ASSESSING ENVIRONMENTAL SENSITIVITY FOR IMPACT STUDIES ON TRANSPORTATION SYSTEMS

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ABSTRACT

Environmental impact assessment (EIA) is an evaluation procedure that helps decision-makers and planners to understand the environmental impacts of a proposed project or activity in a systematic, holistic, multidisciplinary way. A method has been developed in the present study to characterise the sensitivity of an area, with respect to transportation line projects. Environmental and socio-economical factors, such as ecology, land productivity and aesthetics, have been considered and analysed together with the main impacts mostly caused by a transportation system on them. This analysis has generated a set of sensitivity maps, which have been subsequently integrated through a spatial decision support system, to obtain synthetic sensitivity maps to be used for EIA. A real case study near the town of Trento, in northern Italy, has been used to exemplify the proposed approach in operational terms to become routine practice at local administrations.

1 INTRODUCTION

Environmental impact assessment (EIA) is an evaluation procedure that helps decision-makers and planners to understand the environmental impacts of a proposed project or activity in a systematic, holistic, multidisciplinary way. Being focused on prevention, a study on EIA should help the planning authority in clarifying some of the trade-offs associated with a proposed development action, leading to more rational and structured decision-making. Therefore, the central issue in EIA is that of the 'acceptability' of the impacts. In the first place, the acceptability will determine whether a project is to be subjected to EIA or not (the so called 'screening phase'). The latest European Directive on EIA (Dir. 97/11/CE) suggests that such an evaluation is to be carried out by means of comparing the project characteristics and the environmental sensitivity of the area. A method has been developed in the present study to characterise the sensitivity of an area, with respect to transportation line projects. Environmental and socio-economical factors, such as ecology, land productivity and aesthetics, have been considered and analysed together with the main impacts mostly caused by a transportation system on them. This analysis has generated a set of sensitivity maps, which have been subsequently integrated through a spatial decision support system, to obtain synthetic sensitivity maps to be used for EIA.

A real case study near the town of Trento, in northern Italy, has been used to exemplify the proposed approach. This research was carried in close collaboration with representatives of the EIA office of the Autonomous Province of Trento, ensuring that the methodology to be developed is in accordance with their needs so that it can become operational.

2 THE SCREENING PROCESS IN EIA

2.1 Stages in EIA

Environmental impact assessment (EIA) aims at identifying, predicting and assessing the environmental impacts related to a development (or project). The EIA procedure differs from country to country, being regulated by the legislation in force at the location of the proposed development. Nevertheless, it tends to have a similar structure that, according to Beinat *et al.* (1999), can be broken down into the eight stages, shown in Figure 1, as follows:

1. **Screening.** It represents the first logical activity of a EIA, being aimed at determining whether the EIA procedure itself is necessary for the proposed development;
2. **Scoping.** It is the process of identifying the most significant issues (environmental components, impacts) that need to be addressed during the EIA;
3. **Baseline study.** It represents the result of the collection of all the relevant data concerning the status of the environment likely to be affected by the developments;
4. **Impact prediction.** It involves the description of the forecasted changes in the environment caused by the presence of the development;
5. **Impact evaluation.** It provides an interpretation of the forecasted impacts in terms of their significance and their relative importance, so that indications can be drawn on the acceptability of the development and on the most suitable alternative to be selected;
6. **Mitigation and compensation.** It requires the analysis of possible measures that can reduce or remove environmental impacts, alleviating the overall damage of the development on the environment;
7. **Review.** It is performed by the competent authority to assess whether the submitted environmental impact statement (EIS) is adequate and conformed to the current regulations;
8. **Monitoring.** It takes place during and after the construction of the development, to check whether the impact predictions were accurate.

2.2 The EIA legislation in Europe

In the European context, EIA has been introduced by the Directive 85/337/EC (EC, 1985), and it is currently regulated by the amending Directive 97/11/EC (EC, 1997). These directives represent a common framework for the generation and application of national laws by each Member State. Indeed, Member States are required to comply with only the minimal provision of the Directive, but they are allowed to produce more stringent obligations. The 1985 Directive *(On the assessment of certain public and private projects on the environment)* introduced the environmental impact assessment for projects likely to have significant effects on the environment, with the aim of protecting human health and ensuring a better overall environmental quality. In this Directive the overall EIA procedure is described and two separate categories of projects are included:
a) projects for which EIA is always required; and
b) projects for which EIA is required only at discretion of the specific regulation of the Member State.

The first Directive was amended in March 1997, by the Directive 97/11/EC, which introduced further regulations concerning screening (see next sub-section), scoping, evaluation of project alternatives and public participation.

2.3 Screening

The screening phase, as shown in Figure 1, represents the first formal stage in the EIA procedure. The purpose of screening is to determine whether EIA is required for a particular project, i.e. whether the project is likely to have significant effects on the environment by virtue of its nature, size or location. The EC Directives on EIA list the projects for which EIA is compulsory (Annex 1 of both directives), and the projects for which EIA may be required (Annex 2 of both directives). Whereas for the first category the screening procedure is quite straightforward, for the second one specific regulations are to be provided by every Member State, either setting project 'thresholds' (based on size and other technical parameters, such as energy consumption or production of waste) or through a case-by-case examination.

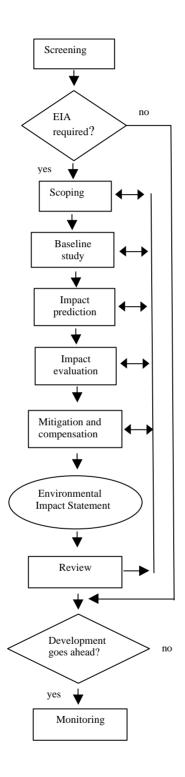The threshold approach has three main drawbacks:
-   thresholds are very hard to be scientifically justified. A rather subjective aspect is, for instance, to decide what is the minimum length of a road track to require an EIA;
-   developers tends to propose projects that are just below the thresholds, or to segment a big project into a set of smaller ones, in order to avoid an EIA and save resources;
-   the cumulative effect is completely disregarded. As a matter of fact, this approach does not consider the impacts resulting from the interactions of activities related to the proposal under consideration with those associated with other past or current projects in the affected areas.

On the other hand, the case-by-case examination has the disadvantage of being more time consuming and of requiring definitive guidelines, in order to become precise and replicable. The directive 97/11/EC (EC, 1997) suggests these guidelines to be defined by considering:
-   the characteristics of projects (size, pollution, nuisances, etc.);
-   the location of the project (environmental sensitivity of the area likely to be affected);

- the potential impact (magnitude, duration, reversibility, etc.).

Effective guidelines for case-by-case screening should ensure that some consideration is given to the wide range of factors which may affect the need for EIA, but, at the same time, should not require detailed investigations. Important aspects of any screening process are, indeed, simplicity and celerity (EC, 1995).

Figure 1: The general sequence of steps in the EIA process (simplified after Beinat *et al.,* 1999).

3 THE PROPOSED APPROACH

This research focuses on developing an approach to help the competent authorities in performing screening for EIA of transportation line projects. Particularly, the approach aims at providing a comprehensive description of the environmental sensitivity of the study area, to be used as guideline for a case-by-case project evaluation. Sensitivity refers to the degree to which an environmental characteristic can change when subjected to the activity of a specific project. The typical effects that a transportation line causes on the most relevant environmental factors will be considered, assessing the sensitivity of these factors, with respect to the selected effect, within the study area.

An example is given in Figure 2, where the land occupation of a motorway (effect) is considered as affecting the connectivity (environmental factor) of the natural habitat of the study area. Following this approach the whole area must be classified according to its specific sensitivity for the development of a linear infrastructure project. The starting point of this approach, therefore, is not represented by a specific project, but by the environmental setting of the area, with its specific fragility and needs, in terms of sustainable use of natural resources.
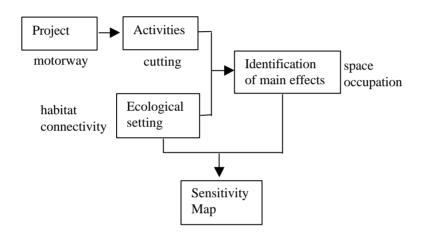

Figure 2: Flowchart for the assessment of land occupation sensitivity to a motorway project.

In implementing the proposed approaches two main steps have to be followed:
a) the identification of a set of typical effects related to a transportation line development;
b) the identification of a set of criteria that can be used for evaluating the sensitivity of the environment with respect to the selected effects.

A number of checklists have been developed for quickly identify the main effects of a specific development on the environment (Leopold *et al.*, 1971; Biswas and Geping, 1992; Palewas, 1994). Potential effects are usually distinguished according to the three phases of the proposed activity: construction, operation and dismantling. Another possible distinction is between direct and indirect effects. A selection of potential effects is usually done on the basis of the possible occurrence of the effects on the one hand and their magnitude and significance on the other hand. Because this study aims at providing an "early stage" evaluation and it is not based on a specific project, the selected set of effects have to be meaningful, but as general as possible.

This lead to the following considerations:
1. the so-called indirect effect (e.g., increasing of settlements after the development of a road track) are too project-specific to be predicted in this study;
2. the discrimination between the three different phases is also too specific to be used here (life of project is hard to generalise);
3. the same applies for the analysis of the risks (safety, etc.) related to the project.

Given this and having analysed a number of studies and guidelines, the following effects have been identified as suitable for the present approach:

- land occupation;
- air pollution;
- soil pollution;
- water pollution;
- noise.

In particular, as an example of application, the space occupation has been selected, analyzing its effects on the ecological components of the environment.

4 A CASE STUDY IN ENVIRONMENTAL SENSITIVITY: THE SPACE OCCUPATION EFFECT ON THE ECOLOGICAL COMPONENT OF TRANSPORTATION PROJECTS

4.1 The study area

The study area is located, as shown in Figure 2, within the Autonomous Province of Trento, in northern Italy, and includes part of the wide valley of the Adige River and its surrounding peaks. It covers about 300 km^2, extending from the northern outskirts of the town of Trento to the beginning of the Non Valley. The area is characterised by alpine geomorphology and the elevation ranges from 200 m up to 2000 m. Oaks, beech and coniferous woodlands, together with alpine shrub-lands, represent the main natural vegetation cover, and they are distributed within the mountainous areas according to slope, aspect, elevation and soil conditions. The cultivated areas include most of the valley floors and part of the lower slopes. They are almost exclusively composed of vineyards and apple orchards. Urban and industrial settlements occupy the rest of the valley floor, whereas villages are scattered in the surrounding hills. Two main rivers cross the area from North to South, and two small lakes are located in the southwestern relieves.
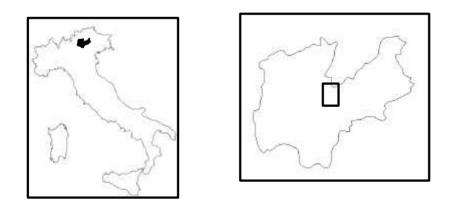

Figure 3: Location of the Autonomous Province of Trento in Italy (left) and of the study area in that province (right)

4.2 Ecology, transportation systems and space occupation

The destruction of habitats world-wide is the greatest threaten to biodiversity and sustainability of ecosystems. The most severe habitat destruction occurs when a natural ecosystem is converted to an artificial system, as it happens for an infrastructure development. The alteration can be caused by habitat loss, habitat deterioration (disturbances, noise, pollution) and habitat fragmentation. An effective mitigation of habitat loss is typically a siting issue, where construction and degrading activities are located at some distance from the habitats of concern (URL1, 1999). A transportation line cutting through the landscape represents a new element that interferes with the existing structure, creating barriers, breaking natural corridors and modifying the intersected patches. The final effects are dependent on the habitat significance and on the spatial arrangement of the landscape elements. Both of these factors have to be

assessed in order to describe the overall ecological sensitivity of the study area and to provide principles for future infrastructure developments.

For these purposes, we can refer mainly to landscape ecology studies (Forman, 1995; Forman and Godron, 1986; Turner 1985; Arts *et al.*, 1995; Giles and Trani, 1999), where methods have been developed to characterize the ecological setting through the analysis of the spatial patterning of the habitat patches. In particular, for this application four different analyses have been conducted:

1. **Analysis of the distribution and composition of natural vegetation.** The vegetation component is evaluated according to its degree of naturalness, which has been obtained from comparison with standardized classes, on the basis of floral composition, vegetation structure and management type.
2. **Analysis of the habitat suitability for selected animal species.** The habitat requirements for representative animal species have been used to model the suitability of the study area.
3. **Identification of possible corridors for organism flow.** Possible animal flows have been outlined within the study area, through a simulation model. Firstly, the land cover map and a DEM were combined to estimate appropriate resistance factors (barriers, corridors, etc.) and to compute a distance map from the pre-selected natural habitat units. After that, flows between those units were simulated and mapped using neighborhood operators (Patrono, 1997). In the final map, the most suitable areas for animal flows were given the highest score.
4. **Analysis of the fragmentation of the natural habitat.** The fragmentation of the residual expanses of natural habitat has been described by means of a spatial index of common use in landscape ecology: the 'Center Versus Neighbors (CVN). The CVN calculates the number of cells with values different from the one of the center cell in each NxN window (Murphy, 1985). This index was applied to a modified version of the land cover map so that for each "natural habitat" cell (value bigger than 3 in the natural habitat map), it calculated the number of "non-natural habitat" cells within a 7x7 neighborhood, expressing the degree of isolation and fragmentation of the natural patches.

5 CONCLUSIONS

The case study has been developed in close co-operation with the Administration of the Autonomous Province of Trento in northern Italy. The study deals with several EIA stages, from screening and scoping to assessment and evaluation. It is also relevant to highlight the role, duties and expertise to be available or maintained at a provincial administration. For instance, answers to the following questions are being sought: "Should the EIA be done within and administration or should it just be audited by it?" and "Is the situation described in the cas study unique or is it common to other types of administrations?"

The proposed methodology and processing strategy are based on the measurement of sensitivity of selected indicators for impact studies of transportation lines using geographical information systems. This leads to a variety of questions. Should that be done by assessing a definite number of proposed alternatives or by identifying the locations of possible alternatives before proposing them? Or should it be done in both ways? Is it customary, in a provincial administration, to study the regional landscape first and then place alternatives in a dynamic context for decision making? What does a GIS database consist of when EIA has to be planned? Should it be constructed for the area of provincial jurisdiction? How far can we apply in practice the sensitivity and fragility concepts in EIA?

The study described in this contribution aims at functionality in an operational context. It means that the database and the methodology described are not only part of an academic research activity. Their target is also the operationalization of the spatial data analysis so that the spatial indicators and indices can be integrated into an EIA as part of routine tasks at local administrations. Complete guidelines and instruction sets should accompany a style of representation and communication that is in harmony with the perception and comprehension of the main stakeholders in the environmental management process. These aspects are at the core of this research.

The approach proposed is by necessity limited to a specific case study at a certain level of detail and of a given dimension. Furthermore, it only considers a limited number of factors. It is being extended to other geomorphologic factors and to other situations in different European contexts. This study is part of the activity of a research network on geomorphology and environmental impact assessment of transportation systems termed GETS.

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