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A review on methodologies adopted during environmental impact assessment of development projects

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Abstract
Environment Impact Assessment (EIA) is one of the proven anticipatory and legislative tool used to predict the environmental consequences of any development project. It is a decision making tool used to anticipate and quantify the positive and negative impact of a proposed development project on environment consisting of a social, economic and biophysical aspects. The purpose of the assessment to assist decision makers in considering the environmental impacts of proposed project when deciding whether to proceed with a project. Numerous EIA methodologies have been developed such as Interaction Matrices, Network, Checklist, Life Cycle Assessment (LCA), Rapid Impact Assessment Matrix (RIAM) and Data Envelopment Analysis (DEA). Although, there are number of studies on EIA methodologies to identify their strength and weakness, the adequacy of impact assessment methodologies was evaluated in terms of specific criteria like impact identification, impact communication and impact interpretation. A review on these EIA methodologies and their adoption has been presented in the current study. The aim of this review paper is to find out that, which method we can use to assess the environmental assessment of highway road expansion in mountainous regions.

Keywords: Impact, assessment, environment, method, development

Introduction

Environment Impact Assessment EIA as required by the National Environmental policy Act (NEPA) in 1969 as stimulator for the growth and development of the environmental attributes. India is an assembly of federal states in which the central and state government have contemporaneous jurisdiction over natural deposits and ecological management (Rosencranz & Rustomjee, 1995; Bakshi, 1998) [98, 7]. In 1994, EIA ratification at central level was enacted by a notification passed under The Environmental Protection Act 1986. In India, EIA has been introduced in 1994 and relied on Institutional framework with strong support of legislative, executive and operational set up (Sinclair & Duck, 2000) [108]. The purpose of incorporating EIA methodologies has been to examine what the possible environmental impact of proposed development plan would be and to asset ways to anticipate any long term negative impacts (Weaver, Greyling, Van, & Kruger, 1996) [121]. Quantitative and Qualitative assessment of environmental parameters of mining units on Environmental components could be considered as major aim of this study (Jarvis & Younger, 2000) [54].

Impact assessment methodologies range from simple to complex and are also progressively changing from a static, piecemeal approach to the one that reflect the dynamism of the nature and the environment (Johnson & Bell, 1975) [57]. It describes some simple and widely used EIA tools and offer information to help in EIA analyst for conducting an adequate analysis. These assessment tools may make preparation of an environment statement a less formidable and more significant task. The recognition and appraisal of environmental impacts of expansions activities were complex due to the multiplicity of impacts caused by human obtrusion to the ecological and community system. However, a large number of impact assessment tools has been build out but EIA is a scientific and professional approach enhanced the public involvement which in turn will contribute to the natural economic growth in the long term of building trust from stakeholders for EIA procedure act as stabilizer of the interest of capitalist and society. The concept of Environmental Impact Assessment (EIA) refers to the examination, analysis and assessment of planned activities with a view to ensuring their environmental soundness and sustainable development. It is said to be a valuable means of promoting the integration of environmental and natural resource issues into planning and program implementation (Tukker, 2000) [117].

EIA has been introduced in the United States in the late 1960s. It has been ratified by many developed and developing countries (Sowman, Fuggle & Preston, 1995; Leu, Williams & Bark, 1996; Bojorquez & Garcıa, 1998; Barker & Wood, 1999; Chen, Warren, & Duan, 1999; Hopkinson, James, & Sammut, 2000; Weston, 2000; Jay & Handley, 2001; Steineman, 2001) [112, 67, 12, 9, 18, 46, 124, 55, 113]. Various EIA methodologies have been originated such as interaction matrices, network, weighting-scaling (or ranking or rating) checklists (Henne, Schneider, & Martinezr, 2002) [40], multi criteria / multi attribute decision analysis (MCDA/ MADA) (Parkin, 1992; Marttumen & Hamalainen, 1995; Hokkanen & Salminen, 1997; Kim, Kwak & Yoo, 1998; Rogers & Bruen, 1998; Wang & Yang, 1998) [90, 78, 44, 62, 102, 119], input-output analysis (Pun, Hui, Lewis, & Lau, 2003) [97], Life Cycle Assessment (Tukker, 2000; Brentrup, Kusters, Kuhlmann, & Lammel, 2004) [13], AHP or fuzzy AHP (Ramanathan, 2001; Goyal & Deshpande, 2001; Solnes, 2003) [99, 35, 109], fuzzy set approaches (Munda, Nijkamp & Rietveld, 1994; Enea & Salemi, 2001; Parashar, Paliwal, & Rambabu 1997) [74, 26, 91], Rapid Impact Assessment Matrix (RIAM) (Hui, He & Dang, 2002; Pastakia, 1998; Pastakia & Jenson 1998; Pastakia & Bay, 1998) [52, 92, 93, 94] and Data Envelopment Analysis (DEA) (Wei, Fan, Lu, & Tsai, 2004) [122].

The existing endowment of biodiversity as well as depletable resources that we are unable to duplicate or substitute by technological innovation (Swanson, 1997) [115] and was being eroded since long time attributed to the spread of unsustainable development & specifically habitat fragmentation, overexploitation of flora and fauna and global climate change. Therefore, to ensure potential problems addressed at an preconstruction and post construction stages in project activities, EIA is considered as an exclusive management tool, which provide rational approach to sustainable development.

Choosing a methodology

EIA investigator imposed with the drawing up of an EIA report is faced with immeasurable quantity of raw and unorganised data. Regarding the types of methods, it should be find out that there is no standardized classification of methods within the practice of EIA. EIA methods range from simple to complex requiring different kinds of data, different data formats, varying level of expertise and technological sophistication for their interpretation. The certain factors that should be considered while selecting a method are:

1. Use: Environment impact analyses were generally considered as decision or information instrument. The interpretation of significant long term possible impacts required a more comprehensive appraisal under an information document while a decision document appraisal required a greater priority on comparison of alternatives, identification and quantification of substitutes.

2. Alternatives: Alternatives are fundamentally and gradually require different levels of analysis to discriminate between alternatives. If differences are fundamental then impact significance can better be identified against some absolute standard than by direct comparison of alternatives since impacts will differ in terms of variety and magnitude.

3. Public involvement: The involvement of public in anticipation of long term negative impacts allows the use of more complex techniques such as computer or statistical analysis. A greater degree of quantification of impact significance through the direct participation of public was considered as essential preparation role.

4. Resources: Applicability of an EIA required an ample amount of resources, both financially and man power. Some methods rely too much on experts, may not be available and become difficult to conduct an EIA. The best therefore, is to go for the simple method like Leopold matrix and the overlay method.

5. Familiary: An analyst should be familiar with both the type of action observed and the study sites to improve the validity of a more distinctive analysis of impact significance.

6. Issue Significance: Quantification and identification of key issues was done by using specific formulas for trading off one type of impact against another type, the bigger the size the greater the need for explicitness.

7. Administrative Constraints: Specific appraisal policy or guidelines may rule out some tools by concreting the range of impacts to be claimed, the need for analysing trade off or the time frame of analysis.

Categorizing methodologies

The various methodologies examined can be divided into five types, based on way of impacts are identified:

1 Ad hoc: These methodologies involve assessment of possible impacts under broad areas by listing composite ecological parameters. A team of experts involved to conduct an EIA in their area of expertise. The short or long term, reversible or irreversible impacts are recognised for each environmental area such as air, water, flora and fauna based on unique combinations of experiences, training and intuition. Adhoc method provides pertinent information of expansion activities on environment without any cause – effect relationship (Anjanejulu & Manickam, 2007) [4].

2 Checklist: This methodology is highly structured approach pertaining to impact identification. It involves scaling technique, which is applicable for the impact of each alternative on each factor. Checklists have seven broad categories and represent one of the basic methodologies used in EIA. They are:

I Simple checklist: It categorizing the environmental aspects that might be considered by the analyst without any assistance.

II Descriptive checklist: It provides additional assistance. Descriptive checklists, including guidelines on the measurement of parameters. Descriptive checklists were more informative in that they include an identification of variables and potential impacts and provide guidelines on how these items are to be measured.

III Scaling checklist: It includes simple devices for assessing significance of suspected impacts. An analyst assessed the significance of suspected impacts through the use of letter or numeric scales assigned after comparison with criteria supplied in the checklist.

IV Questionnaire checklist: It uses a series of carefully directed question to elicit information about possible impacts and their importance.

V Scaling weighting checklist: It capable of quantify impacts.

VI Environmental Evaluation System (EES): Checklist based, including scaling and weighting (Dee & Norbert, *et al*., 1972).

VII Multi-attribute Utility Theory: It is basically a weighting method that can also be used along with other approaches to identify the impacts (Keeney & Raiffa, 1976; Keeney & Robilliard, 1977; Kirkwood, 1982) [58, 59, 63]. However, they have major weakness that they do not consider the secondary impacts and entirely focus on primary impacts may result in misleading interpretation (Mubvami, 1991) [81].

3 Matrix: Impact matrices employ a checklist of environmental conditions likely to be affected with a list of project activities, the two lists arranged in the form of a matrix. This methodology has been used to identify the possible cause-effect relationships between activities and environmental attributes and evaluated cell by cell (Anjanejulu & Manickam, 2007) [4]. Matrices can be very detailed and large; the classical Leopold matrix contains 100 by 88 cells, and is thus, cumbersome to handle (Leopold *et al*., 1971) [66].

As a consequence, numerous extensions and modifications have been developed for almost every practical application (e.g., Clark *et al*., 1981; Lohani & Thanh, 1979; Welch & Lewis, 1976; Fischer & Davies, 1973) [21, 71, 123]. In a more strategic approach, project planning matrices are used to structure and guide the assessment procedures in the goal-oriented ZOPP (Ziel-Orientierte Projekt Planung) method (GTZ, 1987) [36].

The major advantages of this methodology are, as it was considered a good visual tool and provides a comprehensive list of possible impacts on environment. The poor applicability of this method is due to its subjectivity. Scores / Rank are derived subjectivity (Mubvami, 1991) [81].

4 Overlays: These methodologies may be used to collect information on large scale of variables for standard geographical units within the study sites, which will be recorded on a set of transparent maps typically one for each variable. It generally used to assess the changes occurred in the topography before and after the development activities. However, it can be used for preparing composite overlays with analyses of ecological carrying capacity. This methodology is widely used to investigate the physical, ecological as well as land use pattern system of selected development areas (Mubvami, 1991) [81]. Overlay methods use a set of physical or electronic maps of environmental characteristics and possible project impact upon them, that are overlaid to produce a composite and spatial characterization of project consequences (McHarg, 1968; Dooley & Newkirk, 1976) [76, 25].

5 Network: Networks are designed to explicitly consider higher order consequences. They consist of linked impacts including chained multiple effects and feedbacks (Sorensen, 1971; Gilliland & Risser, 1977) [111, 33]**.** This technique generally recognises both the primary as well as secondary impacts by using matrix approach triggered by project actions. This methodology is able to identify direct, indirect impacts, higher order effect, interaction between impacts and shows in the form of tree called impact tree. Impact tree is a visual description of cause – effect linkages. It incorporates mitigation and environment management plan into the planning stages of a development project. Network analysis involves quantitative prediction of the cumulative impacts of the various project activities on single target resources. Network methods have been criticised for their inability to gives information about impact attributes such as probability, importance and magnitude. The main advantage of this method is making sure that all the possible direct and indirect impacts have been explored.

6 GIS: It is an integrated system of data base management and computerized mapping used to construct real world models based on digital data. GIS is a system designed to collect store retrieve and manipulate displayed spatial data to their location and interpreted by using longitude –latitude coordinates. GIS overlays different types of information's as separate data layers which is called 'themes'. Each theme represents a category of features such as road, school, shopping centre, river, lakes forest etc. GIS represent spatial elements in 2 models i.e., vector and raster.

7 Cost – benefit analysis: Cost-benefit analysis (CBA), in a narrow sense, is an attempt to monetize all effects for direct comparison in monetary terms. While providing a clear answer and basis for the comparison of alternatives, the monetization of many environmental problems is sometimes extremely difficult and thus can affect the usefulness of the method considerably (Elgafy, 2005) [27]. Numerous approaches to help monetize environmental criteria have been developed. Some of the more frequently used include the cost of repair, i.e., the estimated cost to restore an environmental system to its original state, or the willingness to pay, based on direct or indirect (e.g., travel cost) approaches to assess the value. Attempts to overcome some of the weaknesses of CBA have led to numerous extensions and modifications, such as the Planning Balance Sheet (PBS) or the Goals Achievement Matrix (GAM). The Planning Balance Sheet (Lichfield, Kettle & Whitbread, 1975)) [68] stresses the importance of recording all impacts, whether monetizable or not, and analyzing the distribution of impacts among different community groups. Thus it adds the analysis as to whom cost and benefits accrue to the basic concept of CBA. The Goals Achievement Matrix (Hill, 1967; Hill, 1968; Hill & Werczberger, 1978) [41, 42, 43] defines and organizes impacts according to a set of explicit goals that the public action is attempting to meet and identifies consequences to different interest groups. It is also designed to accommodate non-monetizable impacts, and uses a set of non-monetary value weights for computing a summary evaluation; it is thus similar to CBA.

8 Modeling: Elgafy (2005) [27] Modeling is an analytical technique, which enables the graduation of impacts that can affect the nature by counterfeit environmental conditions. It considered multidimensional problems that accommodate multiple objectives, multiple criteria as well as multiple purposes. Modeling allows experimentation with the replica in order to gain apprehension into the expected behaviour of the genuine system. A forecast of likely consequences and impacts has to be based on some kind of model. Whether that is a mental model, a set of 'rules of thumb'or heuristics an expert might use, or a formal mathematical model, the necessary information must be somehow inserted in the (mental or mathematical) procedure. This role is usually filled by the expert's knowledge, or by handbooks and similar sources of information (Canter & Hill, 1979) [16].

Review Criteria: Each technique and method for the appraisal of impacts should be systematic in nature and have a good predictive capability. Each of different methodologies for the analysis of ecological impacts of expansion activities have merits and demerits. The adequacy of impact assessment methodologies was evaluated in terms of specific criteria under the four key areas like impact identification, impact communication and impact interpretation and impact measurement. In order to choose a best method, a set of 20 criteria are mentioned in (Table 1).

Table 1: Criteria for the selection of EIA Methodology

Key areas of the assessment process	Criteria	Criteria description
Impact identification	Timing and duration	The methodology should be able to recognised the site and the range of the impact on a temporal scale.
	Indicator based	To identify specific parameters with which to measure significant impacts
	Spatial dimensions	Can identify impacts on spatial scales
	Discriminative	Can be identify project impacts as distinguish from future environment changes produced by other factors
	Comprehensiveness	This methodology should be able to provide sufficient information about the impact to empower effective decision making
Cost and time effectiveness	Data requirement	Primary data collection does not considered as prerequisite and can be used with easily available data information
	Expertise requirement	It is the simplest methodology sufficient to allocate stakeholders with limited background knowledge to hold and to put in an application without difficulty
	Time requirement	Can be completed well within the time required for the EIA review
	Personnel level of effort	Can be performed with limited expenditure and human resources
	Flexibility	Should be flexible enough to allow for mitigation and reshaping if more detailed study is required
Impact measurement	Objective	Should be based on objective criteria rather than subjective
	Measure changes	Should provides for the measurement of impact magnitude which are entirely differ from impact significant
	Quantitative	Proposed specific indicators to be used to determine applicable impacts on parameters
	Commensurate	Uses a commensurate set of units so that comparison can be made between alternatives
Impact Assessment	Credibility	Provides sufficient intellect of analysis and confidence into the stakeholders and the general public
	Aggregation	Accumulates the vast amount of information and unorganised data
	Uncertainty	Identify impacts that have high potential the destruction and low probability of occurance
	Replicability	Analysis can be repeated by other EIA exponent
	Alternative comparison	Comparison of impacts of projects alternatives has been done
	Significance-based	Can explicitly assess the significance of measured impacts on a local, regional and national scale
Communication	Communicability	Gives a sufficiently detailed and complete comparison of the various projects alternatives
		Provides a tool for a linking assessing impacts on affected geographical or social aspects.

(**Source:** Anjaneyulu & Manickam, 2007) [4]

Methodology Description

A unique methodology of impact assessment of tunnelling an socio-economic and environmental aspects during construction and operation phases by incorporating matrix method in which one dimension of matrix is an Environmental Component (EC) and the another one is " Impact factors" (Ifs) was proposed by (Namin, Ghafari & Dianati, 2014) [84]. The approach emphasizes the Mirmohammadi alogorithim for 3 typical tunnels in Tehran, Eurasia tunnel in Istanbul and Tsuen vandraing tunnel in Hongkong, compared them with standard diagram of environmental component that were derived and introduced. This methodology generally introduced 13 EC and 20 IFs during construction and operation phase shown in (Table 2).
Considered environmental components for the suggested algorithm.

Table 2: Environmental components suggested during construction and operation phase.

1	**Human health and immunity**	**8**	**Surface constructions**
2	Social issues	9	Underground constructions
3	Surface water	10	Area landscape
4	Underground water	11	Quietness
5	Air quality	12	Economical issues
6	Area usage	13	Soil of the area
7	Ecology		

(**Source:** Namin *et al*. 2014) [84]

Each parameter of the proposed tunnelling activity was analysed by using the magnitude range. For destructive parameters, the factors mark is between 0 and 10. 0 means it is ineffective and 10 shows the most critical condition. The economic and cultural aspects have a mark between -10 and 10. The –ve sign shows their positive effect. Effect of each IF's on each EC is expressed by 4 statements; Nil, Minimum, Medium and Maximum. Hence, the influence of "Impacting

Factors" on each "Environmental Component" could be written as follows:

$(C^c) = (F^c)*(M^c)$ (1)
$(C^o) = (F^o)(M^o)$ (2)

In the equation above, c and o shows tunnelling construction and operation phases respectively and C is 1 × 13 matrices whose elements represent the environmental components; F is 1 × 20 matrices whose elements represent the impacting factors values. The major advantage of this methodology that it reduces human errors in assessment and has an appropriate pattern to analyses the environmental effect.

The Rapid Impact assessment matrix (RIAM) is an analytical tool that was adopted to prioritize the water resources management problems identified in the river basin in Ghana to carry out EIA (Pastakia, 1998) [92, 93, 94]. In this methodology, the impacts of project action were evaluated against the environmental component on the basis of two assessment criteria comes under two groups:

A – Criteria that are of importance to the condition and individually can change the score obtained.

B – Criteria that are of value to the situation but should not individually be capable of changing the score obtained. The process is expressed by following set of equations (Jenson, 1998) [92, 94]

(a1) x (a2) = aT
(b1) + (b2) + (b3) = bt
(a T) x (b T) = ES

Where (a1) and (a2) are individual criteria for group A, (b1) and (b3) are individual criteria for group B.
a T – Result of multiplication of all (A) scores
b T -Result of summation of all (B) scores
ES – is the assessment score for the condition

This methodology widely used in11 relevant impact indicators. This study showed that RIAM (Yeboah, Asare, Boakye, & Aki, 2005) [125] acted as transparent tool that remained behind permanent record. The major advantages were, to minimize the element of subjectivity and introduced the degree of objectivity. This method have more flexibility and have minimum duration in execution of an EIA (Pastakia & Jenson, 1998) [92, 93, 94]. Environmental Impact Assessment (EIA) for Travancore Titanium Products Ltd Company (TTP), Kochuveli, Trivandrum at a distance of 1km & 5km by using Rapid Impact Assessment Matrix (RIAM) tool was conducted by Aiswarya & Sruthi (2016) [2]. EIA analysis has four sequential phases such as identification, analyzing, prediction and policy making. The purpose of the assessment was to ensure that decision makers consider the environmental impacts when deciding whether to proceed with a project. (Chopra, Aggrawal, & Chowdhry, 2011) [19] conducted an impact assessment of Indian National Highway NH- 21 (Mohali to Ropar district connecting Kharar & Kurali) to highlight the importance of EIA in sustainable development. The parameters covered in this study were socioeconomic, Biological, Air, Water Noise, Ecological Soil and Cultural. Based upon the information and existing data, total impact was assessed by the matrix method.

Multiple –criteria decision making methodology was proposed by Rikhteger *et al*. (2014) [101] to identify and predict the impact generated by Zinc and Lead mining project located in Zanjan Iran. It was an integrated model, based upon the Analytic network process and fuzzy simple additive weight techniques. Fuzzy SAW method was widely used for modelling decision-making problems (Chou, Chang, & Shen, 2008; Hashemkhani, Sedaghat, & Zavadskas, 2012; Hwang & Yoon, 1981; Medineckiene & Bjork, 2011; Palevicius, Paliulis, Venckauskaite & Vengrys, 2013; Sagar, Jayaswal, & Kushwah, 2013; Tamosaitiene, Sipalis, Banaitis, & Gaudutis, 2013) [20, 31, 39, 53, 88, 103, 116]. Fuzzy simple additive weight technology was a powerful mathematical tool for dealing with the inherent uncertainty. This methodology emphasised on a vast numbers of parameters that significantly affect the natural environment. SAW technique was preferred due to its understandable and rational nature. On the other hand ANP method (Fouladgar, Yazdani-Chamzini, Zavadskas, & Moini, 2012) [31, 39] was employed for computation of the relative importance of the evaluation criteria. It was generally simple, intuitive approach that can measure all tangible and intangible criteria in the model. ANP was more adapted to real world problems and not required a strict hierarchical structural.

The local weights of the main and sub-criteria were calculated with the aid of the format of the ANP questionnaire by expert team (including eight evaluators with a high background in the field of risk management) based on the pairwise comparison matrices. It was noted that the weights of the evaluators are considered as the same value. After that, the comparison matrices were aggregated into the final comparison matrix by applying the geometric mean method. In order to valid the matrices, the group consistency index (GCI) was calculated and then the group consistency ratio (GCR) was computed. The GCR was obtained as

GCR =GCI/RCI

The Random Consistency Index (RCI) is derived from a randomly generated square matrix. The group judgement was consistent provided that the GCR is less than 0.1. Analytical hierarchy process (AHP) or multicriteria technique was proposed by Ramanathan (2001) [99] to carry out an EIA. AHP have flexibility to capture the perception of different stakeholders for socio-economic impact assessment, which will help the appraisal committees to outline the environment management plan for mitigating adverse socio-economic impacts.

The matrix method and map overlay method was merged and Geographic Information System (GIS) based overlay map method was evolved by (Li, Wang, Li, & Deng, 1999) to examine comprehensively the environmental susceptibility around road and its impact on the environment. They perceived that new technologies as remote sensing, CAD and GIS were more productive and appropriate to collect and analyse data and contemplate the results of assessment. GIS was considered as the right tool and was used to manage substantial environmental data. This method has been used to analyse both environmental susceptibility grade and road impact extent. It was considered that GIS have been proved feasible in the appraisal application in the road under study. Mountains were progressively being invaded by highways for development and defence purposes. Environmental impact assessment (EIA) of highway projects in mountainous areas was done (Banerjee & Ghosh, 2016) by using Geographic information systems (GIS)-based EIA to reduce the challenges created by mountain environments. GIS is a computer-based system for capturing, storing, querying, analysing and displaying geographically referred data (Chang, 2008). GIS and analytic hierarchical process (AHP), a type of

MCDM, has been considered as suitable method in the forest road network planning (Samani, Hosseiny, Lotfalian, & Najafi, 2010) [105]. MCDM was a set of procedures which facilitate a decision-maker in taking a decision based on a set of possibilities in the form of multiple criteria. The outcome of MCDM was in the form of a ranked order of the chosen alternatives (Malczewski, 1999) [73]. Some of the GIS-MCDM-based EIA studies include genetic algorithm, mathematical programming, statistical modelling, Monte Carlo simulation, cellular automataic simulation. The choice of MCDM method depends on the nature of research problem (Wang, Yang, & Xu, 2006; Zhu, 2011; Zolfani *et al*., 2011) [120, 127-128]. The MCDM involves various spatial analysis methods discussed in (Table 3).

Table 3: Description of spatial analysis methods.

Method	Description
Buffering	a process of creating an area around a map feature delineated by a specific distance from the selected feature
corridor analysis	method of finding the optimal path between source and surrounding cells in a raster map subject to certain criteria
Inverse distance weighing (IdW)	a deterministic spatial interpolation method based on the principle that, estimate of value at a location is more influenced by its immediate surrounding points than the ones away from it
Kriging	a spatial interpolation method based on probabilistic assumption that a spatial change of an attribute has a spatially correlated component. It has several variates like ordinary kriging and universal kriging.
triangulated irregular network (TIN)	a data model which approximates a terrain using non-overlapping triangles

(**Source:** chang (2008) [17, 20], longley *et al*. (2005) [72], demers (2009) [24], and lloyd, 2010) [70]

A recent methodology was presented by Antunes *et al*. (2001) [6] for impact assessment – SIAM (Spatial impact Assessment Methodology) which was based upon the hypothesis that the environmental impacts are dependent upon the spatial distribution of the effects. It was found that the impact significance was assessed by the computation of a set of impact indicators on using information produced by the use of Geographic Information System in impact identification and prediction stages of Environment Impact Assessment (EIA). The application and capabilities of the proposed methodology that can be adapted to the particular attributes of a EIA problem was demonstrated in the case study of impact judgement of a proposed highway in Central Portugal. It was concluded that SIAM could be adopted to the impact assessment of a proposed project where the spatial distribution of the impact is pertinent.

The urbanization and industrialization leads to destruction of natural habitats and biodiversity. So there is need to adopt certain kind of tool and techniques to evaluate the potential effect on biodiversity, EIA acts as an important tool in prediction and assessment of biodiversity related impacts caused by development projects (Gontier, Ortberg & Balfors, 2010) [34]. This study was conducted in 2010 in Isfahan Province in Central Iran by Ghasemian *et al*. (2011) [32] by using GIS and matrix method. Certain effective factors which identified in environmental degradation were climate, geology, hydrology and different types of pollutants. The available data was analysed by using the Universal Transverse Mercator (UTM) system and maps were gathered with scale of 1: 5000 and interpreted with ARC software. They also used overlays method to identify the vulnerable areas affected by pollutants. The quantitative evaluation was done by using matrix of Rau and Wooten (1980) [100].

Net score for impact = magnitude of effect x importance of effect

The effect magnitude of each group was depending upon technical and scientific principles. In this study the range of importance of effect was defined with number 0 to 5. It was found that the sum scores assigned to the development factor was '37' means that +ve effect of project overcome the drawback and does not show calamitous effect on ecology system. The purpose of using these methods was to obstruct environmental degradation and mitigation of vulnerability level of ecological community as well as prohibition of the destruction caused by development projects.

Checklist methodology proposed by Adkins *et al*. (1971) [1] using a +5 to +5 rating system for evaluating environmental impacts. It was developed to deal with appraisal of highway route alternatives. The parameters generally used were categorised into 4 groups like transportation, environmental, socio-ecological and economic impacts. Because of the bulk of parameters used directly to highway transportation, this approach was not adopted to other types of projects. The major limitation of this methodology was that it relied on subjective rating without guidelines which greatly reduce the replicability of assessment. Checklist methodology designed for major water resources projects proposed by Dee *et al*. (1972) [23] emphasized on quantitative impact assessment. This methodology was introduced seventy eight environmental parameters broken into four categories of ecology, aesthetics, human interest and environmental pollution. Environmental parameters were converted into a common base of "environmental quality units" through specified graphs or value function. The use of approach to major project assessment was restricted due to high resources requirement. This approach does not deal with uncertainty, social and economic impacts and public participation. The major advantages of this approach that it produced highly replicable results as well as showed unambiguous nature. An important idea of the methodology is the highlighting of key impacts via a "red flag system". The methodology was developed by Walton *et al*. (1972) [118] for the evaluation of highway alternatives and identification of impacts. A checklist based methodology was relying on social impact categories and public participation. All impacts were measured by either their dollar value or a weighed function of the number of persons affected. But this approach was impractical for large projects due to lack of specific data and poor replicability.

Palwal (2006) [89] conducted an EIA process in India through strength, weakness, opportunity & threat (SWOT) approach and found that in India, impact assessment pivot on legislative and administrative framework. Various limitation ranging from improper screening and scoping guidelines to effective monitoring and post project evaluation were highlighted.

Leopold *et al*. (1971) [66] suggested an open –cell matrix approach used to identify 100 projects activities and 88 environmental characteristics or condition. An analyst evaluate the impacts of every project action on each environmental attributes in terms of impact magnitude and significance. This approach addressed only ecological & physical- chemical aspect, social, indirect impact where as economic and secondary impacts were completely negotiable. This methodology was reliable on several viewpoints. It does not developed in reference to any specific type of project but also applied on broad prospective: resources requirements were very flexible so the assessment made are subjective. The reliance on subjectivity, again without guidance reduce the replicability of the approach. Desertification is a process of environmental resource degradation associated with dry lands. The factor-interaction matrix was then used by Nallathiga, (2005) to in identifying the interactions between various processes leading to desertification under broad categories of Land, Water, Soil, Climate, Vegetation, Socio-economics, which led to drawing the Leopold matrix for assessing desertification. The Leopold matrix comprises the major activities (26) causing resource degradation and major parameters (19) being affected. Leopold matrix comprised of assessing activity-wise impact score (Is), which is essentially the product of magnitude score (Ms) and significance score (Ss) i.e., I ~ M*S. The activity-wise impact scores were aggregated across the parameters along the interactions in order to arrive at individual parameter-wise impacts i.e., ∑Is. The final aggregate impact scores were weighted impact scores over parameters, with the weights derived from the ranking of parameters (Rp). The aggregate impact score i.e., ∑ Rp*Is would indicate the net impacts of various activities leading to resource degradation. EIA matrix method can be utilised for assessing the net aggregate impacts using both assessment criteria as well as expert judgment. The desertification index was constructed based on it and the extent of the problem due to resource degradation was evaluated in the district Anantapur.

This approach proposed by McHarg (1985) employed an overlay method. It involved eleven to sixteen environmental attributes mapped on transparencies called themes. This method is applicable for a variety of project types. Resources requirements of this approach less demanding. Its inability to quantify as well as identify possible impact was considered as major limitation. This method was considered as most useful as a "first cut method" to identify alternative project sites before impact analysis. This methodology was designed by Krauskopf *et al.* (1972) to implement an overlay technique via computer mapping. It was developed for a national highway by using certain environmental attributes. Data on a large number of environmental attributes were collected and stored in the computer on a grid system of 1 km square cells. Because the approach required vast amount of data on the project site, so it was not practicable for broad geographical regions. The high man power skill, money and computer technology were considered as major limitation of this methodology. This methodology was attractive on several viewpoints. It present readily digestible graphic representation of impacts and it easily handles several subjective weighting systems.

This approach was designed to unite a list of manufacturing related activities to environmental aspects and finally to human use. It displays cause – condition effect network and tracing out secondary impact chains. Network method was used to identify impact in terms of magnitude and significance. Significance was addressed only in terms of low, moderate, high or negligible damage. This assessment technique has low replicability due to its subjective evaluation (Moore *et al.*, 1973) [77]. This methodology was designed by Stover and Llyod (1972) [114] quantitative evaluation of environmental impacts from project activities. Fifty different impact parameters were considered. Sub parameters indicate specific impacts, but there was no indication of how the individual measures were aggregated into a single parameter value. In this approach, the actual measurements were not based on specific criteria, resources requirement were moderate to heavy. Therefore, there is potential for ambiguous and subjective results, with only moderate replicability.

Among many environmental impact of industrialization &urbanization the one with highest profile currently was global warming which demands changes from Govt & public sector. Global warming was considered GHG emission from various human activities like land use changes, burning of fossil fuels & deforestation (Buchanan & Honey, 1994) [14]. So it was necessary to reduce GHG by 50% to stabilise global concern by 2100 (Houghton, 2001) [48]. The construction of industry was highly active sector all over the world (UNEP) responsible for a high rate of energy consumption &resources depletion (NBT).There were many methods for assessing the environmental impacts of material & component of industrial sector. Life cycle assessment (LCA) was a methodology used for evaluating impacts of processes and product during their life cycle (Sonnemann, Castells & Schuhmacher, 2003) [110]. LCA was started in 1960s (Selmes, 2005) [107] assessed the whole life cycle of product, process of raw material, manufacturing, transportation & industrialization (Consoli, 1993) [22]. Khasreen, Banfill and Menzies (2009) [60] used this methodology to build material as building within last 15 years in Europe & United States. Industrial means are used on large scale in farming sector to increase the production, leads to depletion of non-renewal resources, increase GHG emission & pollution from chemical substances leads to soil acidification & eutrophication (Bienkowski *et al.*, 2014; Nemecek *et al.*, 2011) [10, 87]. LCA primarily used in industrial sector but now a days it has become act as a management tool in agricultural sector((Caffrey & Veal, 2013) [15].). For the assessment of environmental impact of winter wheat production linked to modern practices of crop production, Life Cycle Assessment was used by (Holka, 2016) [10] in 2 large farms located in Wielkpolska region (Poland).

Life Cycle Assessment methodology used in this study was compared of 4 phases: goal & scope definition; inventory analysis; impact assessment &interpretation (Brentrup, Kusters, Kuhlmann & Lammel, 2004) [13]. Two functional units were used: 1.0 hectare expressing the intensity of wheat production system & 1.0 ton of grain which is a measure of its efficiency. Impact for the different categories of soil & water acidification, euthrophication, the depletion of abiotic resources, photochemical oxidants &climate change were determined (Guinee *et al.*, 2002) [37].

Traditional agricultural production methods had adverse effect on environment and was considered as source of contamination of air, H_2O, soil declining biodiversity & genetic diversity (FAO, 2007) [29]. A study was conducted by (Huerta, 2012) [51] to evaluate and compare conventional and organic methods or production on using LCA. This method has also been used in studies of vegetables (Anton, 2004), fruit trees (Pizzigallo *et al.*, 2008) [96], rice (Blengini & Busto 2009) [11], wheat (Meisterling *et al.*, 2009) [79], grasslands (Haas *et al.*, 2001) [38], milk (Hospido *et al.*, 2003) [47], soil use (Peters *et al.*, 2003) [95], as well as local factors of agricultural production (Mila, 2003), which shows its usefulness in analyses of the potential environmental impact of agricultural production during a life cycle. The methodology employed was the CML 2000 (Institute of Environmental Sciences of the University of Leiden, Holanda), which defined an environmental profile by quantifying the environmental effect of various categories of the product, process or service analyzed (Munoz, 2008) [82]. A unit of reference is established for each of the categories, expressing the impact as the equivalent quantity of each of the components as a function of the characterization factors. The data obtained were analyzed using the software Sima Pro 7.3, which allows LCA to be performed using its own inventory data. The results identified soil management as the stage of conventional production that generates the greatest environmental impact; the most affected impact categories were acidification, with 15.28 kg SO_2 equivalent per ton of grain produced, and eutrophication, with 4.83 kg PO_4 eq/ton of grain. The category most affected by organic production was soil management, mainly due to the Diesel fuel used in agricultural machinery.

Flood risk assessment and flood damage analysis was done in terms of flood vulnerability in the aspects of ecological, community, financial and physical (Nasiri *et al*., 2013) [85]. Generally, vulnerability is defined as the potential for loss when a disaster has been taken place (Sane *et al*., 2015) [106]. Flood vulnerability assessment has been studied in the flood prone areas Malaysia were well identified; however, there was still a lack of appropriate measurement to identify how vulnerable the prone areas will be affected (Akukwe & Ogbodo, 2015) [3]. Currently the visualization tool such as Weighted Linear Combination methods in Geographic Information System (GIS) and Moderate Resolution Imaging Spectro radiometer (MODIS) were commonly approaches used in flood vulnerability assessment but very sensitive to weights of sub-indices which the calculation of weighting depends on arbitrary decisions which will reduce the applicability, which can be placed in such weighting methods (Wei *et al*., 2004) [122]. The assessment of flood vulnerability could provide multi-information about flood disaster scenario in Malaysia studied by Saharizan *et al*. (2018) [104]. Data Envelopment Analysis (DEA) was a powerful approach to measure efficiency of decision making units (DMUs) with a set of input and output variables (Khodabakhshi & Asgharian, 2009) [61]. The flood vulnerability could be calculated by the ratio between the input and output variables which the process of flood hazard is observed as “input-output” system (Huang *et al*., 2012) [50]. A range scale of 0 to 1 was used as the indicator reading to explain the vulnerability level of DMUs (Nasiri & Shahmohammadi-Kalalagh, 2013) [85]. In this study, 11 states in Peninsular Malaysia were selected as the DMUs by using the secondary data (2004 to 2014). Three dimensions were focused in this study based on the previous research and the data availability; (1) Population Vulnerability, (2) Social Vulnerability and (3) Biophysical Vulnerability. DEA model was measured using the Efficiency Measurement System (EMS) software. Based on the efficiency range scale of 0 to 1, the vulnerability score of 1 is concluded as the most vulnerable to flood disaster and the vulnerability score approach to 0 is concluded as the least vulnerable to flood disaster (Nasiri & Shahmohammadi-Kalalagh, 2013) [85]. Generally, the efficiency score of a DMU is measured in terms of the ratio of the sum of weighted outputs to the sum of weighted inputs as follows:

Efficiency = sum of weighted outputs/ sum of weighted inputs

Constant Return to Scale (CRS) DEA model was focused on multidimensional of flood vulnerability assessment for each Peninsular Malaysian states of Population Vulnerability, Social Vulnerability and Biophysical Vulnerability. A input-output model based study was conducted by Huang *et al*. (2011) [49] on data envelopment analysis (DEA), used for the assessment of regional vulnerability to natural hazards in China. The result showed that the overall level of vulnerability to natural hazards in mainland China is high.

Like the power industry, assessment of water resources involves establishing the amount, quality, and availability by evaluation of the possibilities of sustaining their development, management, and control should be emphasized. The issue of greenhouse gas emissions in Europe is becoming important, so it is necessary to avoid deforestation, use new technologies, and use renewable energy sources—either geothermal, solar, wind, or hydropower (European Commsision). Zelenakova *et al*. (2018) [126] proposed an activity construction of small hydropower plant is located in the village Spisske Bystre, district of Poprad, Eastern Slovakia to assess its impacts by using matrix method under different criteria for the purposes of the evaluation. Impact matrix combines qualitative and quantitative methods with verbal and numerical scales. The assessment was done by seven experts—the authors and three more people—the experts working in the field of SHP plant design and/or the assessment of environmental impacts of SHP plants, and one of them is working in the landscape ecology—the nature protection. They used the brainstorming method. They consulted the selection of the criteria and emphasized on the nature, extent, and duration of the effects.

Conclusions

Environment Impact Assessment (EIA) is one of the proven anticipatory and legislative tool used to predict the environmental consequences of any development project. While many EIA methods exist, they are not uniformly used in all impact studies. Conversaly, the greatest encouragement comes from information dissemination on different EIA methods and their interrelationships. However, existing conventional EIA methods are expensive, time consuming and sometimes suffer subjective bias in assessment of the project in the environment. For sound management of environmentally sensitive development projects, conventional EIA have not provided a holistic picture of the impact scenario. Henceforth, GIS overcome limitation of conventional EIA and provide an unbiased and interpretable EIA. Therefore, GIS will consider as the best method to assess the environmental impacts of roadways expansion activity.

References

1. Adkins WG, Dock B. Interim Report: Social, Economic, And Environmental Factors in Highway Decision making, research conducted for the Texas Highway Department in cooperation with the U.S. Department of Transportation, Federal Highway Administration: College Station, Texas; Texas Transportation Institute, Texas A&M University, 1971.
2. Aiswarya M, Sruthi M. Environmental Impact Assessment of Water Using RIAM (Rapid Impact Assessment Matrix). International Journal of Scientific & Engineering Research. 2016; 7(4):206-221.

3. Akukwe T, Ogbodo C. Spatial analysis of vulnerability to flooding in Port Harcourt Metropolis, Nigeria. SAGE Open. 2015; 5(1):1-9.
4. Anjaneyulu Y, Manickam V. Environment impact assessment methodologies. 2nd ed. B. S. Publication. Hyderabad, 2007, 32-34.
5. Anton A, Castells F, Montero JI, Huijbregts M. Comparison of toxicological impacts of integrated and Chemicals pest Management in Mediterranean greenhouses. Chemosphere. 2004; 54:1225-1235.
6. Antunes P, Santos R, Jordao. The application of geographical information systems to determine environmental impact significance. Environmental Impact Assessment Review. 2001; 21:511-535.
7. Bakshi PN. The Constitution of India. Law Publisher, Allahabad, India, 1998.
8. Banerjee P, Ghose MK. Spatial analysis of environmental impacts of highway projects with special emphasis on mountainous area: an overview. Impact assessment and project appraisal, 2016, 2-10.
9. Barker A, Wood C. An evaluation of EIA system performance in eight EU countries. Environmental Impact Assessment Review. 1999; 19:387-404.
10. Bienkowski J, Jankowiak J, Dąbrowicz R, Holka M In*:* Regional differentiation of greenhouse gas emissions from agriculture in Poland. Abstract 425-426. - In: Pepo, P., Csajbok, J. (eds.) Book of Abstracts, ESA XIIIth Congress, Debrecen, Hungary. 25-29 August. University of Debrecen, Debrecen, Hungary, 2014.
11. Blengini G, Busto M. The life cycle of rice: LCA of alternative agri-food chain management systems in Vercelli (Italy). Journal of Environmental Management. 2009; 90:1512-1522.
12. Bojorquez TLA, Garcıa O. An approach for evaluating EIAS—Deficiencies of EIA in Mexico. Environmental Impact Assessment Review. 1998; 18:217-240.
13. Brentrup F, Kusters J, Kuhlmann H, Lammel J. Environmental impact assessment of agricultural production systems using the Life Cycle Assessment (LCA) methodology II. The application to N fertilizer use in winter wheat production systems. European Journal of Agronomy. 2004a; 20:247-264.
14. Buchanan AH, Honey BG. Energy and carbon dioxide implications of building construction. Energy and Buildings. 1994; 20(3):205-217.
15. Caffrey KR, Veal MW. Conducting an Agricultural Life Cycle Assessment: Challenges and Perspectives. The Scientific World Journal, 2013, 1-13.
16. Canter LW, Hill LG. Handbook of variables for environmental impact assessment. Ann Arbor, Mich: Ann Arbor Science Publishers, 1979.
17. Chang KT. Introduction to geographic information systems. 4th ed. New Delhi: McGraw Hill Education, 2008.
18. Chen W, Warren KA, Duan N. Incorporating cleaner production analysis into environmental impact assessment in China. Environmental Impact Assessment Review. 1999; 19:457-476.
19. Chopra T, Aggrawal, Chowdhry P. Analyzing strategic tissues of environmental impact assessment for highway projects with a case study of Indian National highway, ICPT, 2011.
20. Chou SY, Chang YH, Shen CY. A fuzzy simple additive weighting system under group decision-making for facility location selection with objective/subjective attributes. European Journal of Operational Research. 2008; 189:132-145.
21. Clark BDK, Chapman R, Bisset P, Wathern, Barrett M. A manual for the assessment of major developments. HMSO, London, 1981, 210.
22. Consoli F, Allen D, Boustead I, Fava J, Franklin W, Jensen A, Oude N, Parrish R, Perriman R, Postlethwaite D, Quay B, Seguin J, Vigon B. Guide Lines for Life-Cycle Assessment: A 'Code of Practice'; Society of Environmental Toxicology and Chemistry SETAC: Pensacola, FL, USA, 1993.
23. Dee Norbert, *et al*., Environmental Evaluation System for Water Resources Planning, report to the U.S. Bureau of Reclamation, Columbus, Ohio: Battelle Memorial Institute, 1972.
24. Demers MN. Fundamentals of geographic information systems. 4th ed. New Delhi: Wiley India, 2009.
25. Dooley JE, Newkirk RW. Corridor selection method to minimize the impact of an electrical transmission line. Interim Rep., James F. MacLaren Ltd., Toronto, Canada, 1976.
26. Enea M, Salemi G. Fuzzy approach to the environmental impact evaluation. Ecological Modelling. 2001; 13:131-147.
27. Elgafy MA. Environment impact assessment of transportation projects: An analysis using an integrated GIS, Remote sensing and spatial modelling approach. (Ph.D Thesis). Florida State University, 2005.
28. European Commission—Renewable Resources of Energy, 2015.
29. FAO. El medio ambiente y la agricultura. Comit de Agricultura. Roma, 25-28 de abril de, 2007, 1-16.
30. Fischer DW, Davies GS. An approach to assessing environmental impact - Journal of Environmental Management. 1973; 1:207-227.
31. Fouladgar MM, Yazdani CA, Zavadskas EK, Moini SHH. A new hybrid model for evaluating the working strategies: Case study of Construction Company. Technological and Economic Development of Economy. 2012; 18:164-188.
32. Ghasemian M, Poursafa P, Amin MN, Ziarati M, Ghoddousi H, Momeni SA, Rezaei AH. Environmental Impact Assessment of the Industrial Estate Development Plan with the Geographical Information System and Matrix Methods. Journal of Environmental and Public Health, 2011, 1-8.
33. Gilliland MW, Risser PG. The use of systems diagrams for environmental impact assessment: procedure and an application. Ecological Modeling, 1977; 3(1977):183-209.
34. Gontier M, Ortberg UM, Balfors B. Comparing GISbased habitat models for applications in EIA and SEA. Environmental Impact Assessment Review. 2010; 30(1):8-18.
35. Goyal SK, Deshpande VA. Comparison of weight assignment procedures in evaluation of environ- mental impacts. Environmental Impact Assessment Review. 2001; 21:553-563.
36. GTZ (German Technical Cooperation/ Deutsche Gesellschaft fur Technische Zusammenarbeit The approach provides a systematic), ZOPP in Brief, ZOPP Flipcharts, An Introduction to the Method. Eschborn, Germany, 1987.
37. Guinee J, Gorree M, Heijungs R, Huppes G, Kleijn R, DeKoning A, Van Oers L, Wegener SA, Suh S, Udo de

Haes HA, Bruijn DH, Duin VR, Huijbregts MAJ. Handbook on life cycle assessment. Operational guide to the ISO standards. I: LCA in perspective. IIa: Guide. IIb: Operational annex. III: Scientific background. Kluwer Academic Publishers, Dordrecht, Netherlands, 2002.
38. Haas G, Wetterich F, Kopke U. Comparing intensive, extensive field and organic grassland farming in southern Germany by process life cycle assessment. Agriculture, Ecosystems & Environment. 2001; 83:43-53.
39. Hashemkhani ZS, Sedaghat M, Zavadskas EK. Performance evaluating of rural ICT centers (telecenters), applying fuzzy AHP, SAW-G and TOPSIS Grey, a case study in Iran. Technological and Economic Development of Economy. 2012; 18:364-387.
40. Henne LJ, Schneide DW, Martinezr LM. Rapid assessment of organic pollution in a West-Central Mexican river using a family-level biotic index. Journal of Environmental Planning and Management. 2002; 45:613-632.
41. Hill M. A method for the evaluation of transportation plans. Highway Research Record. 1967; 180:21-34.
42. Hill M. A goals-achievement matrix for evaluating alternative plans. Journal of the American Institute of Planners. 1968; 34(1):19-29.
43. Hill M, Werczberger E. Goal programming and the goal achievement matrix. International Regional Science Review. 1978; 3(2):165-181.
44. Hokkanen J, Salminen P. Choosing a solid waste management system using multicriteria decision analysis. European Journal of Operational Research. 1997; 98:19-36.
45. Holka M, Jankowiak J, Bienkowski JF, Dabrowicz R. Life cycle assessment(LCA) of winter wheat in an intensive crop production system in Wielkopolska region (Poland). Applied Ecology and Environmental research. 2016; 14(3):535-545.
46. Hopkinson P, James P, Sammut A. Environmental performance evaluation in the water industry of England and Wales. Journal of Environmental Planning and Management. 2000; 43:873-895.
47. Hospido A, Moreira MT, Feijoo G. Life Cycle inventory of the Galician dairy sector. In: 4th International Conference on: Life Cycle assessment in the Agri-food. Halber, N. and Weidema, B. (Ed). Horsens, Denmark. Danish Institute of Agricultural Sciences, 2003.
48. Houghton JT, Ding Y, Griggs DJ, Noguer M, Van Der Linden PJ, Dai X, Maskell K, Johnson CA. Climate Change 2001 Third Assessment Report (TAR) :The Scientific Basis, The Summary for Policymakers; Cambridge University Press: Cambridge, UK, 2001.
49. Huang J, Liu Y, Ma L. Assessment of Regional Vulnerability to Natural Hazards in China Using a DEA Model. International Journal of Disaster Risk Science. 2011; 2(2):41-48.
50. Huang D, Zhang R, Huo Z, Mao F, Zheng EYW. An assessment of multidimensional flood vulnerability at the provincial scale in China based on the DEA method. Natural Hazards. 2012; 64(2):1575-1586.
51. Huerta JH, Alvear EM, Navarro RM. Evaluation of two production methods of Chilean wheat by life cycle assessment (LCA). Paginas. 2012; 30(2):101-110.
52. Hui IK, He L, Dang C. Environmental impact assessment in an uncertain environment. International Journal of Production Research. 2002; 40:375-388.
53. Hwang CL, Yoon K. Multiple attributes decision making methods and applications. New York, NY: Springer Berlin Heidelberg, 1981.
54. Jarvis AP, Younger PL. Broadening the scope of mine water environment impact assessment: A UK Perspective. Environmental Impact Assessment Review. 2000; 20:85-96.
55. Jay S, Handley J. The application of environmental impact assessment to land reclamation practice. Journal of Environmental Planning and Management. 2001; 44:765-782.
56. Jensen K. Environmental Impact Assessment Using the Rapid Impact Assessment Matrix (RlAM), Olsen & Olsen, Fredensborg, Denmark, 1998.
57. Johnson FL, Bell DT. Guidelines for the identification of potential environmental impacts in the conservation and operation of a reservoir. Forestry Research. 75-76. Department of forestry, University of Illinois Champaign, 1975.
58. Keeney R, Raiffa H. Decision with multiple objectives: Preferences and value tradeoffs: Cambridge University Press, 1976.
59. Keeney RL, Robilliard GA. Assessing and evaluating environmental impact at proposed nuclear power plant sites. Journal of Environmental Economics and Management. 1977; 4(2):153-166.
60. Khasreen MM, Banfill PFG, Menzies GF. Life-Cycle Assessment and the Environmental Impact of Buildings: A Review. Sustainability. 2009; 1:674-701.
61. Khodabakhshi M, Asgharian M. An input relaxation measure of efficiency in stochastic data envelopment analysis. Applied Mathematical Modelling. 2009; 33(4):2010-2023.
62. Kim TY, Kwak SJ, Yoo SH. Applying multi-attribute utility theory to decision making in environ- mental planning: A case study of the electric utility in Korea. Journal of Environmental Planning and Management. 1998; 41:597-609.
63. Kirkwood CW. A case history of nuclear power plant site selection. The Journal of the Operational Research Society. 1982; 33:353-363.
64. Krauskopf TM, Dennis CB. Evaluation of enviornmental impact through a computer modelling process, Enviornmental impact analysis: Philosolophy and Methods, (eds.) Roberts Ditton and Thomas Goodale, Madison, Wisconsin: University of Wisconsin Sea Grant Programme, 1972, 107-125.
65. Leopard LB. A Procedure for Evaluating Enviornmental Impact, Geological Survey Circular 645, Washington: Govenment Printing Office, 1971.
66. Leopold LB, Clarke FE, Hanshaw BB, Balsley YJR. A procedure for evaluating environmental impact. Geological Survey Circular 645. U.S. Government Printing Office. Washington, DC, 1971.
67. Leu WS, Williams WP, Bark AW. Development of an environmental impact assessment evaluation model and its application: Taiwan case study. Environmental Impact Assessment Review. 1996; 16:115-133.
68. Lichfield N, Kettle P, Whitbread M. Evaluation in the Planning Process, Pergamon Press: Oxford, 1975.
69. Li X, Wang W, Li F, Deng X. GIS based map overlay method for comprehensive assessment of road environmental impact. Transport and Environment. 1999; 4(3):147-158.

70. Lloyd CD. Spatial data analysis – an introduction for GIS users. Oxford: Oxford University Press, 2010.
71. Lohani BN, Thanh NC. Probabilistic water quality control policies. Journal of Environmental Engneering Division, 1979, 713-725.
72. Longley PA, Goodchild MF, Maguire Dj, Rhind DW. Geographic information systems and science. 2nd ed. West Sussex: john Wiley and Sons, 2005.
73. Malczewski J. A GIS based multicriteria decision analysis: a survey of the literature. International Journal of Geographical Information System. 1999; 20:703-726.
74. Munda G, Nijkamp P, Rietveld P. Qualitative multicriteria evaluation for environmental management. Ecological Economics. 1994; 10:97-112.
75. Medineckiene M, Bjork F. Owner preferences regarding renovation measures – The demonstration of using multi-criteria decision making. Journal of Civil Engineering and Management. 2011; 17:284-295.
76. McHarg I. A Comprehensive Highway Route-selection Method. Highway Research Record. 1968; 246:1-15.
77. Moore JL. A Methodology for Evaluating Manufacturing Enviornmental Impact Statements for Delaware's, Columbus, Ohio: Battelle Memorial Institute, 1973.
78. Marttunen M, Hamalainen RP. Decision analysis interviews in environmental impact assessment. European Journal of Operational Research. 1995; 87:551-563.
79. Meisterling K, Samaras CY, Schweizer V. Decisions to reduce greenhouse gases from agriculture and product transport: LCA case study of organic and conventional wheat. Journal of Cleaner Production. 2009; 17:222-230.
80. Mila L. Contributions to life cycle analysis for agricultural systems. Site-dependency and soil degradation impact assessment. Tesis doctoral. Facultat de Ciencies. Universitat Autonoma. Bellaterra, 2003.
81. Mubvami T. Environmental impact assessment. Department of rural and urban planning. University of Zimbabwe, 1991.
82. Munoz E. Revaloracion sustentable de residuos sólidos de la industria elaboradora de cloro soda mediante análisis de ciclo de vida. Tesis magíster. Universidad de La Frontera. Temuco, Chile, 2008, 80.
83. Nallathiga R. Dsertification assessment using matrix method. Proceedings of the fifth international conference on operation research for development. Jamshedpur, Operations research society of India (ORST), 2005.
84. Namin FS, Ghafari H, Dianati A. New model for environmental impact assessment of tunneling projects. Journal of Environmental Protection. 2014; 5(53):0-550.
85. Nasiri H, Shahmohammadi-Kalalagh S. Flood vulnerability index as a knowledge base for flood risk assessment in urban area. Sustainable Water Resources Manangement, 2013, 331-336.
86. Natural Building Technologies (NBT). Building Environmental Impact. Natural Building Technologies, 2009.
87. Nemecek T, Huguenin EO, Dubois D, Gaillard G, Schaller B, Chervet A. Life cycle assessment of Swiss farming systems: II. Extensive and intensive production - Agricultural Systems. 2011; 104:233-245.
88. Palevicius V, Paliulis GM, Venckauskaite J, Vengrys B. Evaluation of the requirement for passenger car parking spaces using multi-criteria methods. Journal of Civil Engineering and Management. 2013; 19:49-58.
89. Palwal. EIA practice in India and its evaluation using SWOT analysis. Environmental Impact Assessment Review. 2006; 26:492-510.
90. Parkin J. A philosophy for multiattribute evaluation in environmental impact assessments. Geoforum. 1992; 23:467-475.
91. Parashar A, Paliwal R, Rambabu P. Utility of fuzzy cross-impact simulation in environmental assessment. Environmental Impact Assessment Review. 1997; 17:427-447.
92. Pastakia CMR, Bay J. Initial Environmental Evaluation of Alternative Methods to Conserve the Rupa Tal, Nepal. In: Jensen, K., Ed., Environmental Impact Assessment Using the Rapid Impact Assessment Matrix (RIAM), Olsen & Olsen, Fredensborg, 1998, 52-61.
93. Pastakia CMR. The rapid impact assessment matrix (RlAM)-A new tool for environmental impact assessment. In: Environmental Impact Assessment Using the Rapid Impact Assessment Matrix- RIAM (Ed. K. Jensen), Olsen & Olsen, Fredensborg, Denmark, 1998.
94. Pastakia CMR, Jensen A. The rapid impact assessment matrix (RIAM) for environmental impact assessment. Environmental Impact Assessment Review. 1998; 18(5):461-482.
95. Peters J, García Quijano J, Conten T, Van Wyk G, Holden NM, Ward SM, Muys B. A new land use impact assessment method for LCA: theatrical fundaments and field validation. In: 4th International Conference on: Life Cycle assessment in the Agri-food. Halber, N. and Weidema, B. (Ed). Horsens, Denmark. Danish Institute of Agricultural Sciences, 2003.
96. Pizzigallo A, Granai C, Borsa S. The join use of LCA and emergy evaluation for the analysis of two Italian wine farms. Journal of Environmental Management. 2008; 86:396-406.
97. Pun K, Hui IK, Lewis WG, Lau HCW. A multiple-criteria environmental impact assessment for the plastic injection molding process: A Methodology. Journal of Cleaner Production. 2003; 11:41-49.
98. Rosencranz A, Rustomjee S. India- citizen's right to a healthful environment. Environmental Policy and Law. 1995; 25(6):324-329.
99. Ramanathan R. A note on the use of the analytic hierarchy process for environmental impact assessment. Journal of Environmental Management. 2001; 63:27-35.
100. Rau JG, Wooten DC. Environmental Impact Analysis Handbook, McGraw-Hill, New York, NY, USA, 1980.
101. Rikhteger N, Mansouri N, Oroumieh AA, Chamzini AY, Zavadskas EK, Kildiene S. Environmental impact assessment based on group decision –making methods in mining projects. Economic Research. 2014; 27(1):378-392.
102. Rogers M, Bruen M. Choosing realistic values of Indifference, preference and veto thresholds for use with environmental criteria within ELECTRE. European Journal of Operational Research. 1998; 107:542-551.
103. Sagar MK, Jayaswal P, Kushwah K. Exploring fuzzy SAW method for maintenance strategy selection problem of material handling equipment. International Journal of Current Engineering and Technology. 2013; 3:600-605.
104. Saharizan NS, Zahid Z, Husin SAS. Spatial flood vulnerability assessment peninsular Malaysia using data envelopment analysis (DEA). Journal of Technology Management and Business. 2018; 5(1):51-57.

105. Samani KM, Hosseiny SA, Lotfalian M, Najafi L. Planning road network in mountain forests using GIS and Analytic Hierarchical Process (AHP). Caspian journal of Environmental Science. 2010; 8:151-162.
106. Sane OD, Gaye AT, Diakhate M, Aziadekey M. Social Vulnerability Assessment to Flood in Medina Gounass Dakar. Journal of Geographic Information System. 2015; 07(04):415-429.
107. Selmes DG. Towards Sustainability: Direction for Life Cycle Assessment. Ph.D. Thesis. Heriot Watt University: Edinburgh, UK, 2005.
108. Sinclair AJ, Duck AP. Public involvement in environmental impact assessment: A case study of hydro development in kullu district, Himachal Paradesh, India. Impact Assessment and Project Appraisal. 2000; 18(1):63-75.
109. Solnes J. Environmental quality indexing of large industrial development alternatives Using AHP. Environmental Impact Assessment Review. 2003; 23:283-303.
110. Sonnemann G, Castells F, Schuhmacher M. Integrated Life-Cycle and Risk Assessment for Industrial Processes; Lewis Publishers: Boca Raton, FL, USA, 2003.
111. Sorensen JC. A Framework for identification and control of resource degradation and conflict in the multiple use of the coastal zone. University of California, Berkeley Department of Landscape Architecture, M.S.thesis, University of California Press, 1971.
112. Sowman M, Fuggle R, Preston G. A Review of the Evaluation of Environmental Evaluation Procedures in South Africa. Environmental Impact Assessment Review. 1995; 15:45-67.
113. Steinemann A. Improving alternatives for environmental impact assessment. Environmental Impact Assessment Review. 2001; 21:3-21.
114. Stover, Llyod V. Enviornmental Impact Assessment: A Procedure, Miami, Florida: Sanders and Thomas, Inc, 1972.
115. Swanson T. Global Action for Biodiversity. Earthscan, London, 1997.
116. Tamosaitiene J, Sipalis J, Banaitis A, Gaudutis E. Complex model for the assessment of the location of high-rise buildings in the city urban structure. International Journal of Strategic Property Management. 2013; 17:93-109.
117. Tukker A. Life Cycle Assessment as a tool in environmental impact assessment. Environmental Impact Assessment Review. 2000; 20:435-456.
118. Walton L, Ellis J, James EL. A manual for conducting environmental impact studies. Virginia Highway Research council, 1971.
119. Wang MS, Yang JS. A multi-criterion experimental comparison of three multi-attribute weight measurement methods. Journal of Multi-Criteria Decision Analysis. 1998; 7:340-350.
120. Wang YM, Yang JB, Xu DL. Environmental impact assessment using the evidential reasoning approach. European Journal of Operational Research. 2006; 174:1885-1913.
121. Weaver AB, Greyling T, Van WBW, Kruger FJ. Logistics and team management of a large environment impact assessment: Proposed Dune Mining at St Lucia, South Africa. Environmental Impact Assessment Review. 1996; 16:103-113.
122. Wei YM, Fan Y, Lu C, Tsai HT. The assessment of vulnerability to natural disasters in china by using the DEA Method. Environmental Impact Assessment Review. 2004; 24(4):427-439.
123. Welch HW, Lewis GD. Assessing environmental impacts of multiple use of land management. Journal of Environmental Management. 1976; 4:197-209.
124. Weston J. EIA, decision-making theory and screening and scooping in UK Practice. Journal of Environmental Planning and Management. 2000; 43:185-203.
125. Yeboah KK, Asare EB, Boakye PG, Aki MN. Rapid Impact Assessment Matrix (RIAM) – An analytical tool in the prioritization of water resources management problems in Ghana. Journal of the Faculty of Environmental Science and Technology. 2005; 10(1):75-81.
126. Zelenakova M, Fijko R, Diaconu DC, Remenakova I. Environmental impact of small hydro power plant- a case study. Environments. 2018; 5(12):2-10.
127. Zhu X. GIS and spatial decision support. In: Dawsen Cj, editor. Environmental science, engineering and technology: geographic information system. New York, NY: nova Scientific, 2011, 1-33.
128. Zolfani SH, Rezaeiniya N, Zavadskas EK, Turskin Z. Forest roads locating based on AHP and CoPrAS-G method: an empirical study based on Iran. Ekonomie. 2011; 4:6-21.