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Application of Mathematical Matrices for Environmental Impact Assessment, A Case Study of Thermal Power Plant

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Abstract

Environmental Impact Assessment plays a crucial role in environmental land use planning and has been known as the most effective approach to identify proposed impacts of the projects and followed that proposing mitigation measures. Mathematical matrix is one of the environmental impact assessment methods that has been used extensively since it provides incorporate impact compensation factors, expert discussion, and provide more objective and practical feedback. The purpose of this study was to evaluate the environmental impacts of the Bistoon thermal power plant located in the west of Iran using the matrix method and proposing mitigation measures for minimizing the adverse effects. First, the activities of the project were identified. Then, environmental components, including physical environment, biological environment, socio-economic environment, were analyzed using maps and field checks. The impacts of the project activities were predicted on the environment and quantified using the mathematical matrix method. The results illustrated that the importance of effects is in a medium and low range; therefore, the status of the project is not very serious and can be verified by implementing a series of remedial actions and environmental improvement plans.

Keywords *Environmental Impact Assessment, Mathematical Matrix, Mitigation measures, Thermal Power plant*

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I. INTRODUCTION

Nowadays, a wide range of environmental crises such as global warming, biodiversity loss, environmental pollution, and depletion of natural resources have emerged, resulting in threatens to humans and the natural environment [1]; [2]. However, some socio-economic, political, and strategic problems are closely related to environmental crises. These kinds of crises, mostly encompass urbanization, population growth, poverty, diseases, and food insecurity [3]Recent investigations have clearly shown the adverse effect of environmental degradations on human health, leading to physical, psychological, and mental disease, and adverse impacts on other environmental components as well [4],[5].

Environmental impact assessment plays a significant role in promising that the development projects will go relating to environmental limits. Environmental Impact Assessment (EIA) process where specify, predict, and assess the influences on the biophysical and social environment considered as an appropriate tool in minimizing the opposing impacts [5]. In an EIA technique, in addition to recognizing the effect and importance of a project, the approaches of mitigating the probable impacts are also recognized and familiarized. Thus, in the EIA method, not just the guard of the natural environment could be measured but also, and the maximum economic and communal profits would be accomplished.

There are various ranges of EIA methods in assessing the consequences of sophisticated projects. Checklists, networks, matrices, and overlays

have been known as commonly-used methods. The application and efficiency of a method differ from others depending on the type of projects, activities involving in projects with its size that are impacted by the environment and EIA evaluator. The methods of EIA range starting from simple reaching to complex requiring various types of Data, Data formats, and different levels of expertise and technical advancement interpretation. All of these factors must be taken into account while choosing a method.

Bistoon thermal power plant is one of the most important industries in Kermanshah province located in the west of Iran, which besides providing the province with the energy it also plays a role in the electricity supply of neighboring provinces. Apart from having a positive impact on the economic situation, it has adverse effects due to its proximity to the Bistoon protected area, proximity to the Bistoon natural-national area as well as the vicinity to residential areas. Besides, other major industries, such as the cement plant, the petrochemical plant, and industrial area, are adjacent to Bistoon power plant strengthen the cumulative effects. Therefore, to identify and predict the negative environmental consequences and apply control and mitigation methods, the Mathematical Matrix is used to gain a better environment in this area.

II. METHODS

A. Case study

Bistoon power plant is located in the west of Iran in Kermanshah province. This important industry is placed between Kermanshah city (20 km distance) and Bistoon city (8 km distance) as shown in Fig. 1. The total area Area = 0.96 km2 in 640 MWe capacity. The power plant has been built to meet the needs of the country's western electricity grids (Kermanshah, Kurdistan, and Ilam provinces) and to supply electricity to neighboring industries. The main fuel consumed is natural gas power gasoline in some parts of the power plant. The water required for the plant is supplied by three wells with a seepage capacity of 6,000 cubic meters per hour and is distributed by the pipeline.

B. Mathematical Matrices

The assessment of environmental impact must be dependent on a process planned for a comprehended and systematic appraisal of all predictable ecological effects for sophisticated projects. Generally, evaluation is attained by subsequent stages.

1. Project description
2. Baseline study or description of the environmental state.
3. Identification and forecasting of impacts and effects; and
4. Estimation of significance effects.

Fig. 1. Location of the study

Following that, in the current study, an accurate description of the project and the environmental state around the project were studied. Then, the activities of the project have been specified and managed in a matrix vertical to the ecological reasons. Afterward, evaluating probable across effects, challenges were completed to characterize their importance. Three important groups of criteria been characterized:

A. Basic criteria

B. Supplementary criteria

The basic standards are magnitude (M), extent (E), and duration (D). The ranking of basic standards was from 1 to 9 might not remain inattentive in any assumed study, or it will have no impact at all. Finally, the total elementary effects might be determined as overall basic impacts [7]

$$MEDij = \frac{1}{27}(Mij + Eij + Dij) \quad (1)$$

The value of SAC will be between:

$0 \leqslant SACij \leqslant 1$ Essentially, the MED is synergized with SAC. the impact (Iij) in mathematic matrices could be illustrated as [8]

$$lij = MED\ (1- SACij\ )(1 - EX \quad (3)$$

In the end, the significance of the contraction (Gij), may takings into attention the mitigation events (Tij), is gotten of the subsequent equivalence:

$$Gij=Iij\ [(1-(Tij/9))] \quad (4)$$

Mitigation measurement (Tij) was stated on an ordinal gage from zero to nine. The importance can be arranged as in Table I

TABLE I. SCALES AND RAGES OF THE MITIGATION MEASUREMENT

Numbers	Scales	Ranges
1	Low	0-0.24
2	Moderate	0.25-0.49
3	High	0.50-0.74
4	Very High	0.75-1

III. RESULTS AND DISCUSSION

The impacts of Bistoon thermal power plants were assessed on the environmental components. More specifically, the positive and negative effects on the physical, biological, and social environments such as air, soil, water resources, vegetation cover, and employment were identified and projected. Then the impacts were evaluated and quantified using the mathematical matrix method. Table II: The environmental parameters affected by different project activities in both construction and operational phases. The table shows that the environmental parameters affected by various project activities in both the development (construction) and operational aspects. The results illustrate, while the project has such ecological damage, the positive impacts on the socio-economic effects have existed. The significant effects of the effects are shown in Table II. These results show that 75% of the importance of the impact (G) is in the medium range and 25% in a low range. Therefore, the status of the project is not very serious and can be verified by implementing a series of remedial actions and environmental improvement plans.

The biological status (habitats and plant species) and the climate of the region are most affected by project activities. Therefore, by taking a number of corrective actions in the project activities such as complete gasification of the power plant and installation of filters to reduce pollutants, the climate and health would be improved. Also, reducing the negative impacts on habitats and plant species could be achieved by the improvement programs in the protected area, such as considering environmental sensitivity, and creating the corridors between disrupted habitats is another good way to improve the biological status. Changes in soil texture and landforms have been affected by landscaping and excavation in the construction of the project, and improvement plans such as improving soil texture and proper land leveling should be undertaken. Water quality and air quality have not been affected as much as other components; however, monitoring of air and water quality is strongly recommended.

TABLE II. THE ENVIRONMENTAL PARAMETERS AFFECTED BY DIFFERENT PROJECT ACTIVITIES IN BOTH CONSTRUCTION AND OPERATIONAL PHASES

G	I	T	SAC	MED	C	A	S	D	E	M	Impacts
0.33	0.75	5	0.19	0.70	1	4	0	7	7	5	**Local climate chabge**
0.27	0.30	1	0.11	0.26	0	0	3	2	2	3	**Landform changing**
0.27	0.30	1	0.11	0.26	0	0	3	2	2	3	**Soil erosion**
0.15	0.34	5	0.11	0.30	0	3	0	4	2	2	**Water quality**
0.22	0.65	6	0.26	0.56	0	7	0	6	3	6	**Air pollution**
0.41	0.46	1	0.30	0.33	0	4	4	3	2	4	**Habitat degradation**
0.30	0.44	3	0.33	0.30	3	2	4	3	2	3	**Plant removal**
0.28	0.64	5	0.44	0.44	4	4	4	5	3	4	**Health**

TABLE III. FREQUENCY OF THE IMPACTS

Gij	Significant	Frequency
0-0/25	Low	2
0/26-50	Moderate	6
0/51-75	High	0
≥0/76	Very high	0

Environmental impact assessment is an essential tool in assuring that the development projects will go according to environmental limits. The first step in EIA is defining and describing the present environmental condition and determining the parameters of the environment, which are in a way to be impacted, executing the target project with the associated talented activities. In this study, the impacts of Bistoon thermal power plant located in the west of Iran were assessed on the environmental components. The components were grouped into three sections, including physical, biological, and socio-economic environments, and were assessed based on the maps, satellite images, and field checks. The accuracy of the data plays a crucial role in the precision of the assessment results.

An applied approach to gain wiser EIA is by improving the matrices, which may gain useful, practical ways to achieve better EIAs so that users can gain benefits and assess influences deeply. In mathematical matrices, the accurateness of the experts' findings may be assessed. Mathematical matrices decrease the matrices weaken and permit operators to evaluate the competence of anticipated mitigation events. Environmental impact assessments must be dependent on a way of designing a comprehended and methodical judgment to all predictable

ecological influences. Generally, that assessment is attained by subsequent stages. This paper shows the development of ecological influence valuation approaches of thermal power plant case study using the improved mathematical matrix in Iran.

The most proper approach to result in a sophisticated EIA is going to the developed matrices which been practiced in the research. As a result, researchers will profit from the positive points and assess influences further strictly. The accurateness of experts' opinions about mathematical matrices to alternate observations can be appraised. Mathematical matrices decrease the matrices weaken by allowing employers to evaluate the competence of expected influence mitigation events. Also, in mathematical matrices, the accurateness of the experts' findings would be assessed.

IV. Conclusion

Environmental Impact Assessment (EIA) is a proper way to reduce the environmental impacts of activities and projects. Evaluation of the development impacts in the study area shows that the project is environmentally acceptable and that by implementing a series of remedial actions and improvement plans, steps can be taken to reduce the negative impacts. The best option is to complete the gas-fired power plant, which, in addition to being a corrective action for the project in question, also avoids CO2 increases and reduces an effective global environmental problem.

The impacts were assessed using the Mathematical Matrix that evaluates the sensitivity of expert judgments, allows for disagreement between experts, provides more objective and practical views on subjective approaches, and offers solutions to mitigate impacts. Also, the mathematical nature of the computation makes the computation of the computationally robust and can be useful in adopting the method as an acceptable method. However, it is suggested to use other evaluation methods in further studies to compare the results and choosing the proper method and to identify the effects of the project

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