Geographic Information System-based PROMETHEE II Method: An approach for ranking industrial zones

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Journal of Digital Information Management

ABSTRACT: *The integration of Geographic Information Systems (GIS) and multi-criteria decision analysis (MCDA) is a privileged and a crucial way to evolve GIS into a real decision support system in the industrial site selection field. This study combines PROMETHEE II (Preference Ranking Organization METHod for Enrichment Evaluations) and Geographic Information System (GIS) to provide decision makers with a ranking model for industrial sites in Algeria. The ranking is based on a detailed study of geographic, environmental and socioeconomic criteria. A mixed integration mode between GIS and MCDA is proposed in this study. The result obtained by R-PRO (Ranking PROMETHEE) for ranking industrial zones in Algeria is refined by viewing the GIS-IZ (GIS for Industrial Zones). The system was designed for the evaluation of a new methodology of multi-criteria analysis guided by data mining. Only the Decision Making Support System (DMSS) part is presented in this paper.*

Subject Categories and Descriptors
[I.4 Image Processing and Computer Vision]; [H.4.2 Types of Systems Decision support]; [H.2.8 Database Applications]: Data mining

General Terms
Geographic Information Systems, Decision Analysis, Data Mining

Keywords: Geographic Information System (GIS), Multi-Criteria Decision Analysis (MCDA), Industrial Zones, MCDA-GIS integration, PROMETHEE II

Received: 14 January 2017, Revised 8 March 2017, Accepted 18 March 2017

1. Introduction

This work aims to rank the Algerian industrial zones programmed by the state to satisfy the expectations of investors. The objective is to reach the economic regional balance and population stabilization with respect to the environment.

Generally, the site selection is the process of finding the best sites for a project establishment depending on the socio-economic and environmental criteria [1].

Issues related to the field are the problems of zonal aptitudes in the context of decision support. Complexity in decision making for selecting industrial sites derive from the inherent trade-offs between socioeconomic, technical and environmental criteria. Chaotic location causes epidemics and attacks on the health of the citizens.

The linear model of Simon (intelligence, design, and choice) and its extensions are insufficient to deal with the problem of complexity [2].

Each zone is a spatial action only if it is defined by its geographic location, shape and spatial relations [3]. Most judgment criteria and all actions of the problem under study have a geographic character. We adopt the approach of coupling between GIS and MCDA as the latter is favored for this problem.

The conceptual idea beyond MCDA-GIS integration work is twofold: it is to use the functions of GIS to prepare the inputs necessary for the MCDA methods, on the one hand, and on the other, it is to employ the GIS presentation potentialities to visualize the results of the analysis on the map [4].

GIS is required to model, store, manage, view, analyze, and represent objects or collections of spatial objects, but it is a limited tool in spatial decision support problems. GIS has a lack of more powerful analytic tools enabling it to deal with conflicting objectives in decision problems [5]. MCDA overcomes the lack of GIS by supporting efficiently the different phases of the decision-making process with multiple and conflict criteria.

PROMETHEE II as an MCDA method allowing total ranking is used because it is successfully applied in the field of industrial location [6]. It is a reachable method, understandable by the decision maker, and have mathematical properties [7]. It requires, INPUT, a performance table which contains values for each action (industrial zone) according to a set of criteria, in addition to thresholds and intra-criteria weights necessary to its use.

This study aims to provide decision makers with a Spatial Decision Making Support System (SDMSS) for industrial site selection based on GIS-PROMETHEE II integration. RPRO unit (Ranking PROMETHEE) is developed for total ranking. A mixed integration mode between GIS and MCDA is proposed to give more flexibility in supporting decision making: i) visualization is realized by GIS-IZ unit (Geographic Information System for Industrial Zones) on the map (full integration); and ii) Mapping criteria to prepare input for the MCDA method is done by commercial GIS separately (indirect integration).

The remainder of this article is presented as follows. Section 2 is devoted to related works and Section 3 is devoted to background, the proposed approach and global decision system architecture is in section 4 and 5. A case study is illustrated in Section 6, before conclusion and perspectives.

2. Related work

Spatial decision problems give rise to the GIS-based multi-criteria decision approach. It is In the context of the synergistic capabilities of both GIS and MCDA that theoretical and applied research on GIS-MCDA advances [8]. In this section, we present some works on the theoretical aspects of the approach as well as some applications, we focus on the applications using conjointly PROMETHEE and GIS.

2.1 Theoretical research

The earlier works on this approach, according to [9] are that of Diamond and Wright (1988), Janssen and Reitveld (1990),Carver (1991), Langevin et al (1991).

A general overview of the works using the approach from 1999 to 2011 is found in [9][10][11]. Authors in [4] [5] indicate GIS limits in tackling spatial decision problems and underline the necessity of GIS-MCDA integration. Authors also give models and integration directions and conclude with a proposal integration strategy that addresses the limitations of the past works.

J. Malczewski in [9] Assumes that spatial decision problems give rise to the GIS-based multi-criteria decision approach. This author confirms that, in the context of the synergistic capabilities of both GIS and MCDA, that theoretical and applied research on GIS-MCDA progress. The author in [12] Investigates the motivation behind MCDA and GIS integration and interrogates: what this integration is exactly needed for and if it is really interesting to invest labor in the development of such solutions. Authors in [8], while developing a Decision Support System for Land reform in South Africa, he gives new article statistics from 1990 up to 2015 showing the increasing use of the approach.The authors also highlight that when integrating two separate fields, both advantages and drawbacks emerge.The author in [13] links between land use planning and GIS-MCDA integration and affirms that GIS and multi-criteria analysis constitute a very interesting package for land management.

2.2 Applied research

Among the 1552 scientific papers related to the PROMETHEE methods found in the PROMETHEE bibliographical database on 2017 [14] , we cite some recent articles using GIS-based PROMETHEE approach: In [15] Authors presents a GIS-MCDA approach to preserving biodiversity in the AHAGAR National Park in Algeria. They provide decision makers with a tool named SDMA (Spatial Decision Making Aid) in which outranking methods such as PROMETHEE methods are integrated into *Arcview* GIS 3.2. In [16], authors underline that mine contamination is one of the main obstacles to economic recovery. They propose a DSS base GIS-PROMETHEE for determining the objective priority required to reduce the risks stemming from mine contamination. The study in [17] sought to locate the most suitable areas for flood spreading operation in the Garabaygan of IRAN. The authors propose an SDMS via an integration of PROMETHEEII and AHP in GIS environment. The author in [18] describes the application of (PROMETHEE II), in combination with fuzzy analytical hierarchy process (FAHP), as a weighting technique to explore landslide susceptibility mapping (LSM).He integrates eight geo-data layer involving slope, aspect, distance to river, drainage density, distance to fault, mean annual rainfall, and distance to the road. In [19], the PROMETHEE II method is used for ranking desertification alternatives. Obtained results and ranking should be considered in projects of controlling and reducing the effects of desertification and rehabilitation of degraded lands plans. Author in [20], compare AHP and PROMETHEE II for selecting best techniques in building, he concludes that PROMETHEE II is the appropriate method since its results are consistent, easy to understand and requires less information from decision makers. In [21] risk index and cost are the main criteria used to determine the preferable route of power transmission line (PTL) using conjointly AHP and PROMETHEE. GIS and MCDA are used synergistically to generate the best solution.

Among works using GIS-MCDA approach for industrial site selection we cite: [22], in this study author declares that the selection of an appropriate site is a critical decision that influences the lifestyle of the surrounding communities. For this, analysts should strive to determine the optimum location. His proposed approach entails two phases: screening and evaluation. He integrates three decision tools: Expert system (SE), Geographic information system (GIS) and multi-criteria decision analysis module using COM (Component Object Model) concept for connecting them. The Visual Rule Studio is used to develop the expert system, ArcGIS 8.2 to supply GIS platform, and Microsoft Excel 2002 to provide tools to implement AHP. Authors in [23] follow the work above and value the best selection of an Industrial Site and estimate that 80% of the data used in this field by managers are geographic in nature. The authors feel that synergistic effect generated by coupling GIS and MCDA contribute to the efficiency and quality of spatial analysis for industrial zone selection. They propose GIS-based MCDA architecture in two phases, screening and evaluation and result in raster and vector output suitability maps generated by ARCGIS. The aim in [24] is to develop a methodology to use GIS and MCDA for a new industrial site selection in Al-Nasiriyah city trying to find the optimum solution for industrial estate site selection.

Other works which lean on the approach in other domains we can cite: [25], where the objective is to estimate the ecological values of the Piedmont region of northern Italy and generate maps for use as assistance with the decision variables in the field of planning and land management to protect the environment and echosystems. In [26] the objective is to measure the vulnerability of forest habitat interfaces, the authors used the AHP method to treat six decision criteria (layout, topography, vegetation structure, habitat structure, properties of buildings, socioeconomic structures). They proceeded to map the vulnerability of each criterion by using ARCGIS. In [27] the goal is to alleviate the dissatisfaction of some group of citizens when planning a linear park section of less than 15 km from the new port area of Quebec. Another work that is within the scope of energy diversification is to design an MCDA-GIS model to guide a project on wind energy in Canada [28]. In [29] Authors couple AHP and OWA(Ordered Weighting Averaging) with GIS for mapping accessibility patterns of housing development sites in *Cammore Alberta*. The proposed system support Housing developers to trade off between benefits and costs to access facilities by residents.

3. Background

We begin this section by arguing the necessity to use the GIS-MCDA integration approach to get the best solution for spatial decision problems, and then Basic concepts of PROMETHEE II are presented.

3.1 Integration between GIS and MCDA

Spatial decision problems constitute a large part of decision-making problem. They are characterized by geographic data with spatial attributes (coordinates, shape...). Their complexity is related to the heterogeneity of data and concepts mobilized to model the geographic reality. This type of problems often has a multi-criteria aspect [3]. Geographic information Systems (GIS) are important for the analysis of decision problems such that the geographic components of the data are considered. GIS is primarily an explanatory help tool for decision. Multi-Criteria Decision Analysis methods (MCDA) provide the techniques necessary to structure and evaluate alternatives in decision-making problems, according to a defined set of criteria and proposed weighting. GIS research areas and MCDA methods for decision support are distinct but help each other to get the best spatial decision problem solutions in consideration of the complexity that lies in the following points: (i) the multidimensional and interdisciplinary nature which is difficult to formalize, (ii) the involvement of several persons and institutions, generally with preferences and diverging objectives, (iii) the need to define multiple conflicting criteria whose importance is not the same [4]. The solution of such problems generates a spatial multi-criteria decision. The geographic criteria and all actions (zones) should be mapped for decision makers. Data are processed by a GIS for spatial analysis and mapping on the one hand and aggregated by MCDA on the other hand, the two tools are used interchangeably [9]. The conceptual idea on which GIS-MCDA integration is based is to use the capabilities of GIS to prepare inputs necessary for MCDA method and exploit the potential of GIS for presentation to see the analysis results on maps [4]. Below, some arguments, which are in favor of this integration.

• To solve a spatial decision problem, we need to consider both the spatial and decision component problem.

• GIS is well suited for the representation of decision problems with spatial reference, but it fails to consider the multi-criteria decision dimension of the problem.

• MCDA allows formulation and modeling of the spatial problems, but it is limited to represent the spatial dimension of this problem.

Some questions related to the approach are: i) a lack of related maintenance policy ii) absence of correlation between the problem, the aggregation rule and GIS, iii) there is also an ambiguity related to the integration mode of the two tools. The author in [4] proposes three integration modes, (a: Indirect Integration, b: Built Integration, c: Complete integration). In this paper, a mixed integration is proposed. We will describe this integration mode in details in the section 4.

3.2 PROMETHEE

In [30], there is recognition of the variety and complexity of MCDA methods. Our choice in this work is PROMOTHEE, because it is successfully used in the field of industrial location. It is used in recent technologies like the selection of cloud solution for big data accessing [31]. Its success goes to its user-friendly and mathematical properties and further it is understandable by the decision maker. Its results are consistent, easy to understand, and require less information from decision-makers compared to AHP [8].PROMETHEE is an outranking method based on dominance relationships among alternatives and against the criteria (P: Preference I: indifference, R: Incomparability):

$$\begin{cases}\forall j: g_j(a) \geq g_j(b) \\ \exists k: g_k(a) > g_k(b)\end{cases} \Longleftrightarrow aPb \qquad (1)$$

$$\forall j: g_j(a) = g_j(b) \Longleftrightarrow aIb \qquad (2)$$

$$\begin{cases}\exists s: g_s(a) > g_s(b) \\ \exists_r: g_r(a) < g_r(b)\end{cases} \Longleftrightarrow aRb \qquad (3)$$

$g_j(a)$ denotes the evaluation of action "a" under criterion "j" .These relationships, create a dominance graph. An appropriate multi-crititeria analysis method wishes to enrich this graph. It is preferable for decider to reduce the number of incomparabilitys in order to optimize the decision. The concern of incomparability is an asset, because it reflects reality. Other assets of PROMETHEE, according to its inventor J.P. Brans reside in the following requirements [32]:

R1: The amplitude of the deviations between alternatives within the criteria is taken into account. It is denoted by:

$$d_j(a,b) = g_i(a) - g_j(a) \qquad (4)$$

R2: $g_i(a)$ is expressed with its own measurement unit, and the scale effects should be eliminated

R3: The binary comparisons provide all the possible information on the two compared alternatives (*a* is preferred then b; a and b are indifferent; a and b are incomparable). The purpose is, of course, the maximum reduction of the number of incomparability, only when being realistic.

R4: The method should be understandable by the decision-makers; and the "Black box" procedures should be avoided.

R5: The technical parameters which have no significance for the decision maker should be rejected.

R6: An appropriate MCDA method should provide information about the confrontational nature of the criteria.

R7: The MCDA methods use the relative importance of the criteria through weights given by the decider and featured by his subjectivity and hesitation. An attractive method provides tools for the study of sensitivity.

In addition to the performance table necessary to the outranking methods in general, PROMETHEE requires two clear types of information which are easy to find and assimilated by the decision maker for the best compromise solution.

3.2.1 Information between the criteria

Information between criteria are described by the set $\{w_j/ j=1\ldots k\}$ of relative importance (weights) for different criteria. These are positive numbers independent of units of measurement with $\Sigma w_j = 1$.The decision maker is free to give these weights featured with his hesitation and subjectivity. These weights should be normalized by dividing each weight by the sum of all the others.

3.2.2 Information on the criteria

The PROMETHEE II method uses the difference between the evaluation of two alternatives "a" and "b" according to a criterion "j" as given in (4), to build a preference structure. The gap d_j) is reversed if the criterion is to minimize. For example cost criterion is to be minimised. The degree of preference is proportional to the degree of the gap and the preferences are measured by real numbers between 0 and 1. In the mind of the decision maker, preference between two alternatives "a" and "b" is a function of the gap d_j which is expressed mathematically by:

$$p_j(a,b) = F_j\,[d_j(a,b)] \qquad (5)$$

If the criterion is to maximize

$$p_j(a,b) = F_j\,[-\,d_j(a,b)] \qquad (6)$$

If the criterion is to minimize

The couple $\{g_j(.),\ p_j(a,\ b)\}$ is the generalized criterion associated with $g_j(.)$ criterion. It is the concept of generalization that characterizes PROMETHEE compared to other outranking methods. The generalized criterion function associated with preference, indifference and intermediate thresholds provides six types of preference functions. The behavior of each action overlooked to the others is determined by three flows:

The positive flow:

$$\varphi^+(a) = \sum_{x\in A} \pi(x,a) \qquad (7)$$

The negative flow:

$$\varphi^-(a) = \sum_{x\in A} \pi(a,x) \qquad (8)$$

The net flow :

$$\varphi(a) = \varphi^+(a) - \varphi^-(a) \qquad (9)$$

The preference index for an alternative "a" compared to another “b” is denoted by equation (10) and illustrated in the Figure 1.

$$\pi(a,b) = (1/m)\sum_{j=1}^{k} p_j(a,b)\, w_j \qquad (10)$$

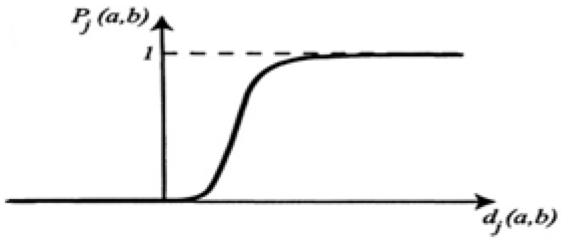

Figure 1. Preference function [33]

m: criteria number, $p_j(a, b)$**:** Preference of the action “a” over “b”, w_j: Weight of criterion j. The value of the net flow determines the rank of an alternative.

4. Proposed Spatial Decision Making Approach

As mentioned, Salem in [4] proposes three integration modes, Indirect integration, Built-in integration and Full integration. In this paper, a mixed integration is proposed: Preparing geographic criteria to support decision making in weighting is made by GIS independently (indirect integration) in screening phase while the visualization function is integrated directly (Full integration) in the MCDA module in the evaluation phase and is considered as a finality of the decision analysis (Figure 2).The objective is to give more flexibility for studying geographic criteria and mapping alternatives.

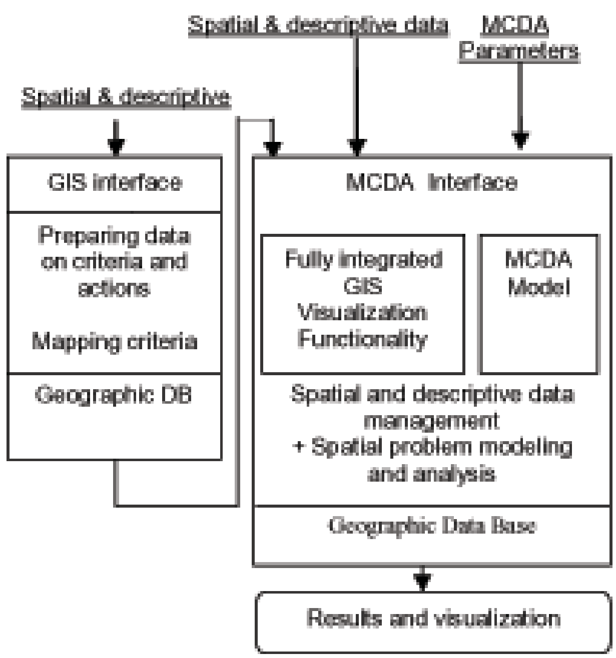

Figure 2. GIS-MCDA proposed integration mode

The proposed approach consists of two phases: Screening and evaluation as explained below and depicted in the Figure 3.

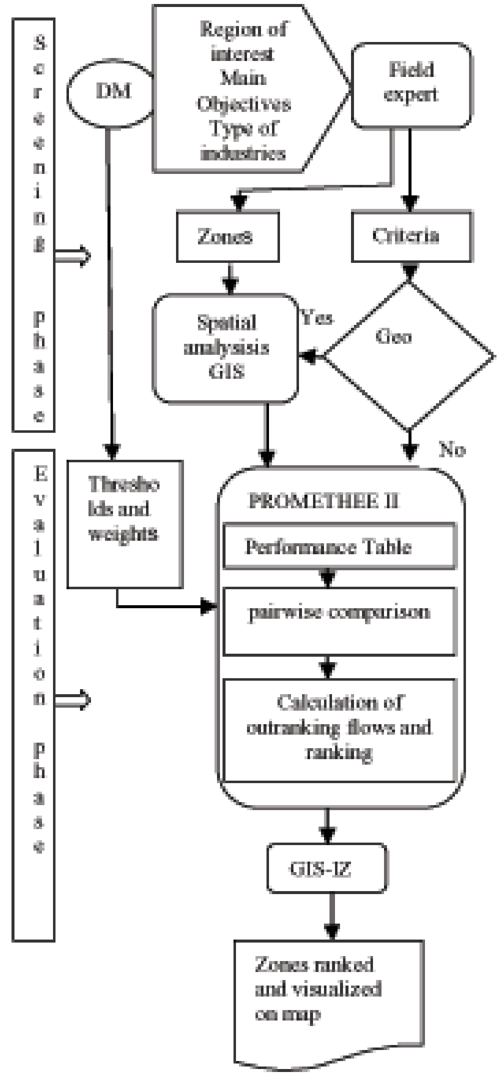

Figure 3. Framework of Proposed

4.1 Screening phase:

Screening phase: After the choice of zones at the beginning of the decision-making process, the study of the zones begins by collecting data about criteria and actions from geographic, socioeconomic and climate databases as archives of regions, the maps for the criteria are built using GIS. A field of expertise is available to construct the performance table. This table includes an evaluation of each zone according to all criteria, and it is the essential element requested by the ranking module RPRO. POMETHEE II also request thresholds of indifference and preference in addition of intra-criterion weight, such data are ready by a group of decision makers and analysts.

4.2 Evaluation phase:

Consist of the total ranking of zones using qualitative and quantitative data. The outranking method PROMETHEEII is used, and it involves four essential steps [33].

• Step1: Determination of deviations based on pairwise comparison over alternatives.

• Step2: Application of the preference function.

• Step3: Calculation of an overall or global preference index.

• Step4: computation of outranking flows using the PROMETHEE II method.

Finally, GIS-IZ ensures the display of these zones with their ranks on the map of Algeria.

5. Proposed Spatial Decision Support System (SDSS)

Inspired from the general Decision Making Support System Architecture in [34], taking into account the geographical aspect of data, the proposed DMSS has the architecture shown in the Figure 6.

5.1 DMSS Inputs:

Include a database of pertinent decision data, a geographic database for actions and criteria and an appropriate method (PROMETHEE II in this case). The decision maker utilizes computer technology via a user interface to access at various bases or executes the processing.

5.2 DMSS Processing: Process in three phases:

5.2.1 First phase:

It is the phase of determining the aptitude of candidate zones in different regions. Zonal aptitude is defined by the proprieties of an area to satisfy pre-established conditions or to be favorable to the development of a given phenomenon [35]. The Boolean zoning is a multi-criteria decision-making approach using a single logic operator ($\cap$) to combine the criteria for selecting zones, for example the aptitude binary index $C_{slope,j}$ for a zone j according to the slope criterion is given such that:

If $C_{slope,j} \leq 20°$ Then 1, else 0.

The aptitude of a zone is calculated using the intersection of several indices such that:

$$I_{apt,j} = C_{1,j} \cap C_{2,j} \cap ... \cap C_{k,j}$$

$C_{k,j}$ Is the aptitude binary value of the zone j according to the criterion k

5.2.2 Second phase (Aim of this paper):

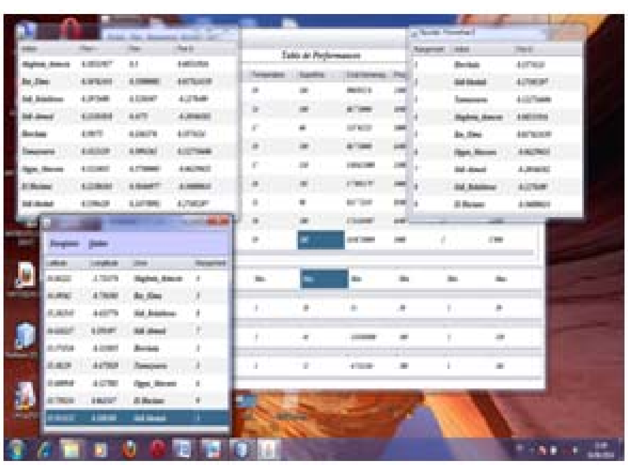

Figure 4. RPRO Interface

It is the total ranking of zones using RPRO (Ranking PROMETHEE) unit to develop a ranking for zones. Figure 4 shows the interface of RPRO module that includes the input of the performance table as well as the flows and results display for PROMETHEEII to be performed.

5.2.3 Third phase:

Consist to choose one of three available architectural variants, the selection criteria are: architecture, management cost, number of fragmented islands and the types of planned investments.

In this phase, GIS-IZ module ensures the display of zones before and after each decision-making phase. To accomplish this task, the vector mode is adopted, each industrial zone is considered as a geographical entity of the abstract spatial type “POINT”, it is implemented with their geographical position (latitude and longitude) using Geo-Tools in three steps:

• Introduce the file with shape file (SHP) extension, which represent the Algerian administrative division map.

• Insert another file with the same extension representing industrial zones.

• Make a projection between the two the matic maps.

DMSS Outputs: GIS-IZ unit display the zones with their corresponding ranks on the map of Algeria as in the Figure 5.

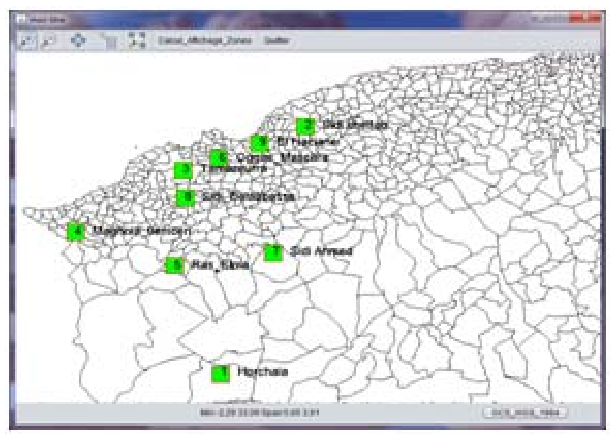

Figure 5. Main visualizing interface

6. Case Study

Industrial zones under study are programmed by the Algerian state in 2013 to satisfy the expectations of investors. The objective is to reach the economic regional balance and population stabilization with respect to environment [36].

6.1 Actions

Each zone is an action (A1: Tlemcen, A2: Sidi Bel Abbes, A3: Ras Elma, A4: Saida, A5: Naama, A6: AinTémouchent , A7: Mascara , A8 :Mostaganem. A9: Relizane.).

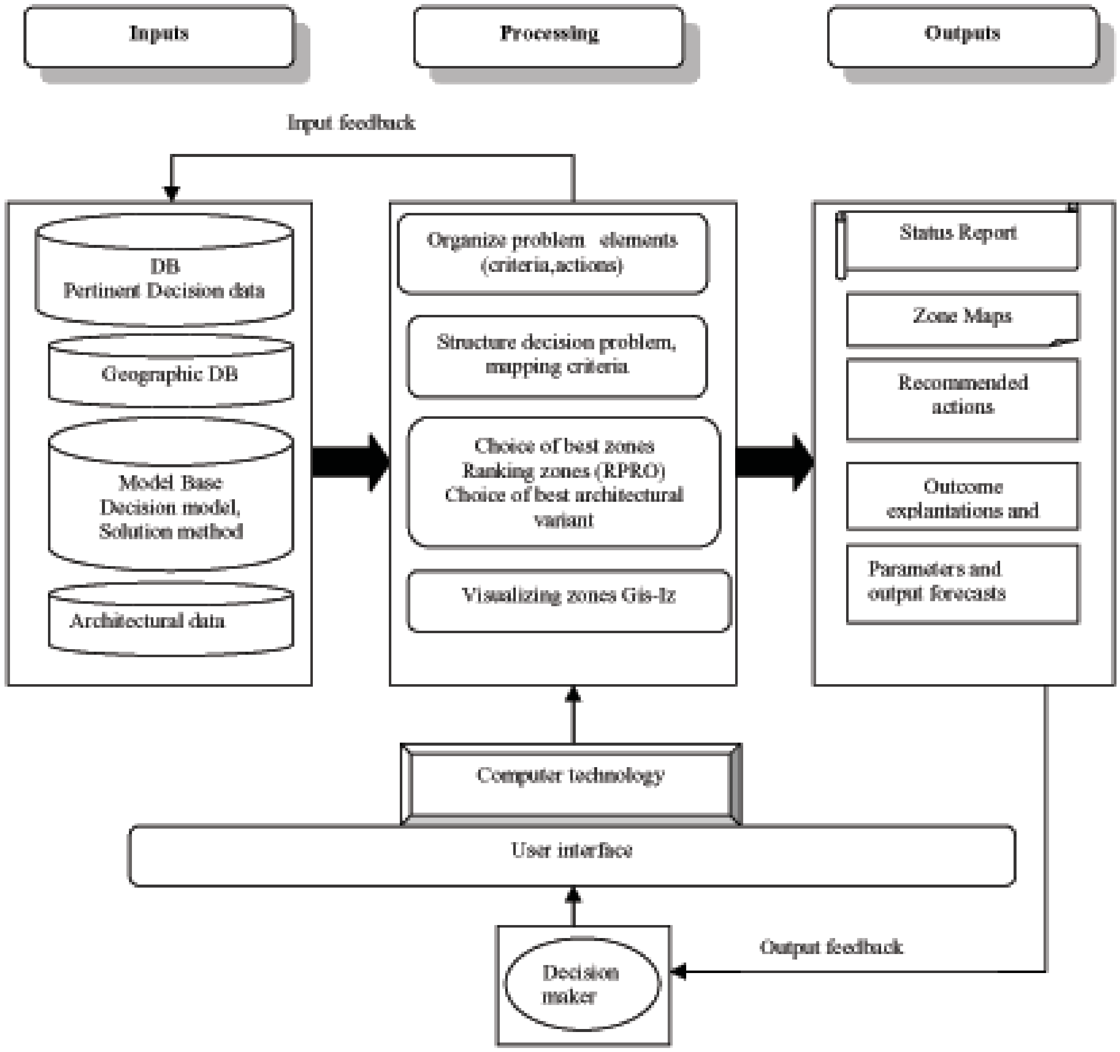

Figure 6. General System Architecture

6.2 Criteria

The criteria used in this study are classified into three categories: Natural constraints, socio- economic criteria and environmental impacts. According to these categories, 8 different evaluation criteria are defined. Figure 7 shows the hierarchy of criteria.

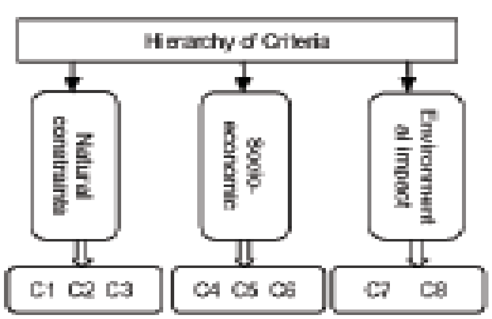

Figure 7. Hierarchy of Judgment Criteria

6.2.1 Natural Constraints

C1: Seismicity: The seismic zoning of the Algerian territory as in Figure 9, reveals five seismic zones.

C2 (Rainfall), **C3** (Temperature)**:** The average numerical

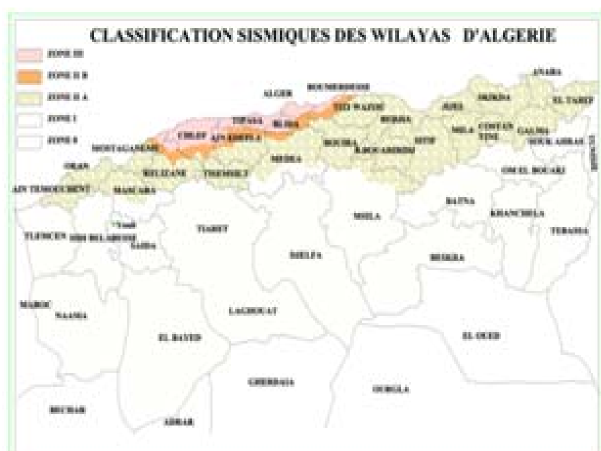

Figure 8. Represent seismic classification of Algeria

values of these two criteria are taken from climate stations installed in the country.

6.2.2 Socioeconomic Criteria

C4: Area: area of each industrial zone.

C5: Managing fee

C6: Proximity to transport networks (roads, railway and airport)

6.2.3 Environmental impacts

C7: Bioclimatic floors as shown in Figure 9.

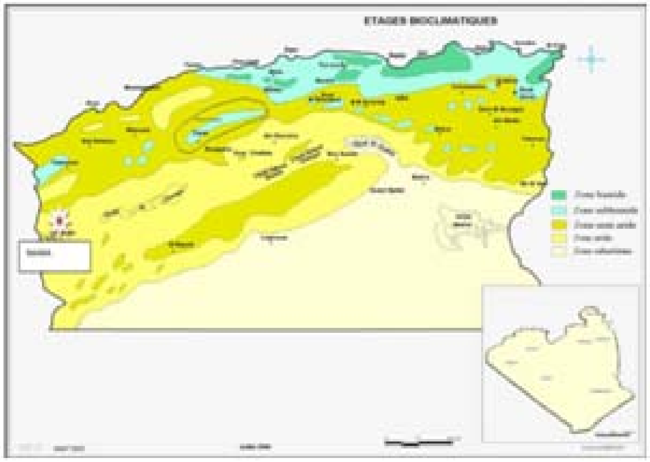

Figure 9. Bioclimatic Floors of Algeria [36]

C8: Proximity to the urban center of residence:

6.3 Intra-criteria weighting

Weights of criteria are defined by the technical team of ANIREF direction [36], following two steps:

Step1: Classification of the eight criteria in descending order of importance according to a unanimous decision from consultation among all members of the team (engineers, technicians and managers).

Step2: Consists of distributing a set of 100 points between the various criteria. The values of the final weights are given in the Table 1. Note that a criterion can be a factor to maximize or a constraint to minimize. The sense of each criterion is given according to the opinion of the expert.

Criteria	Weight (%)	Weight (point)
C1	10%	10
C2	5%	5
C3	5%	5
C4	20%	20
C5	15%	15
C6	20%	20
C7	5%	5
C8	20%	20

Table 1. Table of intra-criteria weights

6.4 Action assessment among all criteria

Action evaluation according to C1,C2,C3 criteria are illustrated in the table 2.

Actions	C1 and its Numerical value	C2	C3
A1	Low to moderate(2)	350	19
A2	Low to moderate(2)	310	24
A3	Low to moderate(2)	410	17
A4	Low to moderate(2)	380	19
A5	Low(1)	190	17
A6	Moderate(3)	400	18
A7	Moderate(3)	320	21
A8	Low to moderate(2)	350	20
A9	Moderate(3)	370	19

Table 2. Actions evaluation according C1, C2 and C3

Action evaluation according to C4,C5,C6 criteria are illustrated in table 3.

Actions	C4(ha)	C5 (DA)	C6(m)
A1	104	900592576	2500
A2	100	867750000	4100
A3	60	523765223	5000
A4	100	867750000	6500
A5	150	1301625000	3500
A6	205	1778911797	3000
A7	98	851772119	8100
A8	200	1735585907	6500
A9	500	4338750000	3000

Table 3. Actions evaluation according C4, C5 and C6

Action evaluation according to C7 and C8 criteria are illustrated in table 4.

Actions	C7 and its numerical values	C8
A1	Semi aride zone(2)	14000
A2	Semi aride zone(2)	17000
A3	Semi arid zone(2)	13500
A4	Semi aride zone(2)	15000
A5	Arid zone(1)	18000
A6	Semi arid zone(2)	16500
A7	Semi arid zone(2)	18300
A8	Semi aridezone(2)	13000
A9	Arid Zone (1)	17800

Table 4. Actions evaluation according C7 and C8

After the evaluation of all actions according to criteria, weighting and determination of the sense of all criteria we obtained the performance table (see Table 5).

Criterion/Action	C1	C2	C3	C4	C5	C6	C7	C8
A1	2	350	19	104	900592576	2500	3	14000
A2	2	310	24	100	867750000	4100	3	17000
A3	2	410	17	60	523765223	5000	3	13500
A4	2	380	19	100	867750000	6500	3	15000
A5	1	190	17	150	1301625000	3500	2	18000
A6	3	400	18	205	1778911797	3000	3	16500
A7	3	320	21	98	851772119	8100	3	18300
A8	4	350	20	200	1735585907	6500	3	13000
A9	3	370	19	500	4338750000	3000	2	17800
Citerion sense	Min	Min	Min	Max	Min	Min	Min	Max

Table 5. Performance table

Actions	Positive flow (φ^+)	Negative flow (φ)	Net flow(φ)	Rank
A1	0.38531917	0.3-	0.08531916	4
A2	0.2971698	0.5250107	-0.2278409	8
A3	0.36762434	0.35000002	0.017624319	5
A4	0.23181818	0.4375	-0.20568182	7
A5	0.59375	0.2363376	0.3574124	1
A6	0.4321429	0.3094263	0.122716606	3
A7	0.3124035	0.37500003	-0.06259653	6
A8	0.22386363	0.58466977	-0.36080614	9
A9	0.5196429	0.24578992	0.27385297	2

Table 6. Flow Values and Ranks

6.5 Interpretation of the Results

The Decision Maker found that GIS-based multi-criteria technique is very clear and flexible and can be used to analyze the potential Industrial sites in Algeria. In this study, we have considered only a sample of 8 zones among 41 programmed by authority, but, by optimizing the number of criteria and alternatives, standardization of criterion scores and making a suitability map for each criterion we can consider them in totality. The result of the study shows that any increasing in the used criteria leads to decrease the suitable area also, leads to the best affecting on the final result.

The rank of an industrial zone so obtained and illustrated in table 5, is an index with which we can:

- Criticize the choice of zones.
- Alert the planners and builders of zones.
- Assign the zone to adequate investment projects.

Although the significance of the result comes from the use of a validated method and a specific core GIS to data of the case study, remains a sensitivity analysis of preference and indifference thresholds to validate the solution stability. Here the indifference threshold is set at 5% of the difference between the highest and lowest score while the preference threshold is set at 10% of the difference.

7. Conclusion And Perspectives

The industrial site selection is a spatial decision problem which involves a large set of possible alternatives. There is a clear need for a model based on a combination between GIS and MCDA to support decision making. This paper proposes an approach based on the combination between PROMETHEE II and GIS to provide decision makers with a ranking model to select industrial sites in Algeria. The process of decision-making is consisted of a two-stage analysis: An initial site screening followed by a detailed assessment of the suitability candidate sites. The quantitative and qualitative data collected for each zone comforted the decision maker and has established a trust in him on the MCDA-GIS integration approach. GIS-based PROMETHEE II method for solving this problem is justifiable and accepted by the decider. The proposed mixed integration mode allows GIS to prepare geographic data in screening phase and to visualize ranked zones on a map in the evaluation phase.This research allowed us to determine the usefulness of the approach study for a site selection sector where the decision is important and dangerous, and intersects with the geography and even history.

As a future direction, we will engage Data mining to focus on further exploration of appropriate multi-criteria decision methods and show how data mining is used to model the decision maker preferences characterized by subjectivity and hesitance. This would allow decision makers to make such important decisions better and more efficient.Fuzzy PROMETHEE II will be used instead of PROMETHEE II alone to handle data uncertainties.

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