Environmental Impact Assessment of Various Projects using the Environmental Performance Value

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Abstract
The Environmental Impact Assessment (EIA) is a procedural tool which has as goal to assess and evaluate possible environmental effects of a proposed project or action. The main aim of EIA is to reduce the environmental impact of a project at the earliest possible stage during the project cycle. The evaluation of impact significance is widely considered as one of the most difficult and least understood elements of the process. In this paper, 30 environmental impact assessment studies covering projects of different types and groups have been examined. Five assessment criteria (nature, magnitude, permanence, reversibility and confrontability) as well as several environmental components, covering all aspects of abiotic, natural and anthropogenic environment are used. Furthermore, two environmental conditions (existing and potential) and two basic phases of a project life cycle (construction and operation phase) are considered in order to calculate the Environmental Performance Values (EPV) of each project. The results fluctuate in a range band from -108 to 36 (major negative to major positive impacts) and EPV can contribute to the implementation of environmental and social accepted projects and consequently to the sustainable development of regions.

Keywords
environmnental impact assessment, environmnetal performance values, sustainability

1. Introduction

Project scale Environmental Impact Assessment (EIA) tools were the first generation which began in the United States with the passage of the National Environmental Policy Act (NEPA) in 1969 (Shepard, 2005; Turner, 1998; Sharifi and Murayama, 2013). EIA was initially developed to address the increasing pressure on human environment, which had been accelerated in scope, scale, and intensity throughout the years and resulted in public environmental concerns (Gibson et al., 2005). After more than 40 years, it seems reasonable to say that EIA is now universally recognized as a key instrument for environmental management, firmly embedded in domestic and international environmental law (Morgan, 2012).

Although EIA processes differ between countries, there are several common components such as screening, scoping, identification of alternatives, impact analysis, mitigation and impact management, evaluation of significance, preparation of an Environmental Impact Statement (EIS), review of EIS, decision making and monitoring and review.

At the screening stage, it is decided whether an EIA is required or not as well as the desired level of detail, while at the scoping stage, the required information for the EIA is resolved. The identification of alternatives defines the possible alternatives. At the impact analysis component the environmental, social and other related impacts of the project are identified and analyzed. Through mitigation and impact management, it is proposed how the impacts will be mitigated, reduced or managed and through evaluation of significance, if the impacts are acceptable. The preparation of an Environmental Impact Statement (EIS) or report includes the documentation of the proposal, impacts, impact mitigation and management options. Public is involved in the review of EIS stage, where EIS is open for any public comment for a sufficient period of time. The relevant authority, taking into consideration the EIS as well as the public comments, decides whether to accept the proposal as is, modify the proposal or definitely reject the proposal. During the monitoring and review process, an implementation plan is developed and monitoring and review of the project actually begins.

The evaluation of impact significance is widely considered as one of the most difficult and least understood elements of the process. Although, it is very difficult to totally erase the subjectivity, evaluation results can be more reliable, if they are derived from the application of a prior process with clear benchmarks.

Numerous methodologies, tools and techniques have been developed for use in environmental impact assessment processes and various applications of multicriteria decision analysis prevail among them. In the area of multi-criteria analysis, the Rapid Impact Assessment Matrix – RIAM (Pastakia, 1998; Hagebro, 1998; Pastakia and Jensen, 1998; Pastakia and Bay, 1998) is an easily applicable tool which aims to organize, analyse and present the results of a holistic environmental impact assessment (Kuitunen et al, 2008). The RIAM method has been widely tested in many assessment situations and case studies (e.g. Al Malek and Mohamed, 2005; El-Naqa, 2005; Shakib-Manesh et al., 2012; Gilbuena et al, 2013; Suthar and Sajwan, 2014; Upham and Smith, 2014). The method also offers a way to determine and discuss the significance of impacts that is one of the most difficult questions in the context of EIA (Briggs and Hudson, 2013). An integrated and uniform methodology for attributing environmental values to projects, which is based on the RIAM method, is provided through Environmental Impact Assessment Tool (Vagiona, 2015), determining Environmental Performance Values (EPV) for every project or activity.

In this paper, a partially modified methodology of the above mentioned Environmental Impact Assessment Tool is used to evaluate and classify different projects on the grounds of their overall environmental impacts. EPV of 50 projects are calculated. The rest of the paper is organized as follows: section 2 presents the methodology followed and the content of the applied EIA tool. Section 3 presents a short description of the projects examined, section 4 presents the main findings and results whilst section 5 provides concluding remarks.

2. Materials and methods

An attempt to bring subjective judgments in a transparent way into the EIA process was initially performed through the Rapid Impact Assessment Matrix (RIAM) method created by Pastakia and Jensen (1998). This methodology is based on a standard definition of the important assessment criteria (importance of condition, magnitude of change/effect, permanence, reversibility and cumulative), as well as the means by which semi quantitative values for each of these criteria can be collected to provide an accurate and independent score for each condition. The impact of project activities is evaluated against four environmental components (physical/chemical - all physical and chemical aspects of the environment, biological/ecological - all biological aspects of the environment, sociological/cultural - all human aspects including cultural aspects of that particular area of project and economical/operational that identify the economical consequences of environmental change, both temporary and permanent), and for each component a score is determined, which provides a measure of the impact expected from the component. The environmental score ranges from -108 to 108, including 11 range bands. Ijäs et al. (2010) had amended the RIAM method by modifying the scoring system of RIAM (adding susceptibility of the target environment as an extra criterion to the framework) and extending the ordinal scales used.

The concept of the methodology of EIA tool used in this paper is also inspired by the RIAM method and is depicted in Figure 1. The impact of environmental activities is evaluated against 18 environmental components (EC1:climate, EC2:bioclimate, EC3:morphology, EC4:aesthetics - visional features, EC5:geology, EC6:tectonics, EC7:soils, EC8:natural environment, EC9:land uses, EC10:built environment, EC11:historical and cultural environment, EC12:socio-economic environment, EC13:infrastructure, EC14:air quality, EC15:acoustic environment – noise, EC16:vibrations, EC17:radiation, EC18:surface waters and groundwater) taking into consideration two environmental conditions (existing and potential). The projects are evaluated during two typical project phases, the construction and operation phase.

The assessment criteria are distinguished into two groups: primary criteria (PC) that include nature of impact (P1) and magnitude of impact (P2) and secondary criteria (SC) that include permanence of impact (S1), reversibility of impact (S2) and confrontability of impact (S3). The range of scales of P1 is from -1 to 1, where the scale value of 0 denotes ‘no change’, while the range of scales of P2 is from 1 to 3. In the group of secondary criteria, the range of scales of each criterion is from 1 to 3. The scale value of 0 is added to criteria S2 and S3 to denote ‘not applicable’ for positive impacts.

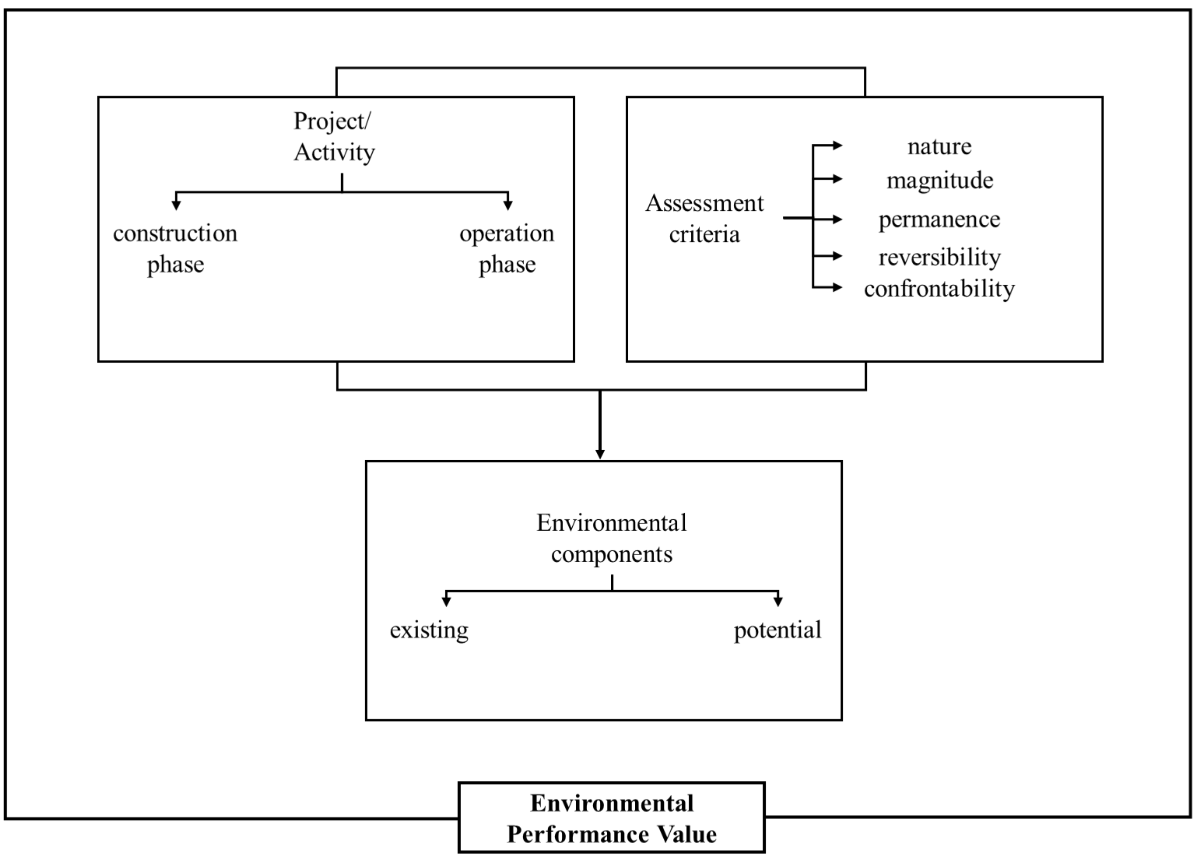

Figure 1: EIA methodology

The total Environmental Performance of the project – activity is obtained using the weighted sum model (WSM), and four different alternatives are derived by combining the baseline and potential environmental condition of the environmental criteria in the study area with the construction and operation phase of the project life cycle (Vagiona, 2015).

In this paper, a slight modification of the algorithm used in the EIA tool is performed and the environmental performance of projects - activities are calculated by summing up the derived values of the environmental components of each alternative. The environmental performance fluctuates from -108 to 36 and the range bands are provided in Table 1.

Table 1: Environmental Performance Values and Range Bands

Description	Environmental Performance Values	Range Bands
Major positive impacts	24<EP⩽36	IV
Significant positive impacts	16<EP⩽24	III
Moderate positive impacts	8<EP⩽16	II
Slight positive impacts	0<EP⩽8	I
No change - status quo	0	NC
Slight negative impacts	-12⩽EP<0	-I
Moderate negative impacts	-32⩽EP<-12	-II
Significant negative impacts	-72⩽EP<-32	-III
Major negative impacts	-108⩽EP<-72	-IV

The ranges are defined as follows:

1. An impact represents the upper limit of a major positive change, if it is significant (P2=3) and has permanent / long term effects (S1=3). The lower limit of a major positive change is derived, either when an impact is significant (P2=3) and lasts approximately 1-10 years (S1=2) or an impact is moderate (P2=3) and lasts more than 10-15 years (S1=3).
2. When an impact is significant (P2=3), but the consequences can still be temporary (S1=2), it presents the lower limit of significant change.
3. The upper limit of a slight positive impact is derived either by a short term moderate impact (P2=1, S1=1) or by a low medium term impact (P2=1, S1=2).
4. Impacts of moderate significance lie between the limits of slight and significance change.
5. Impacts that have no importance or do not change the status quo are scored zero.
6. An impact represents the lower limit of a major negative change, if it is significant (P2=3) and has permanent / long term effects (S1=3). In addition, the changes are permanent (S2=3) and no measures can be adopted to confront the impacts (S3=3).
7. When an impact is significant (P2=3), but the consequences can still be temporary (S1=2), slowly reversible (S2=2) and partially manageable (S3=2), it presents the lower limit of significant change. Moreover, when an impact is moderate (P2=3), the consequences are temporary (S1=2), slowly reversible (S2=2) and partially manageable (S3=2), it presents the upper limit of significant change.
8. A condition is placed on the lower limit of slight change, if it causes slight changes (P2=1) that are short-term (S1=1), reversible (S2=1), and the proposed measures can totally eliminate the impacts (S3=1).

3. Description of case studies

The case data used in the study consisted of projects and activities in the area of Greece. The sample consisted of 30 cases varying from simple activities to more substantial and complicated construction and infrastructure projects (Table 2). The projects and activities are classified into categories of the public and private sector, according to Ministerial Decree No. 1958, pursuant to article 1, paragraph 4 of Law No.

4014/2011. Such works and activities present common characteristics as for the assessment of their environmental impact and are hereby classified into twelve common groups corresponding to categories A and B prescribed by Law No. 4014. These groups are listed down in Annexes I to XII attached to the Decree No. 1958. In the sampling the main intention was to obtain a representative set of cases. The cases were evaluated by the author of this article, although EIA tool is suitable for use by expert assessment panels as well as the public.

Table 2: General groups of the assessed projects

Group id	Types of projects/activities	Assessed projects/activities
Group 1	Land and air transport projects	P2, P11, P17, P19
Group 2	Hydraulic projects	P5, P22
Group 3	Port works	P4
Group 4	Environmental infrastructure systems	P3, P13, P16, P20, P26
Group 5	Mining and related activities	P15, P23
Group 6	Tourist facilities and urban development projects, building sector projects, sport and recreation projects	P7, P10, P14, P18
Group 7	Livestock and poultry facilities	P1
Group 8	Aquaculture activities	P27
Group 9	Industrial and associated facilities	P29, P30
Group 10	Renewable Energy Resources	P6, P8, P9, P12, P21, P24
Group 11	Transfer of energy, fuels and chemicals	P28
Group 12	Special projects and activities	P25

4. Results and discussion

Evaluation and review of the EIA was carried out using the EIA tool to determine the existence of impacts of the planned projects along the immediate and surrounding environment. Impacts that will arise from the implementation of the planned projects/activities on each environmental component are denoted by the symbol (√) and presented in Table 3.

Table 3: Assessed impacts on environmental components

	EC 1	EC 2	EC 3	EC 4	EC 5	EC 6	EC 7	EC 8	EC 9	EC 10	EC 11	EC 12	EC 13	EC 14	EC 15	EC 16	EC 17	EC 18
P1								√										
P2			√	√				√					√	√	√			√
P3					√	√	√	√	√	√		√	√		√	√		
P4																		
P5					√	√	√	√	√	√	√	√	√		√	√	√	√
P6			√	√				√				√	√					
P7			√	√				√	√	√		√	√	√				
P8			√	√				√				√	√	√	√			
P9			√	√				√							√			
P10			√	√								√	√					

P11			√	√				√	√	√		√	√	√	√			√
P12			√	√					√	√		√	√		√			
P13			√	√					√	√		√	√	√				
P14			√	√				√				√	√	√				
P15	√	√	√	√	√	√	√	√	√			√	√	√	√	√		√
P16				√				√				√		√	√			
P17				√				√	√					√	√			
P18									√			√						
P19			√	√				√	√			√	√	√	√			
P20			√	√								√	√	√	√			√
P21	√		√	√				√				√	√	√	√			√
P22	√	√	√		√		√	√						√	√			
P23			√	√			√						√	√	√	√	√	√
P24			√	√				√	√					√	√	√		
P25								√		√				√	√			
P26			√					√				√	√	√	√			
P27								√				√						√
P28			√	√			√	√				√		√	√			√
P29												√		√	√			
P30				√			√		√					√	√			√

By inspection of Table 3, climate, bioclimate, geology, tectonics, historical and cultural environment, vibrations and radiation are the least influenced environmental components. 66% of the projects influence morphology, visional features, natural environment, socio-economic environment, atmospheric and acoustic environment.

In terms of the project phases, the most number of negative impacts occur during the construction phase, while the most severe impacts are generated during the operation. Most of the positive impacts occur during the operation phase, and some even occur during the construction phase, which indicates that upon completion and in the long run, the planned projects will generally benefit the human and ecological environments.

Negative impacts actually influence the acceptance or rejection of a proposed project and often require serious attention from planners and decision-makers, since these eventually constitute the basis for the environmental rules. In Table 4, the Environmental Performance Values of projects are provided, while in Figure 2 the classification of projects/activities to impact bands is presented.

Table 4: Environmental Performance of projects

Project	EP	Project	EP	Project	EP
P1	-0,8	P11	-4,7	P21	0,1
P2	-6,3	P12	1,4	P22	4,7
P3	3,5	P13	-2,1	P23	-20,0
P4	-18,3	P14	0,2	P24	-7,9
P5	-1,3	P15	-23,8	P25	-1,4

P6	0,7	P16	-3,4	P26	-1,0
P7	0,4	P17	-3,7	P27	-0,9
P8	1,0	P18	0,7	P28	-4,4
P9	1,0	P19	-6,0	P29	-1,1
P10	1,7	P20	-1,9	P30	-8,1

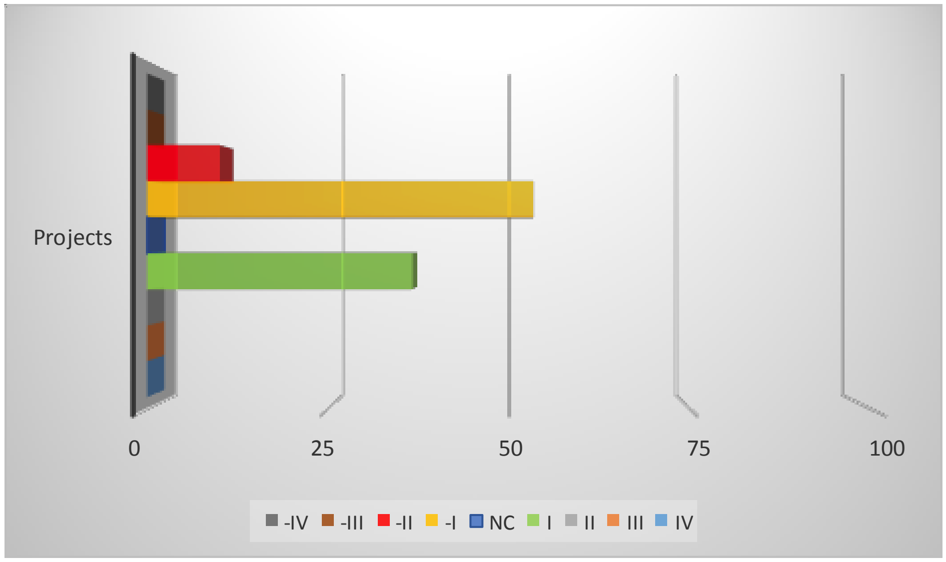

Figure 2: Classification of the proposed projects

The majority of projects is assessed as causing either slight or moderate negative effects, while 1/3 of them positively affect the anthropogenic and natural environment.

5. Concluding remarks

The EIA tool complements very well with the general EIA approach in Greece, making it highly viable for application in various project types. In addition, the EIA tool proved to be an appropriate and recommendable method for a common and uniform assessment of project proposals. Impact assessment inevitably involves some degree of subjectivity and uncertainty (Morris and Therival, 2009). However, the combination of appraisal by quantitative scaling and estimation of the degree of impacts by means of the range bands presents an improvement.

This study also demonstrates the flexibility of the EIA tool to cope with the modifications performed in order to enhance the efficiency and transparency of the evaluation process, with particular reference to the slight modification of the algorithm in calculations and the changes performed to the range bands.

Although all the decision makers depend their decisions on different criteria, this article hopefully revealed how EIA tool can be used in elaborating and clarifying decision-making.

Future research includes the involvement of abandonment phase, which refers to a project phase wherein a project is decommissioned (or abandoned) upon reaching the end of its productive life, or when it simply ceases its operation for whatever reason.

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