

Towards Improvement of Environmental Impact Assessment Methods - A Case Study in Golestan Province, Iran

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Abstract: Environmental researchers in Iran have encountered serious and new challenges about the methods that can adequately respond to research demands posed by the country's recent rapid economic and social development. On one side, traditional methods of environmental impact assessment¹ (EIA) have been criticized severely by specialists and on the other, theoretical bases and practical conditions for implementing new methods of environmental impact assessment are not fully appreciated. Hence, the need to development of useful concepts and methods of environmental impact assessment is felt more than ever. The response of specialists to this need has varied between adopting complicated or simplified procedures in a hasty manner. This paper indicates that improvement of environmental impact assessment methods is achievable, using the basic concepts on ecology and the relevant fields. In addition, authors believe that determining the status and revising current methods of environmental impact assessment will be helpful to recognize the development trend of the EIA. In this paper, we review a new and of EIA and contrast it with a traditional application in Iran. To this end, a case study in the Golestan Province, Iran has been chosen which includes selection of two sites from five suggested locations for landfill and compost plants. The study provides a ground for criticizing and testing some concepts of the new and the traditional methods in selecting from the sites.

Key words: Environmental impact assessment • Traditional methods • Modern methods • Golestan Province

INTRODUCTION

Development, Classification: Reviewing, evaluating and criticizing scientific methods are issues that interdisciplinary teams of researchers in the entire world are always concerned with. Environmental Impact Assessment (EIA) as a branch of science is no exception. EIA is a scientific assessment to be carried out before any project or major activity is undertaken to ensure that it will not harm the environment on a short-term or long-term basis [1].

The range of evaluating and criticizing scientific methods varies between basic and general concepts of each branch of science. This is the same for environmental impact assessment. For instance, Shopley and Fuggle while reviewing the methods of EIA such as Ad Hoc, Checklist, Matrix, Networks, Map Overlay,

Modeling, Evaluation and Adaptive methods [2], classify all the assessment methods in eight groups and check their weaknesses and strengths. It is worth noting these methods are still the same as the past, except their mathematical and statistical bases which have improved through years of practice. In addition, these methods need more information as they become more science-based and complicated. Specialists are always reflecting on the relevance of the environmental impacts from ecological, economical and social aspects to any specific development plan. In 1986, Duinker and Beanlands studied the concept of impacts and their significance [3]. Then in 1988, Thompson counted 24 ways for ascertaining of impacts significance [4]. In addition, the need for merging the results of biological, social and economical impacts is another subject that is not raised by most authors in their studies. For instance, Hobbs

studied viewpoints which were related to this subject and suggested some combination rules [5]. In 1998, Bojorquez-Tapia *et al.* discussed the use of mathematical techniques in order to improve the procedure undertaken in any EIA [6].

Non-parametric statistics such as Bayesian theory [7], Fuzzy logic [8, 9], Neural Networks [10] are examples which are added to the concepts and methods of EIA in recent years, in order to make them more practical and provide acceptable results and a means of consensus among stakeholders.

In another effort, Mahiny suggested comprehensive indexes for rapid environmental impact assessment, in the hope of providing more acceptable assessments when time and resources for assessment are limited. In this study, efforts are made to use geographical information system and remote sensing as a basis for rapid environmental impact assessment. The method is clear, straightforward and reproducible which adds to its appeal to the involved practitioners [11].

Comparative studies are another aspect of efforts to improve the environmental impact assessment methods in recent years. For instance, Ahmad and Wood made a comprehensive study on environmental impact assessment systems in Egypt, Turkey and Tunisia in 2002 [12]. In addition, the methods of decision making, screening and scoping of environmental impacts assessment have been studied and considered comprehensively in England by Weston in 2000 [13]. Merging the methods of environmental impact assessment in Expert System Tools [14] and Decision Support Systems are subjects currently under discussion. Daini used statistical methods to study the environmental impact assessment and strategic impact assessment comprehensively [15]. In 2001, Fujikura and Nakayama in a case study, considered the causes of flaws in the EIA carried out in Canada [16]. In 1998, Warnken and Bukley reviewed the scientific basis of EIA of tourism in Australia [17]. They indicated that the scientific basis of these assessments generally is low, because of:

- Lack of using experimental, quantitative and repeatable predictions,
- No attention to the significance of impacts and
- Using subjective and intuitive assessments.

Our Literature Reviews Reveals at Least Two Things among Others: First, the general trend of all EIA attempts is to make it more science-based and objective. Second, all these efforts are taken to make the EIA more practical and

realistic. Specialists use mathematical bases, ecology and even philosophy, in order to make the methods of environmental impact assessment more scientific. For example, from a philosophical point of view and an objectivity base, each scientific approach should be systematic, replicable, well-documented and clear. Besides, the results of the approach should be transferable to other groups and the used concepts should be standard and understandable all over the world. The Information Technology is used as a favored subject, most of the time to make the environmental impact assessment more practical and objective. The instances of these efforts are development of Geographical Information System (GIS) and Remote sensing (RS) and their routine application in personal computers.

Generally in Iran, experts mostly use Checklist and Matrix methods for EIA, because of the time limitation and common tendencies. These two methods are conducted in a subjective manner and their results are based on personal experiences, depended on the place and time and are not replicable. So, it is possible that two assessors with different mentalities and personal experiences achieve different results for the same development plan using these methods. On the other extreme, to handle these shortcomings, there's a tendency towards adopting complicated methods such as modeling which need a lot of information and experience. However, the required data and knowhow of the method is not available most of the time, so the outcomes are usually unsatisfactory.

The philosophical concepts used for EIA improvement include but are not limited to: being systematic, well-supported, clear, replicable and easily understandable and conveyable. To define these concepts and the assessment more practically, a case study was conducted in Golestan province. In this study, two sites were suggested from five candidates for sanitary landfill and developing compost plant in the east and west of Golestan Province based on their possible impacts. The original assessment method that was used by early assessors in the area was a combination of different methods consisting of spatial methods, matrix and personal experiences, visiting the place and collating expert opinions. Here we discuss how the researchers can simply improve the earlier environmental impact assessment of the landfill and compost plant site selection in Golestan using philosophical bases of science and specifically the ecological concepts. These issues are represented with help from Rapid Impact Assessment Matrix (RIAM) software.

MATERIALS AND METHODS

Golestan Province in the north east of Iran was used for selecting two suitable sites for sanitary landfill, developing compost plant and assessment of their environmental impacts. In this study, the Province is divided into two parts; the eastern part with Azad-Shahr as its center and the western part with Gorgan as the center. Five sites had originally been suggested through field visits and the task was to find the best two for sanitary landfill and compost plants in the east and west of the Province. The location of these sites is presented in Figure 1.

Data collection is the first and the most time-consuming and generally expensive step in environmental impact assessment. To assess the impacts in this project, we required environmental, economic and social information data for the five sites. The early researchers originally used five methods: referring to the general maps, tables, laboratory work, providing diagrams and field and general scientific observations to collect and organize information, in order to select the best two sites from the five candidates.

Time limitation is the most important problem in data collection. Hence, the assessors often obtain general knowledge of any given area using general maps which are available. In some cases, some experiments are implemented to help assessors make decisions. For selecting suitable sites, field observation plays an important role. Experts acquainted with the suggested sites can produce information using direct observation. However, the features of the sites can be categorized and

assessed in 13 subjects that increase clarity and reproducibility and perhaps the rapidity of assessments (Table 1).

As it shown in Table 1, there are 13 social and environmental factors considered for EIA. Each of these factors can be affected positively or negatively by the way the projects are implemented.

The activities generally involved in the suggested projects and their environmental and social impacts are indicated in Table 2.

After analyzing the above data and using traditional methods, earlier researchers suggested site 3 for the eastern part of Golestan Province and site 4 for the western part as places for landfill and establishment of compost plant.

Now, using the information of the previous assessments, we attempted a selection process for the best two sites of compost plant and sanitary landfill using a systematic method (RIAM).

The RIAM method was developed by Pastakia in 1998 and used as a tool for analyzing and showing the result of comprehensive environmental assessments. The method was originally used to assess the impacts of tourism development [18]. The advantages of using RIAM are: comprehensive treatment of the assessment, observing social and environmental factors together, being easy to use, simple and reproducible and showing the impact of each factor separately. Besides, the method encourages selecting among several options, thus promoting the idea of considering alternative locations, methods, intensities and facilities from the very outset. In the original RIAM, impacts are divided into four categories: 1) physical and chemical, 2) biological and

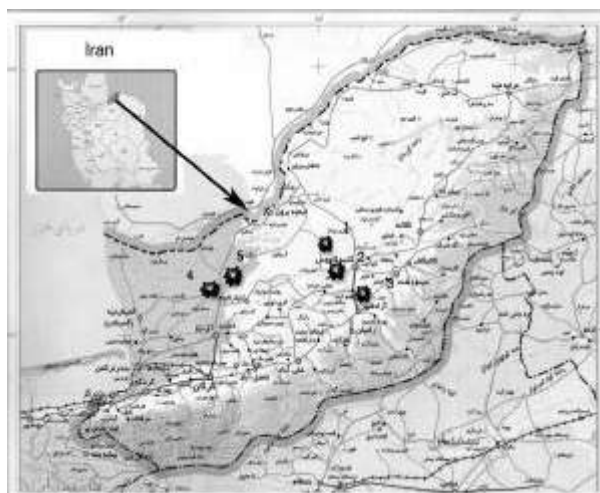


Fig. 1: Five studied locations in Golestan Province for landfill and compost plants

Table 1: Collected information and data by assessors of the sites

	Site 1	Site 2	Site 3	Site 4	Site 5
Climate and air quality	1&2&4	1&2&4	1&2&4	1&2&4	1&2&4
Water resources	1&2&3	1&2&3	1&2&3	1&2&3	1&2&3
Soil and Topography	2&3&5	2&3&5	2&3&5	2&3&5	2&3&5
Noise	2&4	2&4	2&4	2&4	2&4
Land ecosystem	1&2&5	1&2&5	1&2&5	1&2&5	1&2&5
Aquatic ecosystem	1&5	1&5	1&5	1&5	1&5
Road traffic	5	5	5	5	5
Employment	2&6	2&6	2&6	2&6	2&6
Public health	6	6	6	6	6
Land use	5	5	5	5	5
landscape	1&5	1&5	1&5	1&5	1&5
Public participation	6	6	6	6	6
Monuments	1&2	1&2	1&2	1&2	1&2

(1=Maps 2=Tables 3=Laboratory 4=Diagram 5=field observation 6= General study)

Table 2: Studying the impacts of the project activities on environment

+ = study is done - = study is not done closely

factors	Actions														
	Setting up factory	Excavation and Embankment	Flattening and enclosure making	Transferring the soil and employees	Water consumption and transfer	Sewage Treatment	Treating the sewage activities	Creating greenbelt	Transferring and gathering of wastes	providing Fuel and Energy	Wastes disposal and composting	Layering	Transferring the top soil	Extracting and Refining leachates	Gas Collecting
Climate and air quality	+	+	-	+	-	-	-	+	+	-	-	-	+	-	+
Water resources	-	-	-	-	-	-	-	-	+	-	-	-	-	+	+
Soil and topography	+	+	+	+	-	-	-	+	+	-	+	+	-	+	+
Noise	-	+	+	+	-	-	-	-	+	-	+	-	-	-	-
Land ecosystem	+	+	+	+	-	-	-	+	+	-	-	-	-	+	+
Aquatic ecosystem	-	-	-	+	-	-	-	-	+	-	+	-	-	-	-
Road traffic	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Employment	-	-	-	+	-	-	-	+	+	+	-	-	-	+	+
Public health	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Land use	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Landscapes	+	+	-	-	-	-	-	+	+	-	-	-	-	+	+
Public participation	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Monuments	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

Table 3: Categorized Impacts in RIAM software

Category in RIAM	Impacts in each category
PC	Climate and air quality - Water Resources- Soil and Topography- Noise
BE	Land ecosystem- Aquatic ecosystem- landscape
SC	Road traffic- Public health- Public participation- monuments
EO	Employment- landuse

Table 4: The criteria of assessment [18]

Criteria	Grade	Description
A1=the importance of impact	4	Important to national/international interests
	3	Important regionally
	2	Important to areas immediately outside the local context
	1	Important only in the local context
	0	No geographical or other recognized importance
A2= the magnitude of change	+3	Major positive benefit
	+2	Significant improvement in status quo
	+1	Improvement in status quo
	0	No change in status quo
	-1	Negative change to status quo
	-2	Significant negative disadvantage or change
	-3	Major disadvantage or change
B1= Permanence of the impact-causing activity	1	No change/not applicable
	2	Temporary
	3	Permanent
B2= Reversibility of impact	1	Not applicable
	2	Reversible impact
	3	Irreversible impact
B3= Accumulation of impact	1	No change/not applicable
	2	Impact is non-cumulative
	3	Impact is cumulative or synergistic

Table 5: Achieved scores of sites 1 to 5

Criteria	A1					A2					B1					B2					B3				
Site	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Climate and air quality	3	3	3	3	3	-1	-3	-1	-1	-1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Water resources	3	3	3	3	3	-2	-3	0	-1	-3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2
Soil and Topography	2	3	2	2	2	-2	-3	-2	-1	-2	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2
Noise	2	2	2	2	2	-1	-3	-2	-1	-1	3	3	3	3	3	3	3	3	3	3	2	3	3	2	2
Land ecosystem	3	3	3	3	3	-1	-1	-3	-2	-1	3	3	3	3	3	3	3	3	3	3	2	2	3	2	2
Aquatic ecosystem	3	3	3	3	3	-1	-3	-1	-2	-3	3	3	3	3	3	3	3	3	3	3	2	3	2	2	3
Road traffic	2	2	2	2	2	-1	-1	-1	-1	-1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Employment	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	3	3	3	3	3
Public health	2	2	4	2	2	-1	-3	-1	-1	-1	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2
Landuse	3	3	3	3	3	-2	-3	-1	-1	-1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Landscape	2	2	2	2	2	1	-3	1	1	-1	3	3	3	3	3	2	2	2	2	2	2	3	2	2	2
Public participation	3	3	2	3	3	1	1	1	1	1	3	2	2	2	2	2	2	2	2	2	3	3	3	3	3
Monuments	4	4	3	4	4	0	0	-3	0	0	1	1	3	1	1	1	1	3	1	1	1	1	2	1	1

Table 6: The scores and their description in the RIAM procedure. [18]

Range bands	Environmental score	Description of range bands
+E	(+72_+108)	Major positive change/impact
+D	(+36_+71)	Significant positive change/impact
+C	(+19_+35)	Moderately positive change/impact
+B	(+10_+18)	Positive change/impact
+A	(+1_+9)	Slightly positive change/impact
N	0	No change/status quo/not applicable
-A	(-1_-9)	Slightly negative change/impact
-B	(-10_-18)	Negative change/impact
-C	(-19_-35)	Moderately negative change/impact
-D	(-36_-71)	Significant negative change/impact
-E	(-72_-108)	Major negative change/impact

ecological, 3) social and cultural and 4) economic and operational. This helps in identification of impacts. As our aim was to categorize the cases according to their environmental and social impacts, we classified the first two groups as environmental impacts and the latter two groups as social impacts. Environmental and social factors of this research are categorized in Table 3.

- The main criteria for assessment in RIAM are divided to two groups:

- Criteria which represent importance and
- Criteria which represent value.

- Then, the software analyses the criteria based on the scores of the two groups and using special formulas [11]. The basic formulae for the RIAM are [18]:

- $(A1) * (A2) = AT$
- $(B1) + (B2) + (B3) = BT$
- $(AT) * (BT) = ES$

In these formulae (A1) and (A2) are different scores for the A group and (B1), (B2) and (B3) are different scores for the B group. AT is the result of multiplying total scores of group A's scores, BT is the total sum of the B group scores and ES is the total environmental score [11]. Scores and criteria used in the procedure are presented in Table 4.

Using the information that are shown in Table 4, A1, A2, B1, B2 and B3 have been scored in each of these 5 examined sites distinctly for all impacts which are affected by the project [Tables 1 and 2]. Generally, social impacts get positive but environmental factors get negative scores. There is no clear and significant relationship between scores of environmental factors and those of the social factors, because of the inherent difference in these criteria [18].

Based on the information in the project, scoring the factors for each of these five sites is represented in Table 5.

The environmental scores (ES) were classified in the range -E to +E [18, 19]. If the scores are close to -E, it means that the project has more negative impacts on the factor. On the other hand, if the scores are close to +E, it means the project does not have negative impacts on the factor and perhaps it produces positive impacts as well.

Each of the given scores from -E to +E indicates the environmental impacts in a specific range which are shown in Table 6.

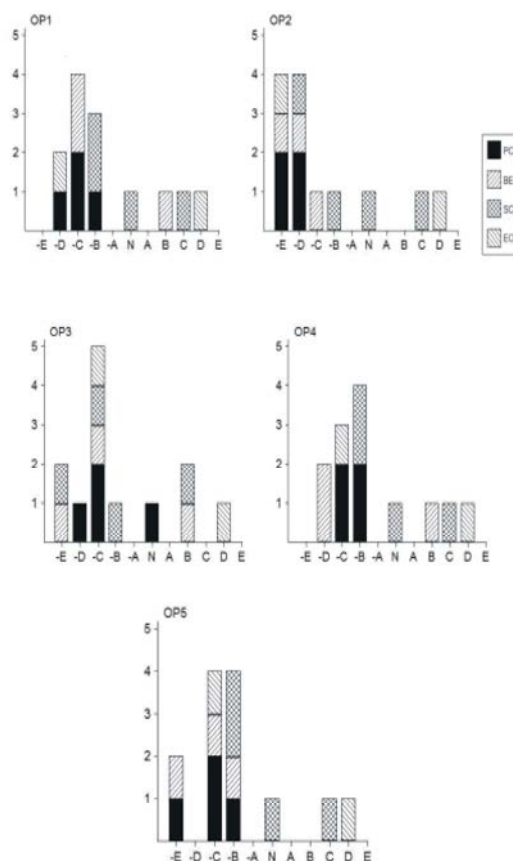


Fig 2: Diagrams produced by the RIAM software for each of the five sites indicated as OP1 to OP5.

The method produces tables and diagrams as the results of analyses. The assessors can select the best site easily by looking at diagrams. However, for showing the result quantitatively, we need to use the tables. RIAM draws some diagrams for each of the five mentioned sites after we entered scores on the total environmental impacts. These diagrams are represented in Figure 2. Generally, the impacts of each project are studied in terms of importance and magnitude. Then, the permanence, reversibility and cumulativeness of impacts are estimated in order to obtain a more complete information for EIA. Provision of a simple and comprehensive framework is an important step in EIA. A simple and comprehensive method is more practical, attractive than the other methods and also it is more efficient to be used in different places. Even if we lack enough information about the sites and environmental impacts, we can assess the impacts with the help of this method to offset the influence of personal judgments and opinions at least to some extent.

Table 7: The outline condition of five landfill and compost sites

	+E	+D	+C	+B	+A	N	-A	-B	-C	-D	-E
Site 1	0	1	1	1	0	1	0	3	4	2	0
Site 2	0	1	1	0	0	1	0	1	1	4	4
Site 3	0	1	0	2	0	1	0	1	5	1	2
Site 4	0	1	1	1	0	1	0	4	3	2	0
Site 5	0	1	1	0	0	1	0	4	4	0	2

Table 8: Calculated medians for each score.

Grade	+E	+D	+C	+B	+A	N	-A	-B	-C	-D	-E
Median	90	53.5	27	14	5	0	-5	-14	-27	-53.5	-90

RESULTS AND DESCUSION

From Table 1 we understand that there are 13 environmental factors for each of the five sites. So, there will be 65 different situations for the sites and factors.

These 65 situations have been treated by the early assessors of the sites through a combination of different methods: using general maps for 30 times (46%), tables for 35 times (54%), laboratory test for 10 times (15%), the diagram for 10 times (15%), field observation for 5 times (8%) and the general field survey for 6 times (9%).

It is obvious from Table 1 that to assess the results just one of those methods is used for 15 cases (23%). For 25 cases (38%), 2 methods and for 20 cases (30%), just 3 methods are used to arrive at a more acceptable and consolidated decision. In addition, just the field observation has been used to study the impacts of the project on road traffic and landuse. General maps and field observations are used to study the impacts on the aquatic ecosystems and the landscape. For studying the impacts on employment, public health and public participation, only tables, general scientific studies or just general studies have been involved. We learn from Table 2 that project activities are outlined in 15 cases which bring about impacts on 13 environmental factors. Hence, there will be 195 situations. Studying the factors which have been analyzed directly and those considered indirectly, indicates that just 73 cases (37%) are studied directly. Then, experts made decisions based on the results to select suitable sites for landfill and establishment of compost plants.

Using the traditional method and amassing the above data, experts suggested site 3 for the eastern part and site 4 for the western part of Golestan Province as places for landfill and compost plants.

On the other hand, from Figure2 which has been drawn by the RIAM software, we understand that the site 4 has the best scores among others and it is affected less than other sites by the development activities.

Table 7 shows the number of the scores gained by each site. As it has been shown in table 4, each of these scores has a range of values. Just like Table 8, we calculate the median of each range as it's range for making calculations.

Each score multiplied by the median of each range and their summation is a special number which was given to each site. The higher score shows the more suitability of any given site. The results of this simple mathematical operation are represented below:

$$\text{Site 1: } (0 \times -90) + (2 \times -53.5) + (4 \times -27) + (3 \times -14) + (0 \times -5) + (1 \times 0) + (0 \times 5) + (1 \times 14) + (1 \times 27) + (1 \times 53.5) + (0 \times 90) = -162.5$$

$$\text{Site 2: } (4 \times -90) + (4 \times -53.5) + (1 \times -27) + (1 \times -14) + (0 \times -5) + (1 \times 0) + (0 \times 5) + (0 \times 14) + (1 \times 27) + (1 \times 53.5) + (0 \times 90) = -534.5$$

$$\text{Site 3: } (2 \times -90) + (1 \times -53.5) + (5 \times -27) + (1 \times -14) + (0 \times -5) + (1 \times 0) + (0 \times 5) + (2 \times 14) + (0 \times 27) + (1 \times 53.5) + (0 \times 90) = -301$$

$$\text{Site 4: } (0 \times -90) + (2 \times -53.5) + (3 \times -27) + (4 \times -14) + (0 \times -5) + (1 \times 0) + (0 \times 5) + (1 \times 14) + (1 \times 27) + (1 \times 53.5) + (0 \times 90) = -149.5$$

$$\text{Site 5: } (2 \times -90) + (0 \times -53.5) + (4 \times -27) + (4 \times -14) + (0 \times -5) + (1 \times 0) + (0 \times 5) + (0 \times 14) + (1 \times 27) + (1 \times 53.5) + (0 \times 90) = -263.5$$

We learn from these numbers that sites 1 and 4 are the best cases for these special goals. We expect that implementing the project in these two sites will have the least negative impacts on the environment and the most positive impacts on the society.

This contrasts with the assessment result of researchers who have not used the RIAM method as they had chosen sites 3 and 4 as the best cases.

Summary: The five sites which are probable options for landfill and establishment of compost plants were studied

and compared with an earlier assessment using traditional methods which included using the general maps, tables, diagrams, limited laboratory tests, field observations and expert views. The comparison was made by implementing a newer method that is included in the RIAM approach. The newer approach have the advantages of being systematic, clear and straightforward, standard in terms of scores, reproducible and easily understandable through producing diagrams and encourages inclusion of project alternatives as a method of impact mitigation. Two methods were compared, in the first, just 37% of possible impacts of the relevant projects activities, had been studied directly. Furthermore, laboratory tests were used just in 15% cases to indicate the impacts. Although merely the lack of laboratory analyses in a method is not a proof of the usefulness of the method's results, 65% of the impacts were not examined directly in the traditional method. In addition, general maps, tables, diagrams, field observations and expert views had been used in 85% of cases. All these issues increase the influence of personal viewpoints and subjectivity in the final results. Besides, they make the method less clarified, replicable, transferable and objective than the other methods. Using the RIAM procedure, the divided impacts will be examined in two parts. The first part is importance, magnitude and permanence of impacts. The second part is reversibility and cumulativeness of impacts. This helps EIA procedure to be more comprehensive. Many experts agree about usefulness of clarity in any given method and provision of a systematic framework for assessment, such as those five mentioned bases in the RIAM procedure. In addition, it is clear and obvious that how each of these impacts are scored. These features have made the method clearer and more replicable. The other advantage of using this method is availability of diagrams, tables and scores classified in specified ranges. So, we can sum up rapidly that a part of the scientific philosophy, which are objectivity, reproducibility, transferability and clarity, is represented to some degree in the RIAM method. The traditional assessment clearly lacks such features and the same assessors might as well get a different result were they repeat their evaluation a second time. It is still possible to improve the RIAM method and develop new scientific concepts in order to have better results. The results of the traditional method offer sites 3 and 4 but the newer procedure applied through RIAM offers sites 1 and 4 as the best choices. More developed methods for environmental impact assessment can be offered, but we should always be careful about the accuracy and precision of the available data for analysis. Besides, most

of the recent methods in Iran, used to assess environmental impacts are affected by personal views of assessors. The RIAM approach is a good starting point to curb some of these shortcomings and to objectively evaluate projects for their impacts. The method can be enhanced using such concepts as fuzzy logic (Zadeh, 1965) and the analytical hierarchy process (Saaty, 1977). Developed as such, the method can be adopted for most of the assessments as a rapid and reliable approach bringing consensus among different interest groups and stakeholders.

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