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Strategic Environmental Assessment of Industrial Development Scenarios Through Multi-criteria Decision Making Technique in Iran

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Abstract: In this study, the ways in which the multiple criteria decision making technique is applied was considered in order to appraise strategic environmental scenarios of industrial development. The main purpose of the study was to systematize the environmental considerations in policies, plans and programs of industrial development of Iran through a strategic environmental assessment approach and further determine the environmental strategies of stable industrial development. The analytical hierarchy process was employed in order to integrate evaluation of industrial development scenarios. The results show that the most suitable scenario of industrial development of Iran is the development of industries such as: electronics, biotechnology and new material manufacturing as well as the innovation of fully grown industries according to environmental considerations. The least suitable scenario of industrial development is the continuation of the existing industrial strategies which consist of export development, privatization, energy consuming industries and machinery technology development without environmental considerations.

Key words: Strategic environmental assessment, strategy, policy making, multi criteria decision making, industrial sector, analytical hierarchy process, sustainability indices

INTRODUCTION

Over the last 15 years, Strategic Environmental Assessment (SEA) has become an important policy instrument for national governments, particularly in Europe[1]. The integration of environmental concerns into strategic decision making and policy making has been widely recognized as an essential feature for moving towards more sustainable development in all policy sectors. SEA is a procedural tool with the purpose of integrating environmental aspects in a structured manner into decision making processes[2]. So that the increasing awareness of environmental impact assessment community has recently led to an intensifying debate on the theoretical foundations and the appropriate practical use of SEA[3]. The project-specific nature of current Environmental Assessment (EA) practice is often seen as a constraint on the ability to account for sustainability. Sustainability will only be realized if consideration is given to the environment at all significant decision points. This includes decisions at the Policy, Plan and Program (PPP) levels. Strategic EA, the EA of proposed and existing PPP and their alternatives, is gaining widespread recognition as a supporting tool for decision making that promotes sustainable development[4]. SEA is a framework within which a range of different analytical tools and methods can be applied[5]. Assessment methods can be evaluated from different perspectives, depending on the role, purpose and mechanism of assessment[6,7]. Thus the effectiveness of SEA depends on how well the assessment fits into the planning context and on its actual contribution to debate on problem definitions[8]. The capability and international experience of the SEA approach makes it a benefit to the industrial sector in developing countries such as Iran. In this study the application of multiple criteria for decision making is considered to define the strategic environmental scenarios of industrial development to systematize SEA in the industrial sector in Iran.

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MATERIALS AND METHODS

This research was carried out, in Iran, in the years 2003-2004. SEA requires that the criteria and effective conditions for stability strategic analysis after screening the policies, plans and programs of industrial development and scoping be specified. One of the most important prerequisite conditions of the present study was to obtain a list of the main indices and the specifying criteria regarding the analysis of alternatives or scenarios of industrial development in Iran. The indices were first used in the definition of scenarios and later in the analysis and appraisal of scenarios. At the end of the study, ranking of industrial development scenarios was performed according to evaluation results and sensitivity analysis in the framework of the decision making model. The optimum models have been considered by mathematicians and industrialists throughout the world, particularly since the industrial revolution. In classical optimum models, the main focus is to have a measurement criterion or a subject of purpose so that the mentioned model can be linear, non-linear or compounded. However recently researchers have more often opted to focus on multiple criteria models for complicated decision making. In these decision making procedures, several measurement criteria have been used instead of a single optimum measurement criterion.

The models of decision making have been divided into two main branches: Multi Objective Decision Models (MODM) and Multi Indices Decision Models (MADM). The Multi Objective Models have been employed to design, while Multi Indices Models have been used to select the superior alternative[9]. In the present study, a MADM approach focusing on the essence, theme and purpose was taken in order to choose the superior alternative or alternatives of industrial development strategies in Iran. Two main classes of different widespread methods of processing the present data using a MADM have been taken into consideration: One class of methods has been derived from a non-compensatory model and the other class has been derived from a compensatory model. The decision making models used here are listed in Fig. 1[9].

Due to the broad capacity and capability of the analytical hierarchy process and effectiveness of the technique in the present study, it was used for the purpose of overall appraisal of scenarios of industrial development. The technique was based on an even comparison and allows the managers to study different scenarios[10]. In this study, Ecpro software was used to analyse the multiple criteria decision making issues with the help of the analytical hierarchy process. For this reason, this study focused first on the hierarchy structure needed. Then the other structural processes of the model were examined, such as: even comparison, the combination of weights and the analysis of sensitivity and ranking. In order to achieve the purpose or the structure, an integrated assessment of the scenarios of industrial development was performed in the first hierarchy level. In the second hierarchy level, two criteria

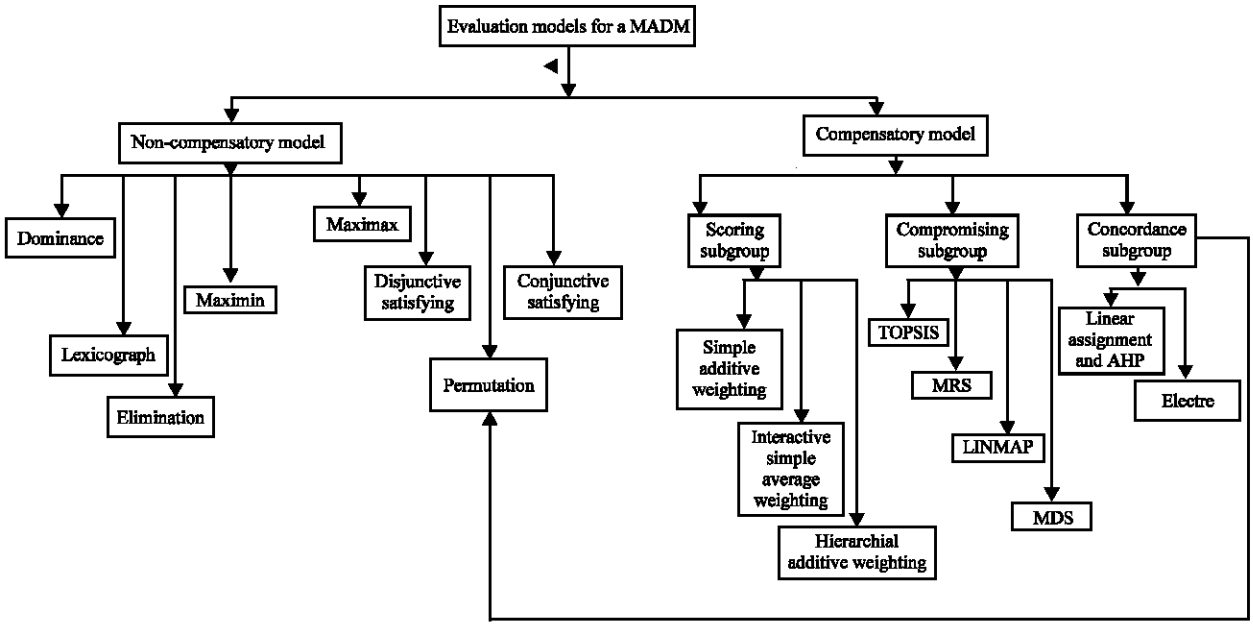

Fig. 1: Position of the models types for multiple attribute decision making[9]

of major index of the stability of industrial development and the stability of environmental quality were established. In the third hierarchy level, four major industrial subindices were used.

In the fourth and fifth hierarchy levels, 13 indices and 48 minor industrial-environmental subindices were defined, respectively. And finally in the last level of the model, industrial development scenarios have been ranked. In order to analyze the decision making sensitivity, several analytical graphics based on the slop, difference, practicality and two-dimensional were developed.

RESULTS AND DISCUSSION

The indices and criteria needed were classified into two classes: (1) the indices of the stability of industrial development and (2) the indices of stability of environmental quality.

The criteria and indices have been classified into two main classes due to the later decision making regarding the study's needs and the methodology of strategic environmental assessment:

The thematic indices: These indices could be directly or indirectly classified regarding the different cases of industrial and environmental themes.

The functional indices: This class of indices was directly or indirectly related to qualitative and practical levels. It is necessary to ascertain the basis or the criteria of index selection with consideration of the aim and methodology of the study in order to choose the optimal indices of environmental stability and industrial development. For this purpose, the following presuppositions were taken into consideration:

- The indices were chosen from the hierarchy levels, to indicate the stability of industrial and environmental development in the highest level of decision making. That is why the major indices have been put into practice to achieve the condition of necessary effectiveness.
- The selective indices do not belong to a particular area. Rather their stability relies on their spread. Thus, they could be used in all areas.
- Some indices were selected for use in the analysis of alternatives and scenarios of industrial development with consideration of the special conditions of Iran.
- The selected indices indicate at least the qualitative or comparative specifications of the variables of development and environment.
- The selected indices indicated the stability coming from the perspective of a geographical (spatial) system, the environmental impacts and the control of environmental pollutions.

The selected indices indicating the stability of industrial development and stability of environmental quality in the same classified framework are given in the Table 1 and 2. Figure 2 and 3, respectively show the share of each industrial waste causing environmental pollution and the share of each industrial subsector causing environmental pollution in Iran. In the next step, different alternatives or scenarios of industrial development in Iran were prepared. The criteria and indices indicating stability of industrial development and the stability of environmental quality in the industrial sector were analyzed.

The industrial policies of Iran were taken into consideration through several types of different sectoral and ultra sectoral policy making at the national level including the fourth plan of economic, social and cultural development, the national spatial plan of Iran, land use planning master plan and finally the industrial development strategy plan of Iran. According to the target of the study, the different scenarios of industrial development in Iran based on the combinations of industrial strategic policies and sustainability indices have been defined in the framework of 7 scenarios, including 4 scenarios of industrial development without environmental considerations and 3 scenarios of industrial development with environmental considerations.

Since application of the planned scenarios of industrial development probably raises some environmental issues (e.g., environmental pollution, direct and indirect environmental impact, potential and actual effects on the spatial system), it is necessary to define some new scenarios based on environmental considerations. Some strategies such as privatization, competition in regional and extra territorial markets, commercial liberation, export development, the innovation of industries and absorption of foreign investment have taken some effective environmental principles into the consideration in the above mentioned scenarios of industrial development.

Figure 4 and 5 indicate the variety of sensitivity analysis of decision making based on practicality and stability in accordance with the conclusion of the

Table 1: Ranking of selective indices related to industrial development sustainability

Functional indices			Thematic indices			
Industrial spatial positioning indices	Industrial status and elasticity indices	Industrial trends and changes indices	Industrial spatial arrangement sustainability indices	Employment sustainability criteria	Economic and investment sustainability indices	Industrial production of sustainability indices
• Changes in regional/ country -wide per area numbers of industries	• Changes in productivity rate of industrial production • Changes in demand elasticity of industrial products • Changes in foreign investment rate in industry sector	• Changes in structure of large, medium and small scale enterprises • Changes in structure subsectors w.r.t. of Government/private • Changes in subsector's industrial production/ total production • Changes in productive employment/total employment ratio • Changesinindustry Sector contribution in GNP • Changes in industry sector value added/GNP ratio • Import/export growth rate of products by Government/private ratio • Changes in import/export of products by private/Government ratio • Changes in skilled human resources growth rate	• Regional/ countrywide per area number of industries	• Subsector's structure of large, medium and small scale enterprises • Subsectors Structure w.r.t Government/ private based Production • Productive employment/ total employment in industry sector • Skilled human resource growth rate	• Sector value added/GNP ratio • Private and Government sector industrial export growth rate • Private and Government sector industrial import growth rate • Private/Government industrial export ratio • private/Government industrial import Ratio • Demand elsticity of Industrial products • Domestic investing rate • Foreign investing rate	• Industrial product per total subsector production ratio • Prodcutivity rate of industrial production • Private/ Government GDP ratio

Table 2: Ranking of selecting indices related to environmental sustainability in industrial sector

Functional indices			Thematic indices		
Environmental spatial positioning indices	Environmental status and elasticity indices	Economic and investment sustainability indices	Environmental sustainability of spatial arrangement indices	Sustainability of environmental impacts mitigation indices	Sustainability of environmental pollution mitigation indices
• Land use change index due to industrial development • Regional proportion of industrial development to other sectors • Consistancy ratio among industrial uses of land	• Environmental fines by industrial subsectors	• Pollutants emission rate by subsectors • Trends of changes in water resources contamination indices • Number of industries equipped with pollution control systems/ total • Proportion of units with EMS to total Industrial subsectors • Changes in emmigration rate due to industrial development	• Land use change index due to industrial development • Regional proportion of industrial development to other sectors • Consistancy ratio among industrial uses of land	• Industries with EMS/total • Emmigration rate due to industrial development • Violation from environmental regulations by subsectors	• Pollutants emission rate by subsectors • Trends of changes in water resources contamination indices • Number of industries equipped with pollution control systems/total

study. Applied abbreviations in them, indicate following terms:

SCENE: Seven Scenarios (for industrial development in Iran)
IDSINDX: Industrial Development Sustainability Index
ESINDX: Environmental Sustainability Index
Crit: Criteria

Mentioned numbers in the (Fig. 4 and 5), indicate weighting importance of each index (criterion) or scenario. Finally, the scenarios of Iran industrial development were ranked as follows:

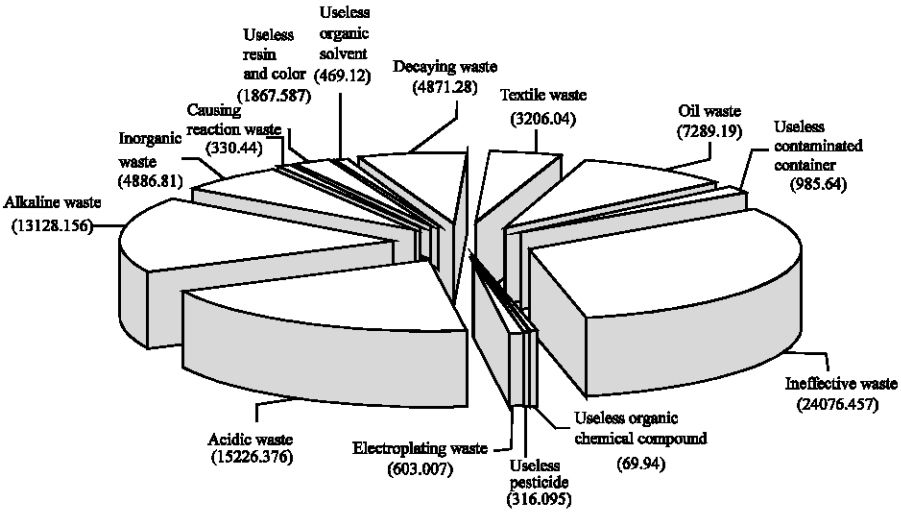

Fig. 2: Contribution of each industrial waste causing environmental pollution in Iran

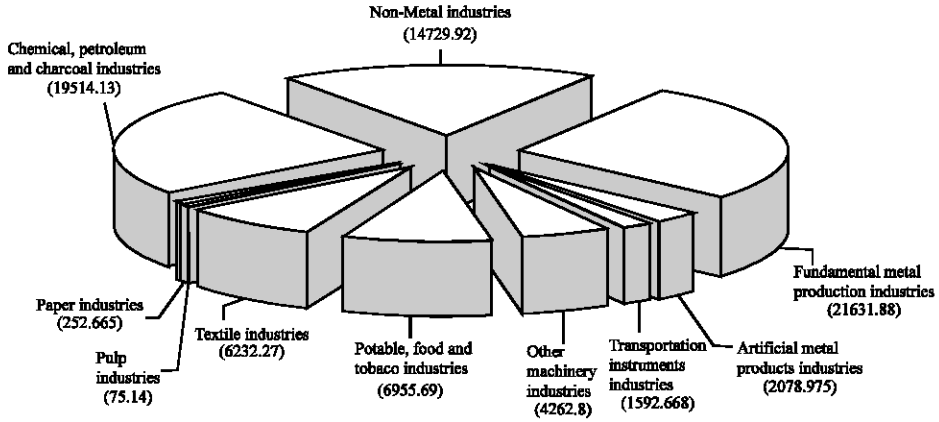

Fig. 3: Contribution of each industrial subsector causing environmental pollution in Iran

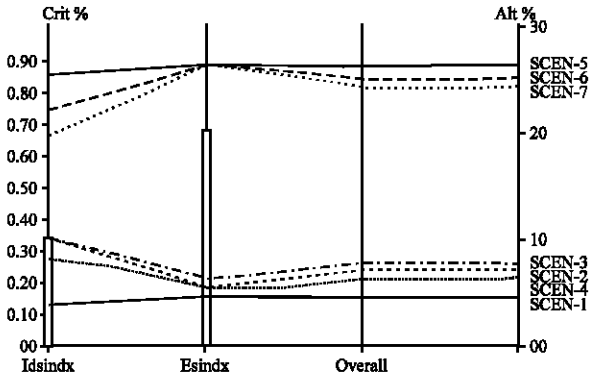

Fig. 4: Performance sensitivity analysis of decision making for Iran's industrial development

The first priority: Scenario 5: The broad development and exploitation of new industries (including electronics and its sub-branches, biotechnology and new material manufacturing) and the widespread dispensing of their products for innovation of fully-grown industries with environmental considerations.

The second priority: Scenario 6: The provision of the rapid formation conditions of skills in industries, the superior industries such as: oil, gas, petrochemistry and the creation of competitive advantages for industries such as: machine technology, the process control systems and mining and excavation equipment and the chemical industries particularly for the purpose of export with environmental considerations.

The third priority: Scenario 7: Innovation, establishment and the minimization of economic and regional issues caused by the natural or forced annihilation of grown-up industries that lack of ability to

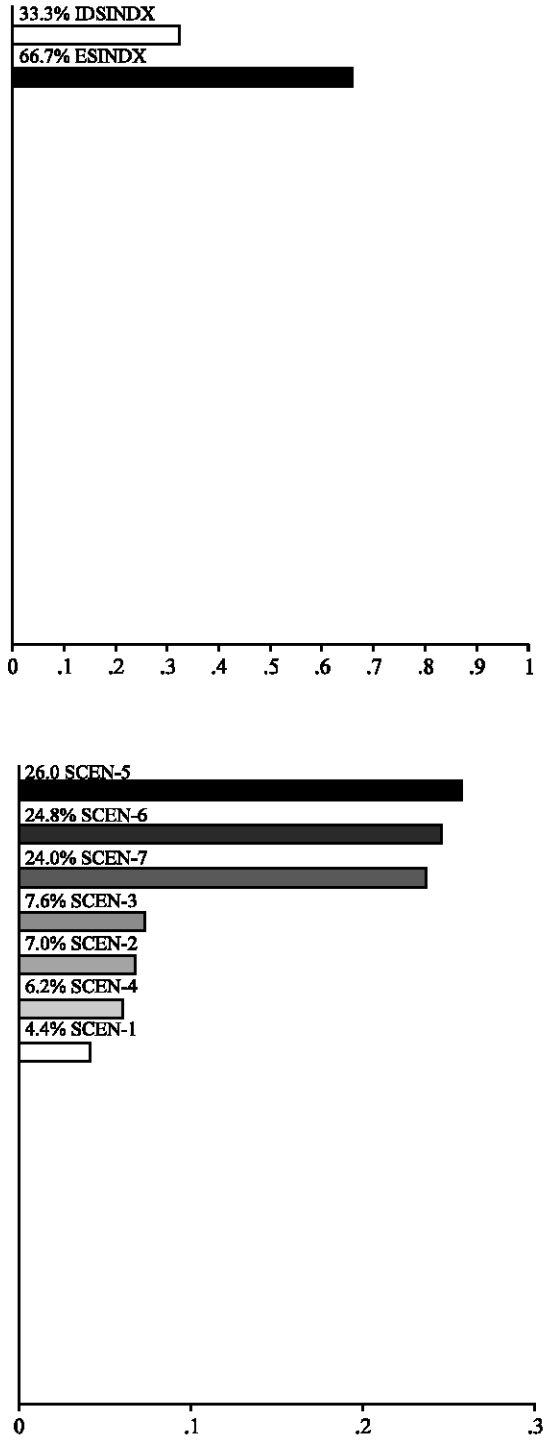

Fig. 5: Dynamic sensitivity analysis of decision making for Iran's industrial development

compete such as: leather, textile and some food industries with environmental considerations.

The fourth priority: Scenario 3: The provision of the rapid formation conditions of skills in industries, the superior industries such as: oil, gas, petrochemistry and the creation of competitive advantages for industries such as: machine technology, the process control systems and mining and excavation equipment and the chemical industries particularly for the purpose of export without environmental considerations.

The fifth priority: Scenario 2: The broad development and exploitation of new industries (including electronics and its sub-branches, biotechnology and new material manufacturing) and the widespread dispensing of their products for innovation of fully-grown industries without environmental considerations.

The sixth priority: Scenario 4: Innovation, establishment and the minimization of economic and regional issues caused by the natural or forced annihilation of grown-up industries that lack of ability to compete such as: leather, textile and some food industries without environmental considerations.

The seventh priority: Scenario 1: The continuation of the present industrial policies and following the present trend of industrial sector (as current base scenario for policy making of industrial sector in Iran).

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