural values (wetlands) in ha - idem - reduction of species in nr.

Driving-Forces: Agricultural Investment Activities	Pressure: Indicators of Environmental Pressure	Pressure: Quantification of Indicators for Environmental Pressure
Water retention works (reservoirs)	Direct impacts - Water quantity Indirect impacts - Water quality - Protected and planned protected areas - Other valuable areas - Endangered species - Landscape	- reduce of discharge flow in m ³ - eutrophication by increase retention period in P and N mg/l - loss in areas with high natural values (wetlands) in ha - idem - reduction of species in nr. - scenic value of landscape (qualitative measure)
Re-afforestation	Direct impacts - Water quantity - Water quality - Soil quality - Protected and planned protected areas - Other valuable areas - Endangered species - Landscape	- decrease in water level in m ¹ - increase in water quality in mg/l N and P - change of chemical loading of soil in heavy metals in ug/l - loss in valuable grassland ecosystems in ha - idem - change in species composition in nr of species - change in landscape pattern (qualitative measure)
Domestic water use	Direct impacts - Water quality - Health conditions	- reduction in N and P in mg/l - improvement in drinking water quality in nr. Persons
Local infrastructure/tourist facilities	Direct Impacts - Protected and planned protected areas - Other valuable areas - Endangered species - Landscape - Living conditions	- loss in areas with high natural values in ha - idem - reduction of species in nr. - scenic value of landscape (qualitative measure) - improvement of living conditions

Furthermore, management indicators can be useful for the assessment and monitoring of land use and land resource processes. Indeed, quality, value and functions of lands can evolve, as well as the benefits society gains from land. Some indicators have been defined in the framework of chapter 10 of Agenda 21, according to:

- land use change, which highlights changes in the productive or protective uses of land resources to facilitate sustainable land use planning and policy development,
- changes in land conditions, which measure changes in the productive capacity, the environmental quality, and the sustainability of the national land resource,
- decentralized local-level natural resource management, which represents the extent to which resource management is in the hands of landholders or other de facto local resource controllers; and partially represents whether local resource controllers and others with direct impact on resources have incentives to conserve them.

The World Bank, in collaboration with UNEP, UNDP, FAO and the Consultative Group on International Agricultural Research (CGIAR), has developed a Land Quality Indicators programme which seeks to develop a set of national and regional integrated indicators for national decision makers, taking into account spatial differences and national disparities. They are intended to monitor the effects of agricultural policies, the level of development of institutional capacities, the durability of land management, and other factors. At the regional level, the objective is to measure the performance and the impact of agricultural projects.

3.6 Presentation Techniques And Methods

Frequently used presentation techniques for landscape and visual impact assessment include *zone of theoretical visibility maps*, *photographs* to record the baseline visual resource, *diagrams* to provide a technical information (scale, shape and position) and *photomontages* or video-montages.

Photographs and photomontages are visualisation methods related to landscape evaluation (Canter, 1998) that can be applied in order to describe affected environments, as well as for impact prediction. They can be helpful to analyse the visual quality of the project site/affected area and the potential visual impacts of proposed actions. Their advantage is that they can show the development within real landscape and from known viewpoints. Various CAD systems help with their application. Photomontages are actually the superimposition of an image onto a photograph in order to create a realistic view of proposed potential visual changes. Figure 3.7. shows examples of computer generated photomontages.

When conducting baseline analysis of potential visual impact of a development, it is important to look at the visual characteristics of areas that are particularly sensitive to aesthetic impacts including the so called “*zone of theoretical visibility (ZTV)*“. These are areas of exceptional scenic quality that have some distinct or unique visual or cultural attributes, and/or areas that have a recognized natural or historical value (LI and IEMA, 2013). Sensitive locations and receptors within the ZTV are identified and presented on ZTV maps. The objective here is to illustrate how the surroundings of individuals or groups of people may be specifically affected by changes in the content

and character of views as a result of the loss of existing elements of the landscape or introduction of new elements (LI and EMA, 2013).

Within the context of a landscape impact assessment process, the visibility zone may represent a key factor in the decision about whether the project/plan shall be considered as having a cross-border impact. Figure 3.8 shows an example of the calculation of a visibility zone of wind power plants, where the visibility of these objects goes beyond the borders of the country carrying out the impact assessment.

Figure 3.7: An example of computer – aided photomontage of study area before and after windturbines installations. Source: Pauditšová and Pauditš (2007).

When conducting baseline analysis of potential visual impact of a development, it is important to look at the visual characteristics of areas that are particularly sensitive to aesthetic impacts including the so called “*zone of theoretical visibility (ZTV)*“. These are areas of exceptional scenic quality that have some distinct or unique visual or cultural attributes, and/or areas that have a recognized natural or historical value (LI and IEMA, 2013). Sensitive locations and receptors within the ZTV are identified and presented on ZTV maps. The objective here is to illustrate how the surroundings of individuals or groups of people may be specifically affected by changes in the content and character of views as a result of the loss of existing elements of the landscape or introduction of new elements (LI and EMA, 2013).

Figure 3.8: Calculation of the zone of potential visibility the windturbines in the cross-border area. Source: Pauditšová and Pauditš (2010).

To effectively present the visual transformation of a landscape in an environmental assessment process, it is appropriate to use digital animations. Software outputs permit to view the evaluated projects within a given environment or landscape in 3D, from different angles and from different cardinal directions. The models of the assessed objects are inserted into orto-photographic maps thus positively supporting imagination and helping in the decision-making process (see Fig. 3.9).

Figure 3.9: Visualization of planned line object (highway) in landscape. Source: Pauditšová et al., (2017).

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