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Fuzzy Decision Support System Using Geographic Information System for planning and Deciding the best usage of Sinai land

Applied to Peninsula of Sinai

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Abstract— Any experiments, local and global success is measured by including the pros and excreted from the activation of the mechanisms for implementation and easy path to simple and without complications and to reach out to this concept must be enabled on important points:

1. Establishment of new mechanisms capable of implementing the provisions issued by the judicial authorities and by fast time rates.
2. Putting A map of the state's territory is characterized by dynamism and ability to deal with all the problems of economic, political and social enjoy the following:

- Planning the most appropriate for use in accordance with the natural resources and economic growth trends and global policies through the planning uses of state land.
- The most appropriate Urban Planning (housing - industrial - tourism ... etc.) Able to accommodate plans of the State in all areas of the General Authority for Urban Planning.
- Integrated environmental studies of such schemes and their impact on the community and develop solutions.

So, the main objective of the study is planning and deciding the best usage of Sinai land, by solving problems and taking decisions, through geo-database, by using Geographic Information System (GIS) environment, to give suitable recommendations to the development strategy of peninsula of Sinai with respect to

the all-available data.

In addition to that we used Multi-criteria Decision Analysis techniques (MCDA), Driven from Spatial Decision Support System (SDSS), and by applying Multi Criteria Analysis and Geographic Information System (GIS) for Territory (MAGISTER) modeling, that provides a general framework for specialized Fuzzy Spatial Decision Support System (SDSS) and investigates the link between Geographic Information System (GIS) and (MCDA) through fuzzy logic techniques.

Keywords- GIS, Fuzzy Logic, Spatial Decision Support System, MAGISTER modeling, MCDA

I. INTRODUCTION

This research and its methodology, suggest new research methods, newly apply and interpret the existing methods, also it complement scientific theories, concepts, models with new data and newly interpret this data, present new empirical data obtained through the application of the existing and new research methods, and independently collected, processed and analyzed by the researcher.

- Methodology of this research contains

1. Data Acquisition
2. Data Preparation, and
3. Data analysis

- Data analysis was taken from two perspectives:

A. GIS perspective, that includes:

1. Preparing the base map to identify the projection system and standardization of geographical maps
2. Building up a complete geo database for the study area
3. GIS analysis applied for the data to get the land suitability according to its capabilities e.g. Tourism, agricultural, mining, grazing and utilities

- DSS perspective, that includes:

1. Applying Simon's model as a Multi Criteria Decision Analysis Technique (MCDA) driven from SDSS
2. Applying MAGISTER modeling
3. Applying Fuzzy DSS for planning and deciding the best usage for Sinai land

- Output:

1. Electronic geo database
2. Applying Fuzzy DecisionSupport System for planning and deciding the best usage for Sinai land
3. GIS application linked by a visual basic.net interface
4. Capability maps (mining, agricultural, tourist, pastoral (grazing))

5. Suitability Map

6. Risk Map of Sinai (earthquakes, active faults, flash floods, and rock failure)

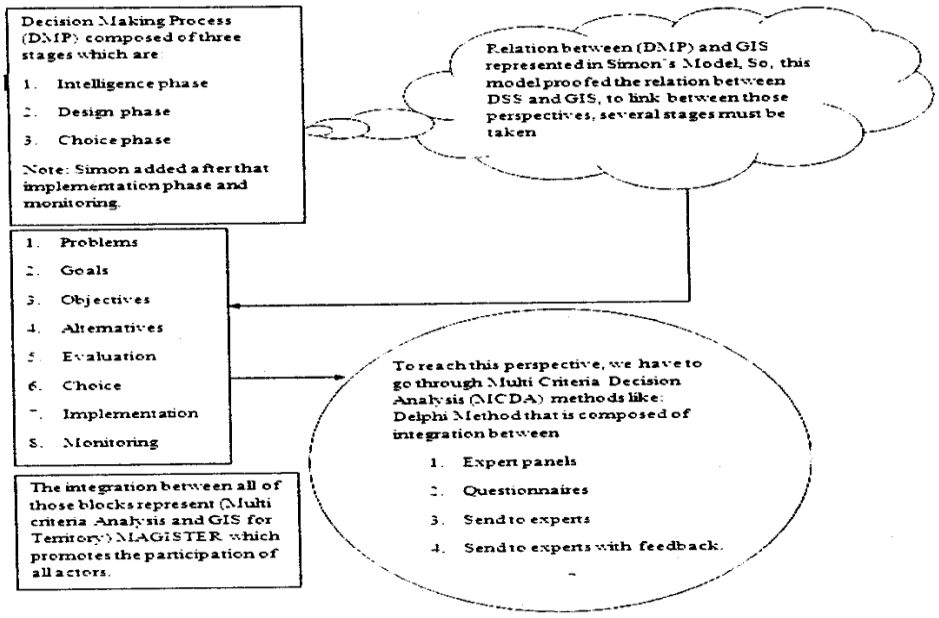


Figure (1): Represents the main research idea.

II. Importance of DSS:

DSS is a computer-based systems, which help decision makers utilize data and models to solve problems, especially the semi-structured and unstructured ones.

Decision support system described as an interactive computer-based system designed to help the decision-makers solve poorly structured problems concerning planning for Land Use classification and many other problems

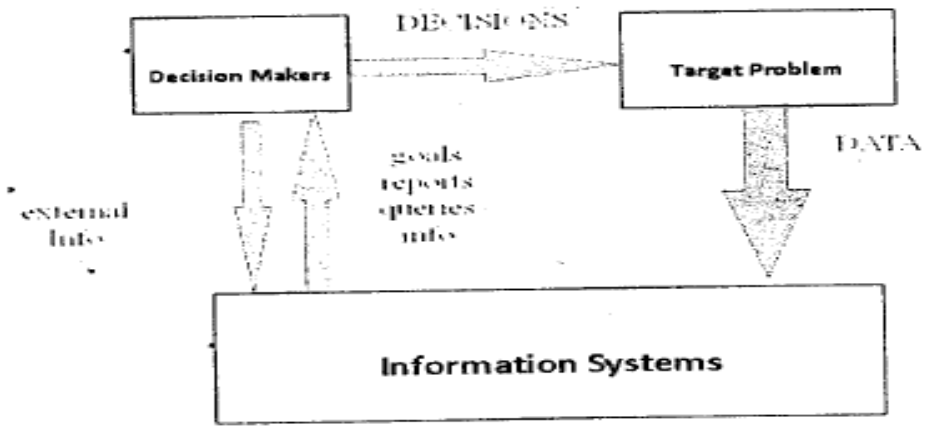


Figure (2): Importance of DSS.

II. Importance of GIS:

A Geographic Information Systems (GIS) is a specialized information system having all the basic possibilities of an information system as query, reporting and

data storage and retrieval.

GIS uses computers and software to control the fundamental principle of geography that location is important in people's lives.

In addition to combining layers of information about a place to give you a better understanding of that place, it also works with thematic layers of spatial data, and Answer questions by comparing different layers of data.

- What is GIS?

Table (1): presents what is GIS (3)

	Geographic	Information	System
Means	Abstract representation of reality by graphic objects, e.g. roads as lines, cities as dots, etc.	Stores data about an object and about its spatial relationships	A connected set of processing tools
Implies	Objects are related to each other in the earth by real-world coordinates	Querying the relationships to answer questions: (how long is this road?)	Dependent on range and quality of input & output methods, tools & interoperability
Offers	Units of length, area etc. that are real world units. We can zoom to any scale we like, and extract real-world information	Modelling a complex system (e.g. how long to the airport on a rainy Tuesday at 5pm, I'm driving a 1962 VW)	Graphic display & interactivity, within limits

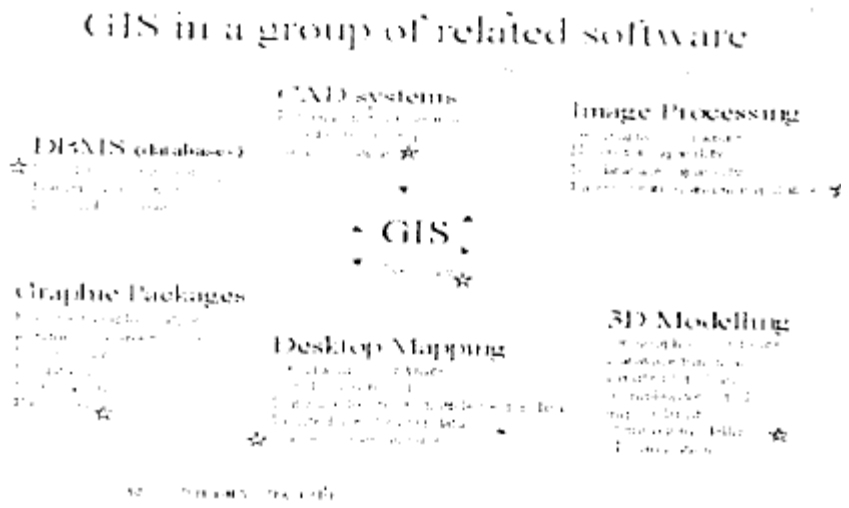


Figure (3): Presents GIS and Related Software (28)

- **GIS can perform a model to extract land capability map**

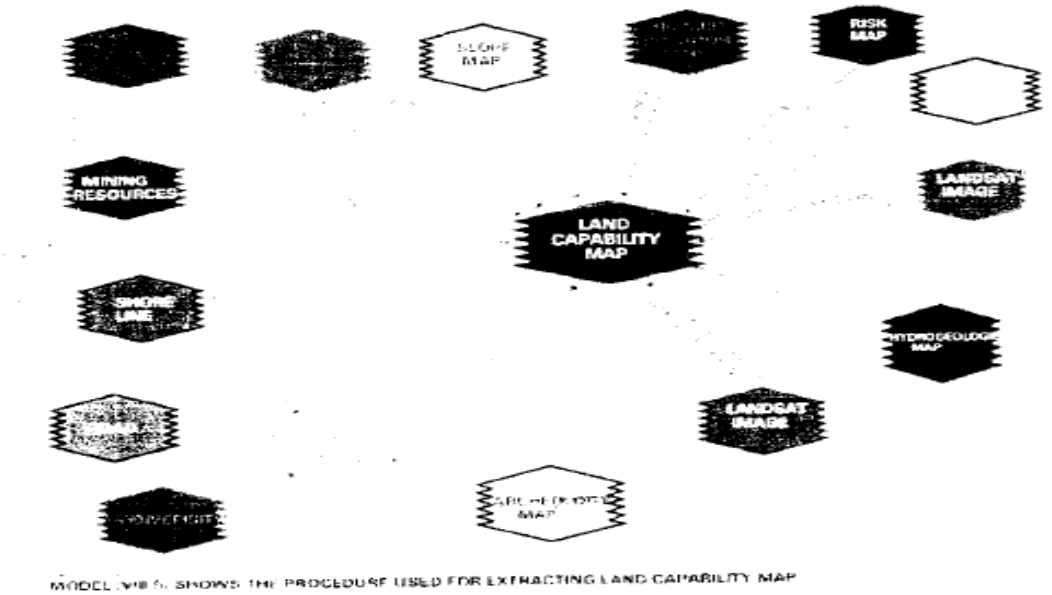


Figure (4): Model shows the procedure used for extracting land capability map

IV. The integration between DSS and GIS and how GIS can be affected by DSS through models applied:

Land-use planners often make complex decisions within a short period of time when they must take into account sustainable development and economic competitiveness.

GIS analysis applied for the data to get the land suitability according to its capabilities, a set of land-use capability maps would be very useful in this respect. Ideally, these maps should incorporate complex criteria integrating several procedures. To illustrate the feasibility of this approach, a land capability map for land use was realized for peninsula of Sinai region figure (4).

Geographical Information System technology was used to assess the criteria requested to define the land capability for Sinai to determine places like: Tourism, agricultural, mining; grazing and utilities.

Because the required criteria are heterogeneous, so using Multi-criteria Decision Analysis techniques (MCDA), which is driven from Spatial Decision Support System (SDSS) is urgently required.

A Spatial Decision Support System (SDSS) (4) usually relies on a GIS that have the additional capability of dynamically displaying any query, report or piece of information in the system as a map.

But GIS have limited capabilities to support the design and choice phases of the decision-making process.

This way a SDSS becomes a more complete system for solving problems spatially, designed to answer questions the decision maker would have prior to making a decision.

In addition, SDSS often includes integrated solutions for security, communication and adherence to organizational procedures.

Both SDSS and GIS use geospatial technology and the difference from other types of information systems is their capability to display information. In a GIS almost any type of data can be stored, analyzed spatially and modeled across time. The geospatial technology is not a new one, but it is becoming more wide used.

How GIS can be affected by DSS through models applied

Simon divides any decision-making process into the phase 01decision-making:

a) Intelligence: is there a problem or an opportunity for change?
b) Design: what are the decision alternatives?
c) Choice: which alternative is the best?

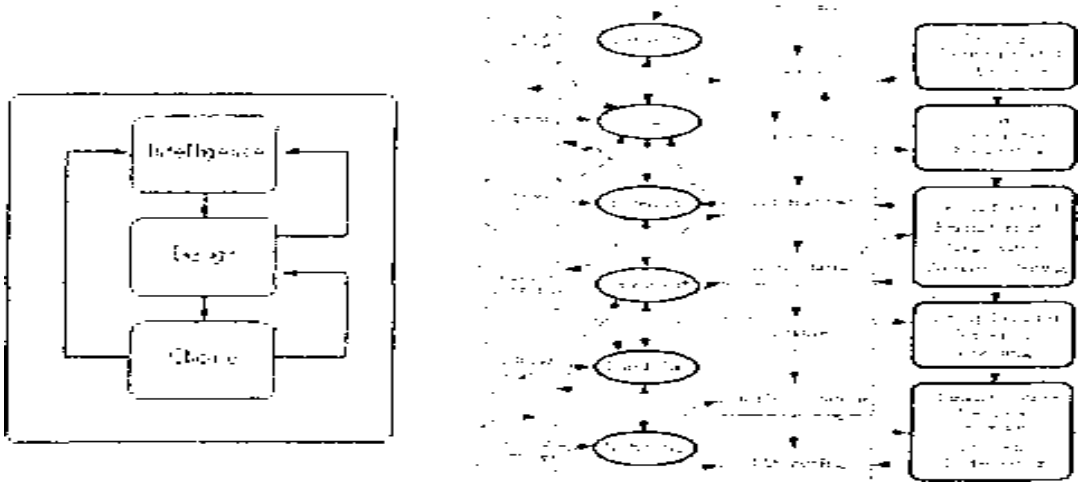


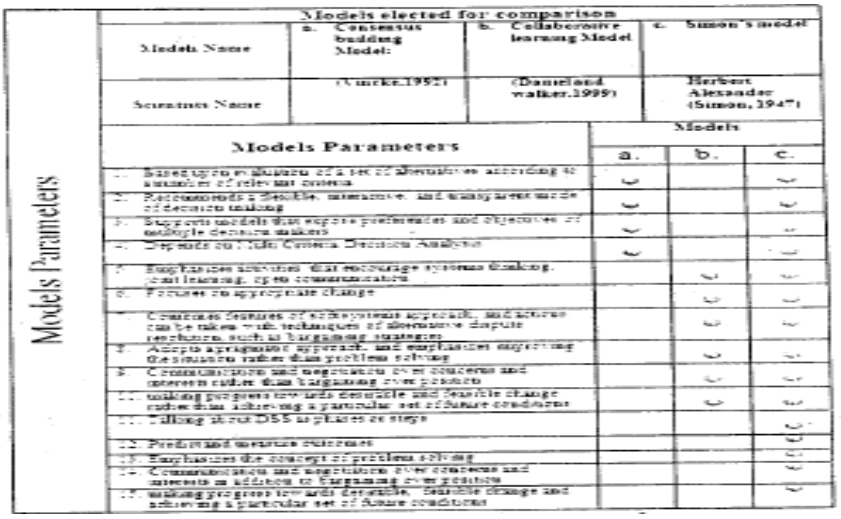
Figure (5): represents Simon's Model (4)

Relation between Decision Making Process (DMP) and GIS represented in Simon's Model, So, this model proofed the relation between DSS and GIS, to link between those perspectives, several stages must be taken, these stages are:

1. Identifying Problems
2. Goals
3. Objectives
4. Alternatives
5. Evaluation
6. Choice
7. Implementation
8. Monitoring

To reach this model perspective, a comparison was done between Simon's

model and two other models illustrated at table (2) (9. 5)



Models Parameters	Models elected for comparison		
Models Name	a. Consensus building Model:	b. Collaborative learning Model	c. Simon's model
Scientists Name	(Cumke,1992)	(Daneland walker,1999)	Herbert Alexander (Simon, 1947)
Models Parameters	Models		
	a.	b.	c.
... Selecting a number of a set of alternatives according to a number of relevant criteria	✓		✓
2. Recommends a flexible, interactive, and transparent mode of decision making	✓		✓
3. Supports models that express preferences and objectives of multiple decision makers	✓		✓
4. Depends on Multi Criteria Decision Analysis	✓		✓
5. Emphasizes activities that encourage systems thinking, joint learning, open communication		✓	✓
6. Focuses on appropriate change		✓	✓
7. Combines features of a behavioral approach, and actions can be taken with techniques of alternative dispute resolution, such as bargaining strategies		✓	✓
8. Accepts a pragmatic approach, and emphasizes improving performance rather than problem solving		✓	✓
9. Communication and negotiation over concerns and interests rather than bargaining over positions		✓	✓
10. ... making progress towards desirable and feasible change rather than achieving a particular set of future conditions		✓	✓
11. ... Calling it not DSS as phases or steps			✓
12. Predicted resource outcomes			✓
13. Emphasizes the concept of problem solving			✓
14. Communication and negotiation over concerns and interests in addition to bargaining over positions			✓
15. making progress towards desirable, feasible change and achieving a particular set of future conditions			✓

Table (3): Models elected for comparison

Choosing the model depends on methods used in it also so, we have to go through Multi- Criteria Decision Analysis (MCDA) methods like Delphi Method that is composed from integration of:

1. Expert panels
2. Questionnaires
3. Send to experts
4. Send to experts with feedback.

The integration between all of previous words represent (Multi criteria Analysis and GIS for Territory) MAGISTER which promotes the participation of all actors.

V. The role of models in decision-making:

A major characteristic of decision-making [6] is the use of models, a model is a simplified representation or abstraction of reality, it is usually simplified because reality is too complex to copy, Basis idea is that analysis is performed on a model rather than on reality itself.

- Categories of Models - Expectations against which reality is measured: (6)

1. Historical - expectation: based on extrapolation of past experience.
2. Planning - the plan is the expectation
3. Inter-organizational- Models: are models of other people in the organization (e.g. superiors, subordinates, other departments, etc.)
4. Extra-organizational - models: where the expectations are derived from competition, customers, professional organizations, etc.

- Another classification of models:

Iconic Models, Analog Models, Mathematical Models, Mental Models

So MAGISTER Model figure (6) depends on multi-criteria decision analysis that includes multiple methods, that is useful to use in planning for land use classification

These methods are as follows:

a) SWOT
b) Benchmarking method
c) DELPHI

Table (4): represents comparison between the three kinds of methods

SWOT analysis method	Benchmarking method	Delphi method
a. It comes out of Delphi studies, literature usually. SWOT is less based on an assessment of the longer term. SWOT is often presented in a 2x2 matrix, an overview of significant internal and external factors influencing strategies or possible futures. b. Graphical plots and other methods are used to select key factors. SWOT analysis is widely used, especially as a preliminary step in planning	a. This has been transferred to the sector and regional or national levels, and to a wide span of policies as well as purely economic ones. b. It offers learning opportunities : how do they achieve that ?, as well as steps for setting goals : "we will be up to that level by the year 2020 " and identifying likely competitive challenges. c. Benchmarking can be performed in a very reductionist way, with performance in terms of individual indicators being abstracted from the systemic context of the organization or region in question. d. It is important to examine the topic area carefully, so as to identify the most appropriate issues around which to build indicators, and to examine which of various indicators might be most useful.	This method is a kind of Multi-Criteria Decision Analysis (MCDA) methods like: Delphi Method that is composed of integration between 1. Expert panels 2. Questionnaires 3. Send to experts - Send to experts with feedback
Additions (Results)		
• SWOT analysis often reflects inadequate definition or presentation of factors. • This may be due to an absence of real expert knowledge; • the reiteration of standard analysis by consultants unfamiliar with local specificities; • Political pressures of associated desire to downplay or to minimize or ignore the regional national weaknesses. • It is also possible to underestimate one's strengths. • Repeated disappointments may lead to local "common sense" becoming fatalistic and supporting the view that a region is inevitably disadvantaged in certain respects, failing to examine any evidence that suggests the contrary.	• We can not say that benchmarking method is a bad one. NO, but it talks in a different scope, it covers firm's comparisons and competences between each other, and it shows the competition influence on the economy, so it is extremely useful but in its scale, not in land use classification planning point of view. So, it is out of scope)	• This method is related to thesis point of discussion according to illustration mentioned above.

so, according to the comparison we can say that Delphi method is the most applicable way to solve the problem of land use classification planning, but this will not be the most appropriate solution unless, we add a small point which is: merging this method with a mathematical model obtained from the GIS tool, helps in taking the right decision in land use classification planning.

- Region characteristics will be illustrated, through three main axes which are:

1. Agriculture
2. Extractive industries
3. Activities of scientific tourism

In addition to applying MAGISTER model as an experimental model, to show us how to decide for land use classification planning.

Finally, we will see what will be added for this model to suite our requirement.

Coming part will talk about illustrating MAGISTER model cycle, and then we will apply it in our case.

- First of all, According to MAGISTER model: (10)

We will mention, the evaluation matrix (figure (6)) that combines between properties (three main axes), and elements of use (region characteristics).

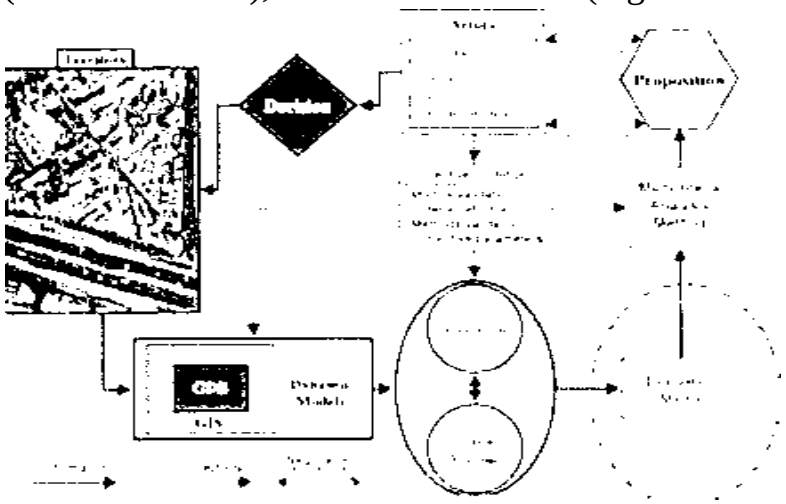


Figure (6): represents MAGISTER model to discuss the evaluation matrix

Properties / Elements of use	Agriculture	Extractive Industries	Tourism	Housing	Activities of Scientific Tourism
Water	60%				
Infrastructure		50%		50%	
Proximity to natural protectorates					
Soil	50%				
Tourist resort OR Monuments			60%		40%
Islands Marine					20%
Labor	20%	20%			
Hills and Highlands					10%
Proximity to Mines and Quarries		60%			50%
Proximity to air ports and ports			20%	20%	
Away from Contaminated Areas			20%	20%	
Total Percentage	100%	100%	100%	100%	100%

Figure (7) the evaluation matrix

We will present MAGISTER model cycle and then practice or apply it according to thesis point of view.

VI. MAGISTER model cycle: (10)

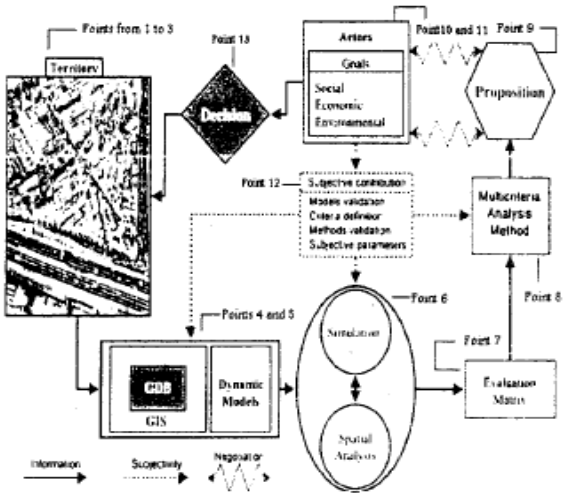


Figure (7): MAGISTER model subsidized by numbers for explanation and clarification

- Explanation:

1. Map is transferred from paper map to digitized map by scanning it to the computer,
2. Features have attributes associated with them,
3. Information is separated into layers

a) The map represents the landscape in an artificial way.

b) Vector layers represent features in one of several ways: points, Lines, And polygons.

c) You might hear people talk about coverage, Geo-database, or shape-files. All these terms are other names for layers of information.

d) With individual layers, we can conduct analysis between layers and only display layers of interest.

4. Representing data into layers-means that, a geo-database that is represented by tables and attributes is done actually.
5. Then, dynamic models where done to show us the data processing (Figure (4)).
6. Spatial analysis is done by those models, and by this analysis we would be able to simulate the results on the digital map.
7. Simulation is not enough to get or to suggest a proposition to take decision. So, an evaluation matrix must be done, that combines between properties (three main axes), and elements of use (region characteristics) mentioned above.
8. According to evaluation matrix, I can analyze the system as a whole, to reach the maximum effectiveness and efficiency as much as possible.

- That could be done by using "Multi Criteria Decision analysis methods" that includes Delphi method.

9. From this analysis, we can propose or suggest some propositions to take decision from.

10. Decision won't be taken unless; we mention goals of the system first.

11. Goals could be social, Economic, or environmental, so, we have to put all of those actors in our consideration.

12. These goals or actors could lead us to change models and parameters that we are working with.

13. Finally, we can say that we would be able to take the right decision to plan for land use classification.

- Referring to point number (8), we have to illustrate, how can Delphi method perform?

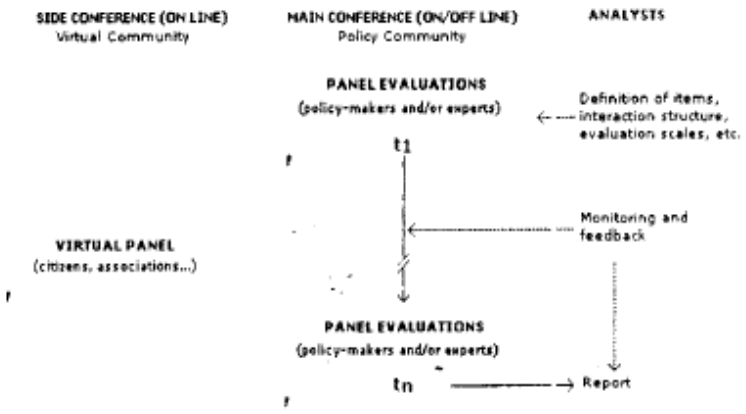


Figure (8): A web-based communication structure (Hyper Delphi)

- Delphi method works through multiple panels or, multiple rounds of evaluation, but it goes through at least three panels.
- Two rounds from them are for policy-makers and/or experts (Figure 12), and one that is called virtual panel (citizens, associations...)
- Delphi method depends on four elements, which are:

1. Expert panels.
2. Questionnaires: for citizen and associations.
3. Send to experts (for evaluation).
4. Send to experts with feedback: after questionnaires happen, analyzers take feedback and then submit them to experts.

So, here in this point we can say that MAGISTER model applying Simon's model phases, which are: Intelligence phase, Design phase, and choice phase.

a) Intelligence phase: is there a problem or an opportunity for change?

b) Design phase: what are the decision alternatives?

c) Choice phase: which alternative is the best?

- Intelligence phase appeared in: Selecting the study area that has the problem appeared in (Figure 7) at (points from 1 to 3)
- Design phase appeared in: applying the Multi Criteria Decision analysis methods, which represented in Delphi method (Figure 7) at (point 8), at this phase we can see alternatives that we will choose from.
- Choice phase appeared in: (Figure 15) at (point 18), at this point we took the actual and final decision chosen from best alternatives.

And now according to Figure (7):which represents MAGISTER model subsidized by numbers for explanation and clarification

VII. Applying methods and theories in applications:

- First: We want to apply this model in the study area (2) (Peninsula of Sinai) and. plan for land use classification, then deciding the area that is suitable for Agriculture.

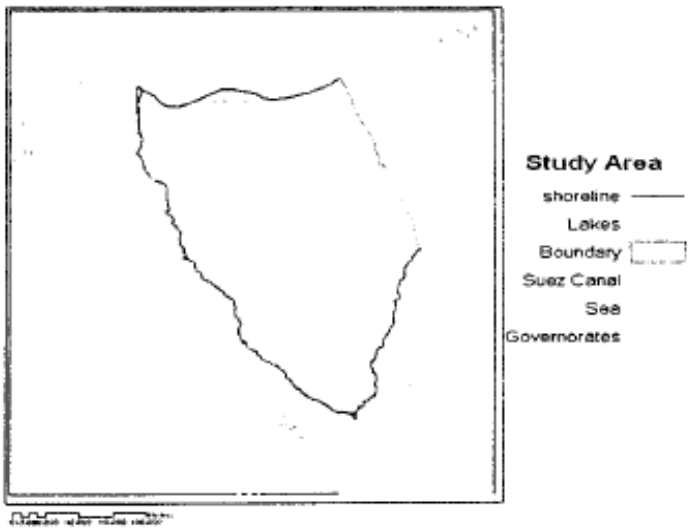


Figure (9): represents the study area, Peninsula of Sinai

❖ Steps taken to apply MAGISTER model on our study area:

1. Data is presented as layers; each layer presents a table in the geo-database that has multiple attributes.

2. Dynamic model as MAGISTER point of view represents, the plane or the procedure taken to determine the area that is suitable for agriculture.

3. We can get characteristics or properties of the agriculture land, from the evaluation matrix that has all elements of use, which must be known to classify the land as agricultural land.

4. Elements of use according to the evaluation matrix are:

a) water, weighted by 60%

b) Soil, weighted by 30%

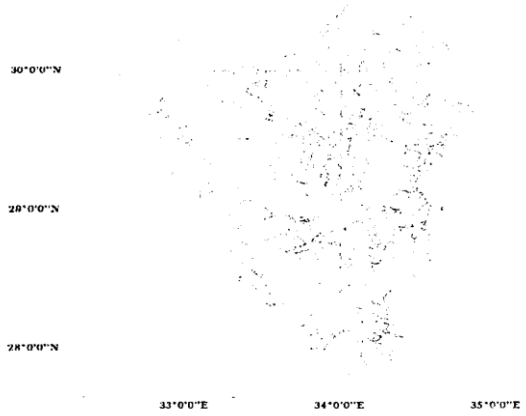
c) Labor, weighted by 10%

As information mentioned above, we can know that water has many shapes, and soil has multiple degrees, according to each degree we can know the land suitability for agriculture.

- Water has the most priority in agriculture; it takes a high percentage according to the evaluation matrix (60%).
- Soil follows water in priority for agriculture; it takes (30%) according to the evaluation matrix.

Finally, labor plays a big role in agriculture, but when we measure priorities, water and soil are the most factors that affect agriculture, so, labor takes only (10%) according to the evaluation matrix.

The following figure represents agricultural area in Peninsula of Sinai, ranged from 1 till 7; the more you go up in numbers the less fertility exists. (13)



Agricultural Capability Map

Figure (10): Agricultural capability map without describing soil fertility degrees

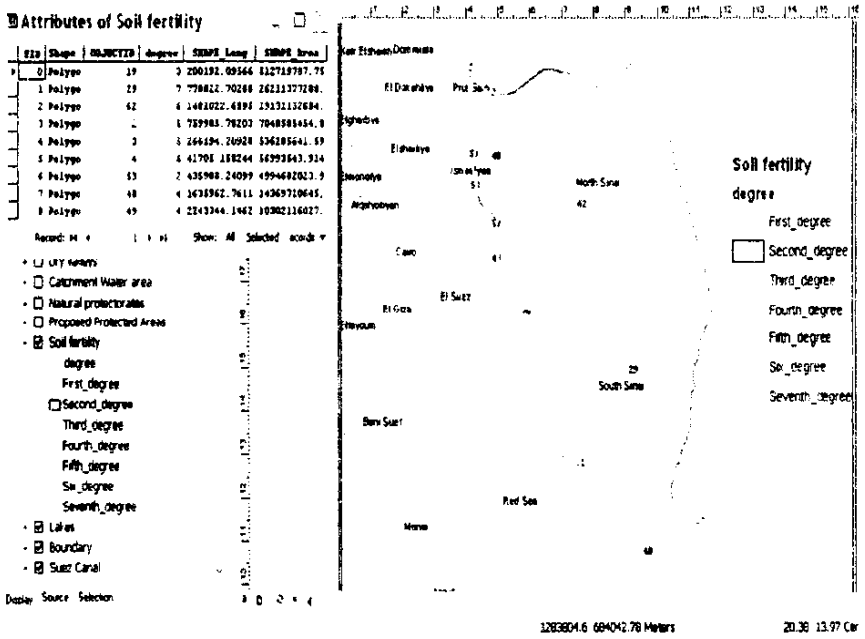


Figure (11): represents Soil fertility degree by using Arc GIS tool

The result of soil fertility degree couldn't be determined unless; we used Delphi method as a MCDA (Multi Criteria Decision Analysis) method.

So, many rounded were taken to determine agricultural criteria.

Questionnaires are made for associations through virtual panels.

After questionnaires are made, experts make another round to monitor and give feedbacks, and then reports made to take final decision.

- Now, we can parenthesize or bracket or limit our steps till now as follows:

1. Determining the study area through digital map, and a geo-database.
2. Geo-database has all attribute tables that collects all data about the study area.
3. Data are represented in field-ID< field-name, shape, object-id degree, and shape-length as shown in figure (12).

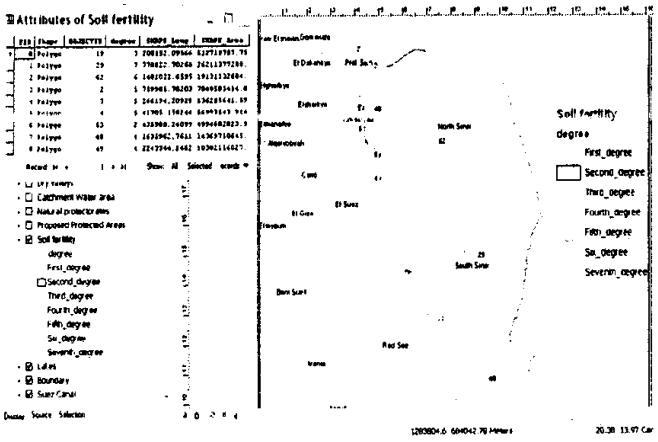


Figure (12): represents soil fertility degree by using Are GIS tool

4. Dynamic models resulted from negotiations were done, those models shows the procedure used for extracting land capability map (figure (4)) Spatial analyses were done by the aid of the evaluation matrix to find a proposition, to determine the land suitability for agriculture.

- No doubt, that this analysis includes Social, economical and environmental goals, for taking a final and a most suitable decision.

We can now say, that our objective be clarified through using Simon's model represented in MAGISTER model that is used for land use classification planning.

- Second: applying MAGISTER model also in the study area (Peninsula of Sinai) and, plan for land use classification, then deciding the area that is suitable for Extractive Industries.

❖ Steps taken to apply MAGISTER model on our study area:

1. Data is presented as layers; each layer presents a table in the geo-database that has multiple attributes.
2. Dynamic model as MAGISTER point of view represents, the plane or the procedure taken to determine the area that is suitable for Extractive Industries.
3. We can get characteristics or properties of the Extractive Industries land, from the evaluation matrix that has all elements of use, which must be known to classify the land as Extractive Industries land.
4. Elements of use according to the evaluation matrix are:(15)

- Proximity to mines and quarries, weighted by 60%
- Infrastructure, weighted by 30%
- Labor, weighted by 10%

As information mentioned above, we can know that mines and quarries has many shapes, and also building materials, according to this information we can know places of them and determine it in map to make buffering surrounds those areas for extracting these materials for making extractive industries.

Mining, quarrying and building materials, all of them have the most priority in Extractive Industries area characteristics; it takes a high percentage according to the evaluation matrix (60%), because industrial areas are been in charge of, or depends On those elements.

Infrastructure also is extremely important, like: electricity, water and deflation.

Infrastructure follows mining, quarrying and building materials in priority for Extractive industries; it takes (30%) according to the evaluation matrix.

Finally, we mentioned that labor plays a big role in industries, but when we measure priorities so, infrastructure, mining, quarrying and building materials are the

most factors that affect industry, so, labor takes only (10%) according to the evaluation matrix.

The following figures represent Extractive Industries area in Peninsula of Sinai; it encompasses Geology elements which are: mining, quarrying and building materials.

We will first mention them separately in ERDAS Imagine tool, followed by a figure that encompass or enclose them all at the same time.

Finally, we will represent it from Arc GIS tool by its attribute table.

The first figure is for mining capability by using ERDAS Imagine tool

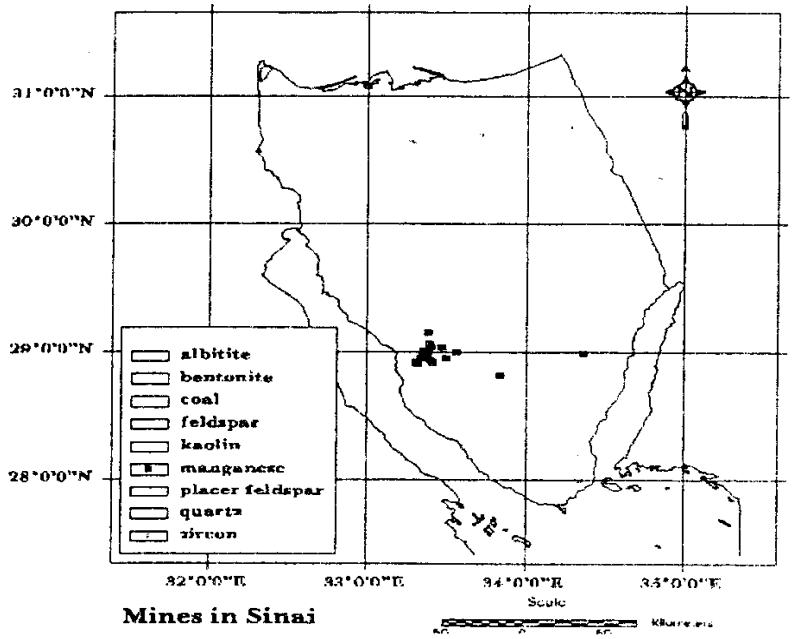


Figure (13): Mining capability map by using ERDAS Imagine tool (16)

The second figure is for quarries capability map by using ERDAS Imagine tool

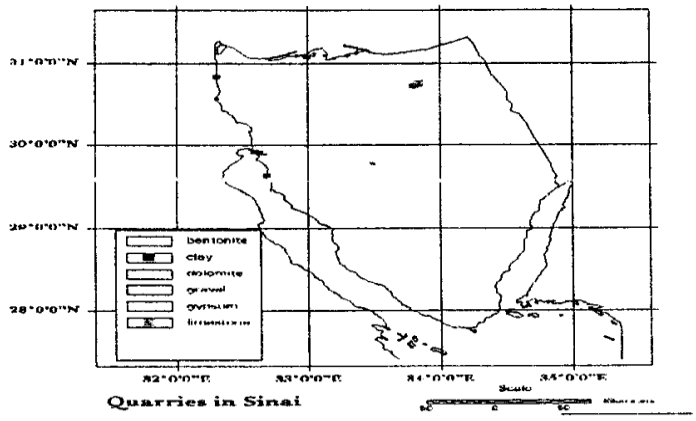


Figure (14): Quarries capability map (17)

The third figure is for Building material map by using ERDAS Imagine tool

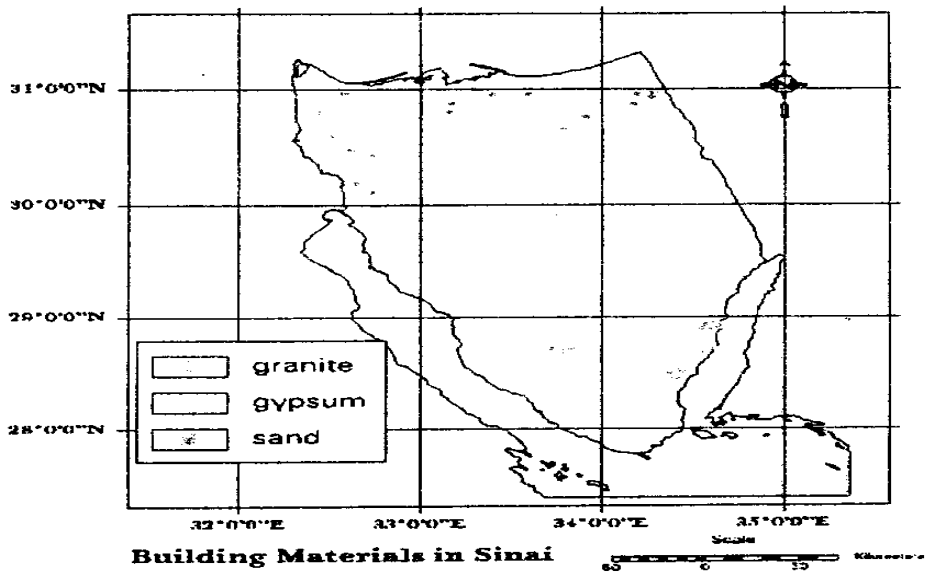


Figure (15): Building material capability map by using ERDAS Imagine tool

The fourth figure is for combining mining, quarrying and building materials represented in Arc GIS tool

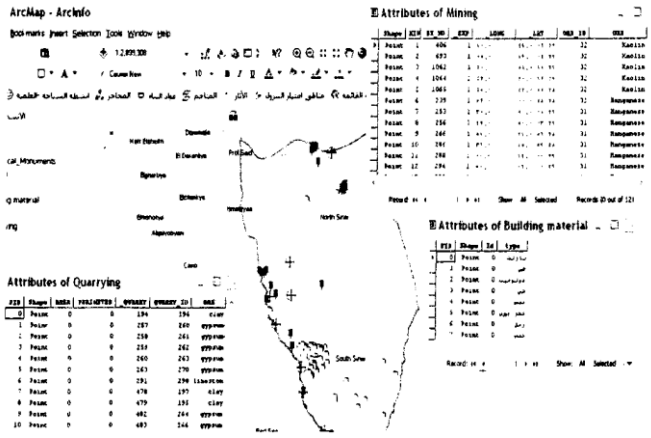


Figure (16): combination of mining, quarrying and building materials represented in Arc GIS tool

- The result of determining the extractive industry land couldn't be determined unless; we used Delphi method as a MCDA (Multi Criteria Decision Analysis) method.
- So, many rounded were taken to determine industrial land criteria.
- Questionnaires are made for associations through virtual panels.
- After questionnaires are made, experts make another round to monitor and give feedbacks, and then reports made to take final decision.

Now, we can parenthesize or bracket or limit our steps till now as follows:

- Determining the study area through digital map, and a geo-database.
- Geo-database has all attribute tables that collects all data about the study area.
- Data are represented in field-ID, field-name, shape, object-id, area, and shape-length as shown in figure (16).
- Dynamic models resulted from negotiations were done, those models shows the procedure used for extracting land capability map (figure (4)).
- Spatial analysis where done by the aid of the evaluation matrix to find a proposition, to determine the land suitability for industry.

This analysis includes Social, economical and environmental goals, for taking a final and a most suitable decision.

❖ Sometimes we **get intersections** in some areas, and we got astonished and frustrated, so, how can we solve this problem? This question will be solved later.

❖ MAGISTER model applied in the study area (Peninsula of Sinai) and, plan for land use classification, then deciding the area that is suitable for Tourism activities.

Steps taken to apply MAGISTER model on our study area:

1. Data is presented as layers; each layer presents a table in the geo-database that has multiple attributes.
2. Dynamic model as MAGISTER point of view represents, the plane or the procedure taken to determine the area that is suitable for tourism activities.
3. We can get characteristics or properties of the tourism activities area, from the evaluation matrix that has all elements of use, which must be known to classify the land as touristic land.
4. Elements of use according to the evaluation matrix are:

- Tourist resort and Tourist monuments, weighted by 60%
- Proximity to air ports and ports, weighted by 20%
- Away from contaminated areas, weighted by 20%

We know that Tourism in Sinai takes many shapes:

- So, two shapes were taken from them which are:
- First: scientific tourism activity, which depends on Active faults.
- Second: coastal tourism activity, which depends on shoreline and lakes.
- Tourist resort, and tourist monuments has the most priority in

tourism activities; it takes a high percentage according to the evaluation matrix (60%).

- Proximity to air ports and ports follows tourist resort and tourist monuments in priority for tourism activities area; it takes (20%) according to the evaluation matrix.
- Finally, we mentioned that being away from contaminated areas plays a big role in defining touristic area, it comes in the same level of priority to proximity to air ports and ports so, it takes (20%) according to the evaluation matrix.

We will present the map figures representing tourism activities area in Peninsula of Sinai in two shapes, one in ERDAS Imagine tool and one in Arc GIS tool.

The following figure will represent tourism activities area through ERDAS Imagine tool; it will give us all activities combined together in one map.

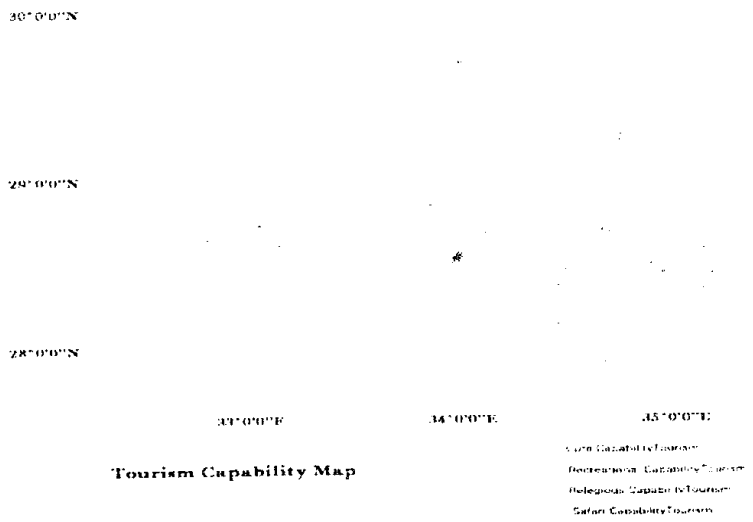


Figure (17): represents tourism activities area through ERDAS Imagine tool

The following figure will represent tourism activities area through Arc GIS tool the first one is: scientific tourism activity, which depends on Active faults.

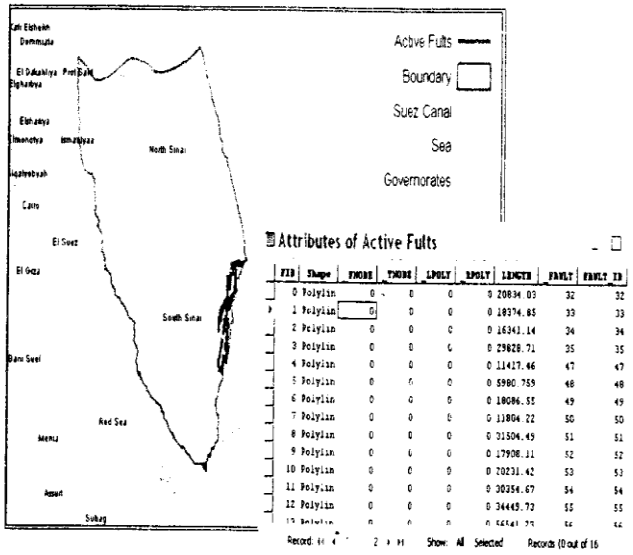


Figure (18): represents scientific tourism activity through Are GIS tool (19)

The second one is: coastal tourism activity, which depends on shoreline and lakes.

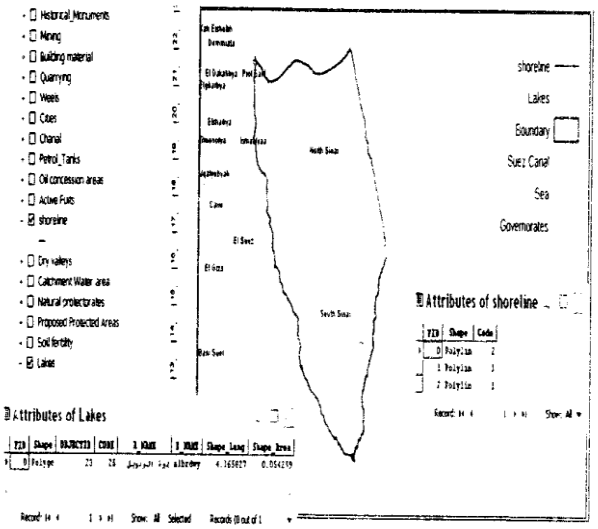


Figure (19): represents coastal tourism activity through Arc GIS tool (20)

- The result of tourism activities areas couldn't be determined unless; we used Delphi method as a MCDA (Multi Criteria Decision Analysis) method.
- So, many rounded were taken to determine tourism activities areas criteria.
- Questionnaires are made for associations through virtual panels.
- After questionnaires are made, experts make another round to monitor and give feedbacks, and then reports made to take final decision.

Now, we can parenthesize or bracket or limit our steps till now as follows:

- Determining the study area through digital map, and a geo-database.
- Geo-database has all attribute tables that collects all data about the study area.
- Data are represented in field-ID, field-name, shape, object-id, degree, and shape-length, code, fault-ID as shown in figure (18) and figure (19).
- Dynamic models resulted from negotiations were done, those models shows the procedure used for extracting land capability map shows in (figure (4)).
- Spatial analysis where done by the aid of the evaluation matrix to find a proposition, to determine the land suitability for tourism activities areas.
- Sometimes we get intersections in some areas, and we got astonished and f□□□□□□ed, so, how can we solve this will be solved how by applying fuzzy logic technique.

VIII. Applying Fuzzy Logic in deciding and planning the best usage for Sinai land:

- Fuzzy logic theory says that it provides a method of reducing as well as explaining the system complexity
- The Idea of Fuzzy Sets: (2)

Fuzzy sets are functions that map a value, which might be a member of a set, to a number between zero and one, indicating its actual degree of membership.

A degree of zero means that the value is not in the set and a degree of one means that the value is completely representative of the set.

- Benefits of Fuzzy System Modeling:

1. Ability to Model Highly Complex Business Problems
2. Ability to Model System Involving Multiple Experts
3. Reduce Model Complexity
4. Improve Handling of Uncertain and Possibilities

A fuzzy model, like traditional Expert and Decision Support System, is based on the input, process, and output flow concept.

A fuzzy model differs in two important properties: What flows into and out of the process, and the fundamental transformation activity embodied in the process itself

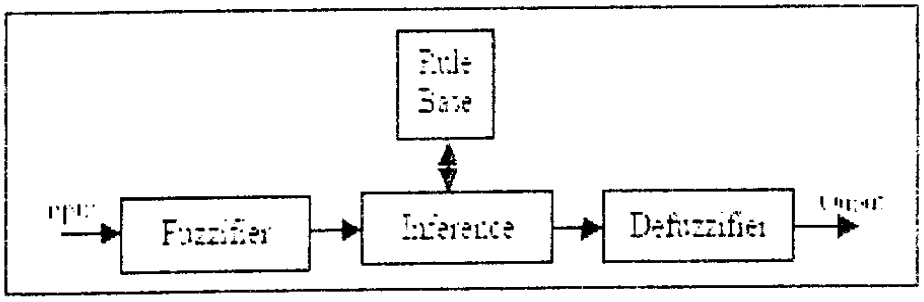


Figure (20): Information flow in Fuzzy System (22)

Now, how we could solve mentioned problem that talks about intersection between layers?

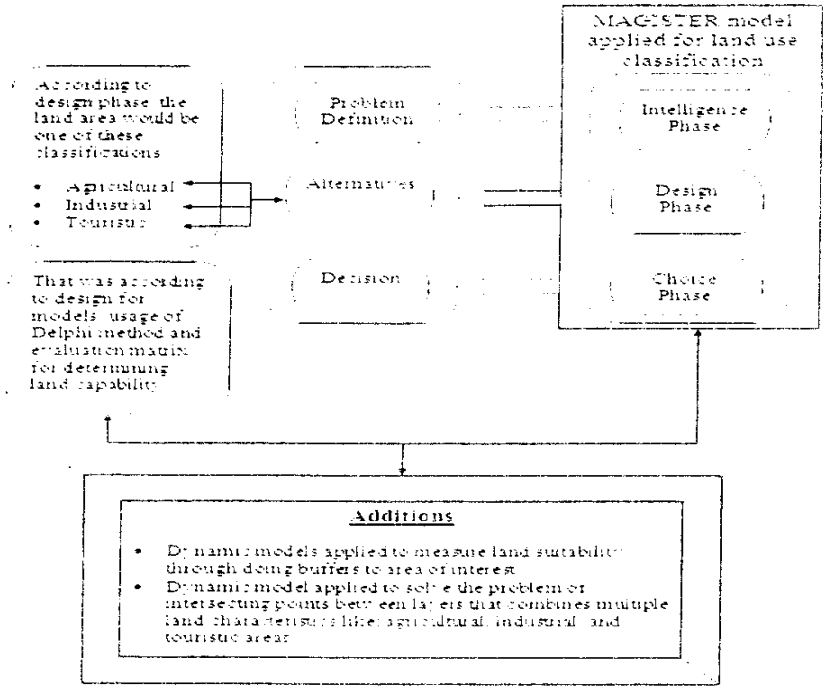


Figure (21): shows additions done to M AGISTER model to solve the problem

- According to figure (7) that presents (MAGISTER model subsidized by numbers for explanation and clarification) we can make this comparison.

Table (5): comparison between MAGISTER model previously and after adjustments

MAGISTER model previously	MAGISTER model after adjustments
1. Map transferred from paper map to digitized map, by scanning it to the computer.	Map transferred from paper map to digitized map, by scanning it to the computer.
2. Features have attributes associated with them.	Features have attributes associated with them.
3. Information is separated into layers.	Information is separated into layers.
4.Spatial analyses were done by dynamic models to show data processing for determining land capability.	Here, dynamic models done in two ways: By dynamic models presenting land capability.
5. No dynamic models to know land suitability.	By dynamic models presenting land suitability.
6. Making Simulation.	Making Simulation.
7. Evaluation Matrix.	Evaluation Matrix.
8. Proposing some propositions to take decision.	Proposing some propositions to take decision.
9. Determine goals.	Determine goals.
10. Taking the final decision.	Taking the final decision.
11. No, additional decisions	Taking decision, it's not the final decision but other processing is done to take a final decision, and this will be illustrated below.

The two shaded rows are the two points of differences between MAGISTER model previously, and MAGISTER model after adjustments.

- Related to table (5), we will draw a graph represents how MAGISTER model after adjustments is better than previous MAGISTER model taking values from table (6).
- the following table represents all criteria from 1 till 11 mentioned

in table (5) that represents differences between new and old model, numbers zero and one are written to proof criteria existence (one is for exist and zero is for not exist (by fuzzy logic analysis technique)).

Table (6): values of evaluation criteria represented in zeros and ones

	MAGISTER model previously	MAGISTER model after adjustments
1	1	1
2	1	1
3	1	1
4	1	1
5	0	1
6	1	1
7	1	1
8	1	1
9	1	1
10	1	1
11	0	1

The following (figure 22) is proofing that MAGISTER model after adjustment is better than, MAGISTER model previously especially after using Fuzzy Decision Support System technique that presents the following graph

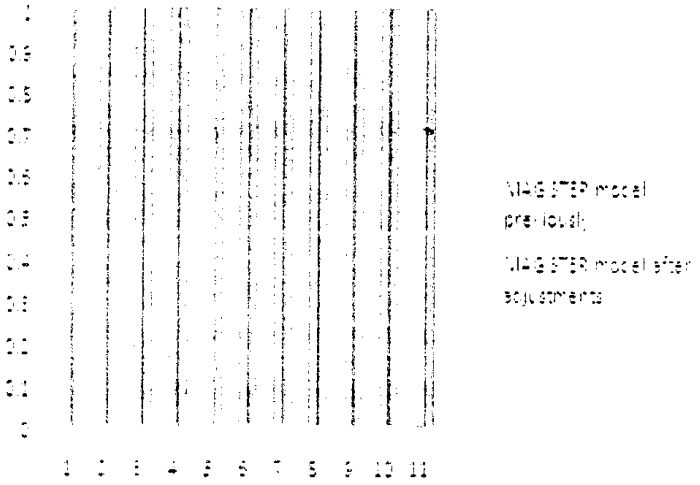


Figure (22): evaluation for MAGISTER model before and after adjustments by using Fuzzy Logic

IX. And now by using Fuzzy Logic technique, we can see the following graph results: (23)

According to the evaluation matrix discussed previously we can conclude the following graph that represents pie charts for matrix:

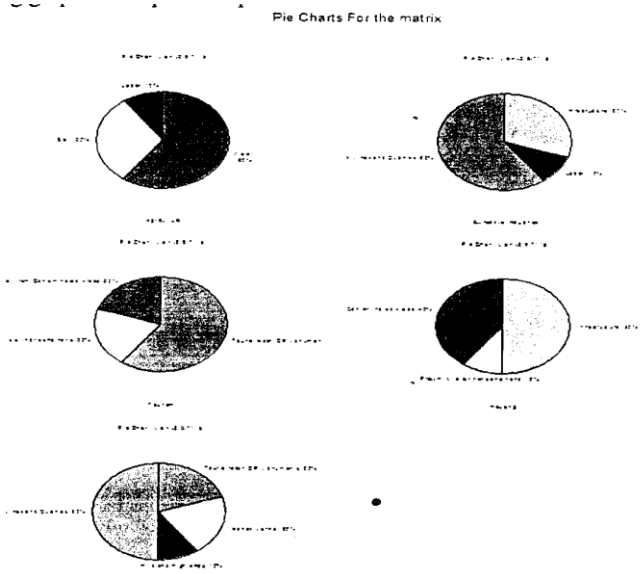


Figure (23): pie charts for the evaluation matrix

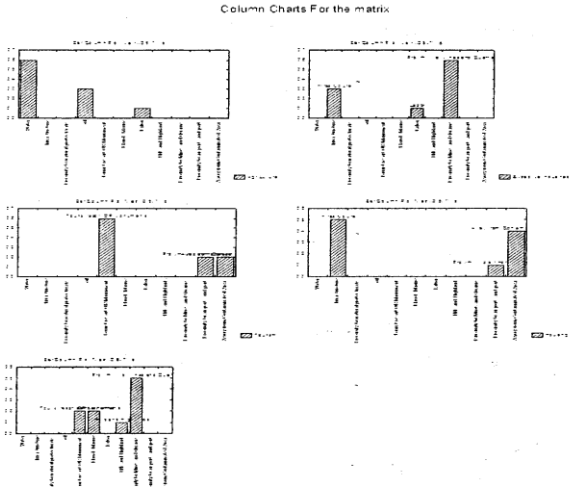


Figure (24): column chart for the evaluation matrix

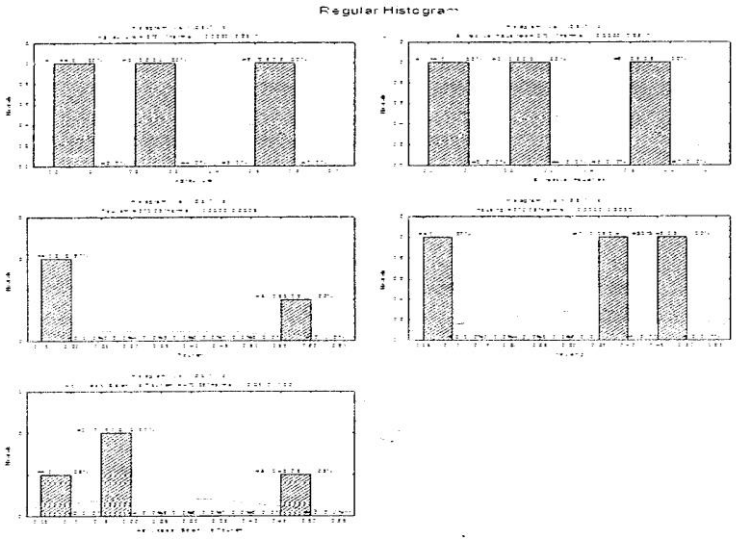


Figure (25): regular histogram for the evaluation matrix

The following diagram is for multiple histogram

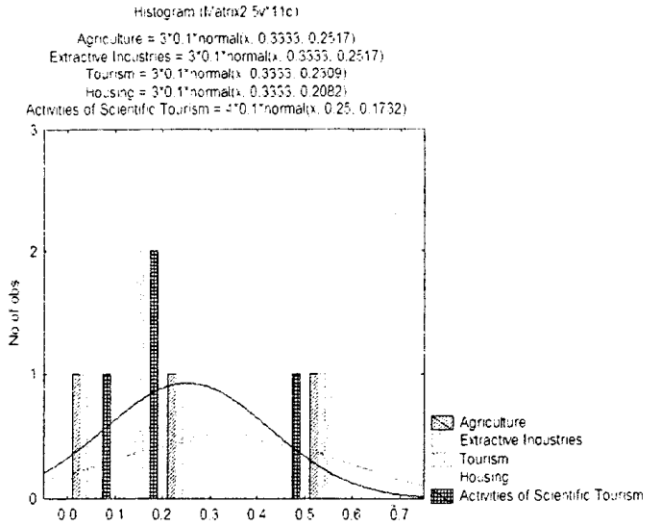


Figure (26): multiple histogram shows number of intersections

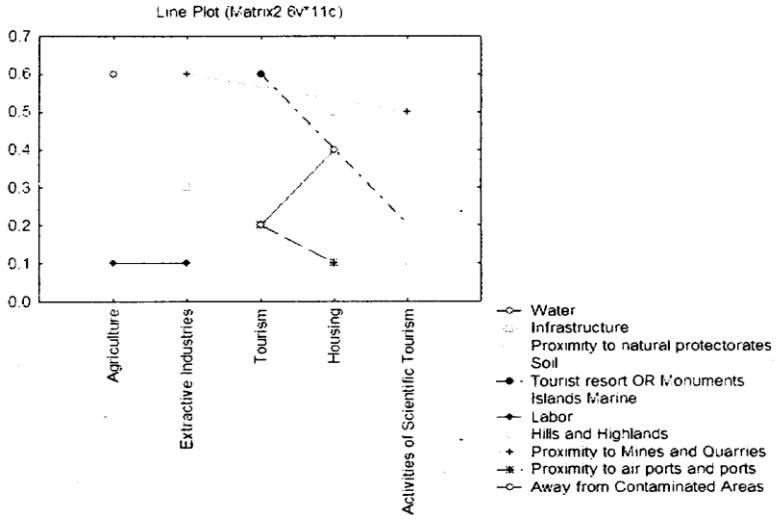


Figure (27): line plot diagram shows intersections

The problem appeared in the intersection between lines (the means intersection in land characteristics)

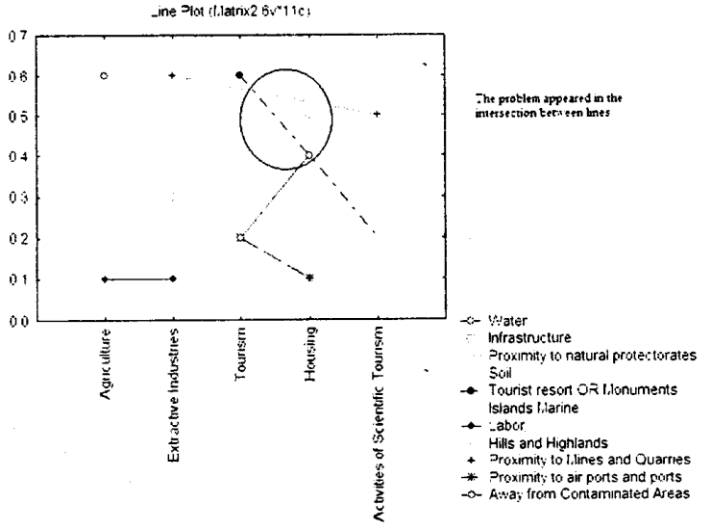


Figure (28): line plot diagram shows intersections by highlighting

- The following figures will represent areas that are suitable for agriculture, industrial and tourism

Figure (29) presents land or area that is:

a) Suitable for agriculture,
b) Has codified water, and
c) Suitable for agriculture and has codified water.

The next figure represents buffers surrounding those areas.

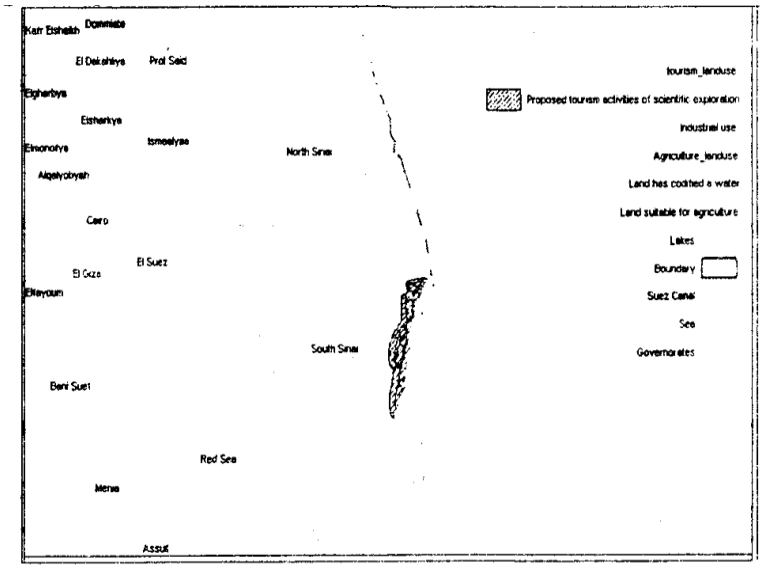


Figure (29): Buffer on agriculture area is (24)

The next figure represents determining Extractive industries area

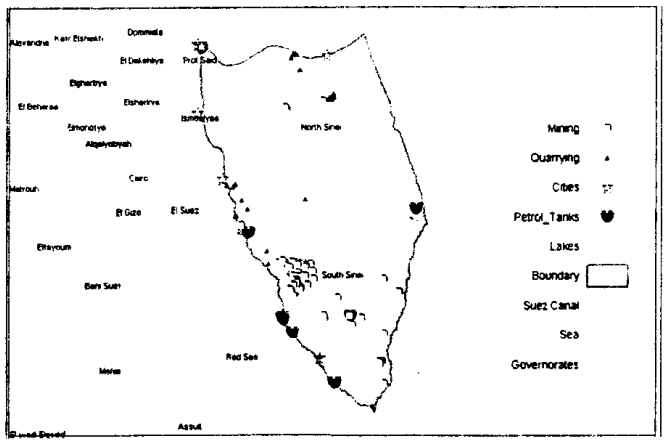


Figure (30): Extractive industries

The next figure represents buffer that surrounds Extractive industries area. (25)

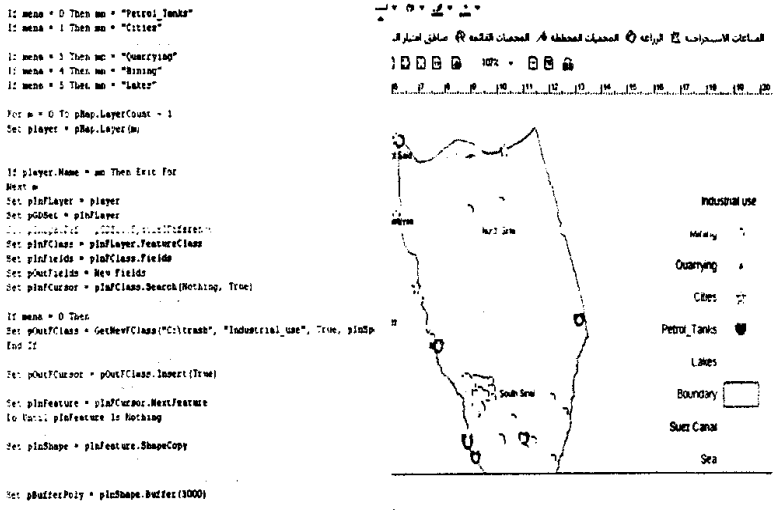


Figure (31): Buffer on extractive industries (26)

- And now we will solve the problem of intersecting multiple layers with each other....

Proposition of land use planning can hold more than one suitable usage for the land, one part or one piece of land can have characteristics of agricultural land, industrial land and touristic land, so we have to determine the most suitable usage according to all criteria's including social, economical and environmental aspects.

So, the most effective solution is to use dynamic models to determine the exact and perfect usage

- The first step is to determine the agricultural area, by subtracting proposed mining activities from agricultural land-use, then subtracting proposed quarrying, and then subtract proposed building material from agricultural land to extract all materials from land to be used for agriculture only.

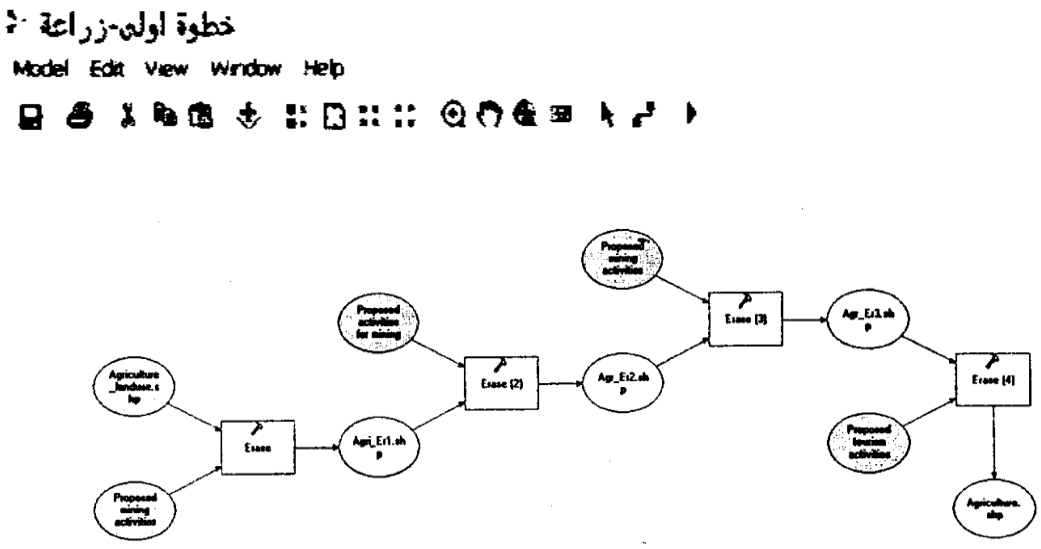


Figure (32): that presents the first step which is agriculture area

- The second step is to determine the industrial area, by subtracting proposed Tourism activities for historical monuments from industrial use, to extract all monuments, and then it could be able to be industrial area.

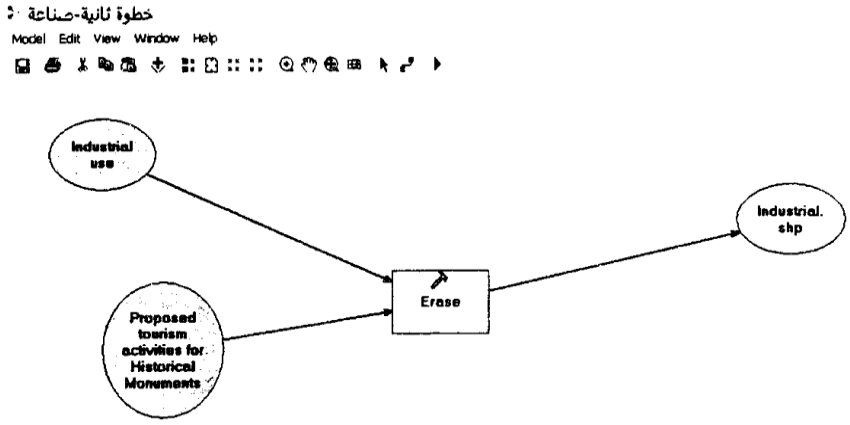


Figure (33): that presents the second step which is industrial area

- The third step is to determine the touristic area, by subtracting proposed mining activities, quarrying, building material and historical monuments from tourism land use, to extract all previous activities, and then it could be able to be touristic area.

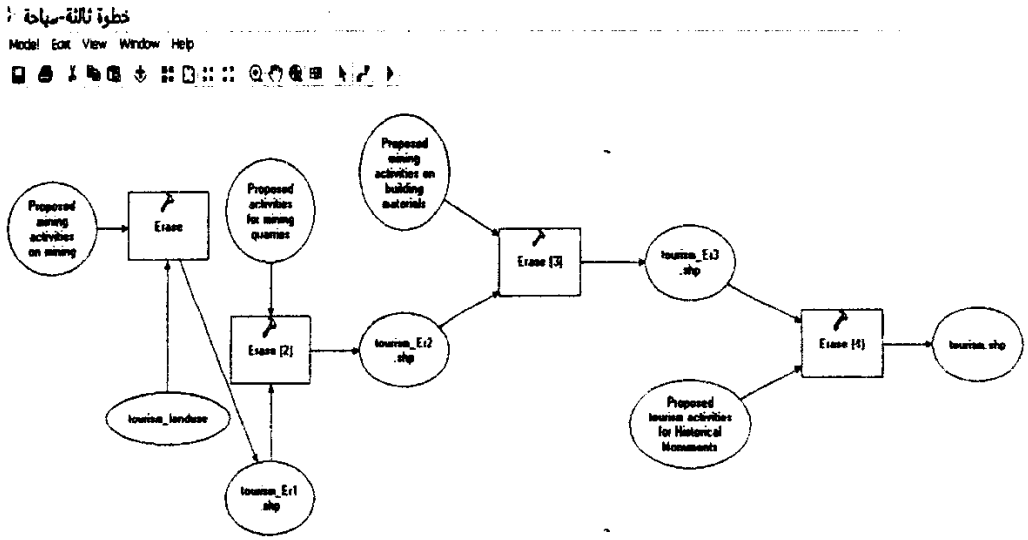


Figure (34): that presents the third step which is touristic area

- The fourth step is to determine the agricultural area, by subtracting industrial area from agricultural area, to extract all extractive industries, and then it could be able to be agricultural area.

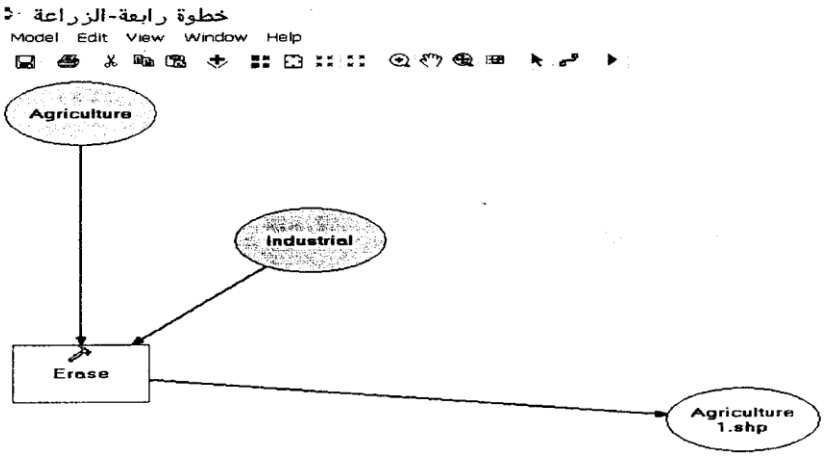


Figure (35): that presents the the fourth step which is agriculture area

- The fifth step is to determine the final touristic area, by subtracting industrial area from touristic area, then subtracting agricultural area. To find the final result for tourism.

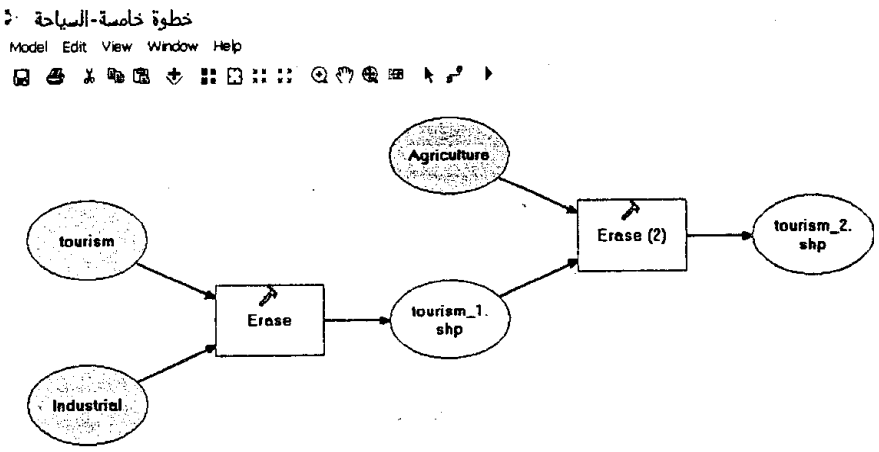


Figure (36): that presents the fifth step which is final touristic area

- The sixth step is to determine the housing area which is the final usage for the land, by subtracting proposed mining activities, quarrying, building material and historical monuments, agricultural, industrial lands to extract all previous activities, and then it could be able to be housing area.

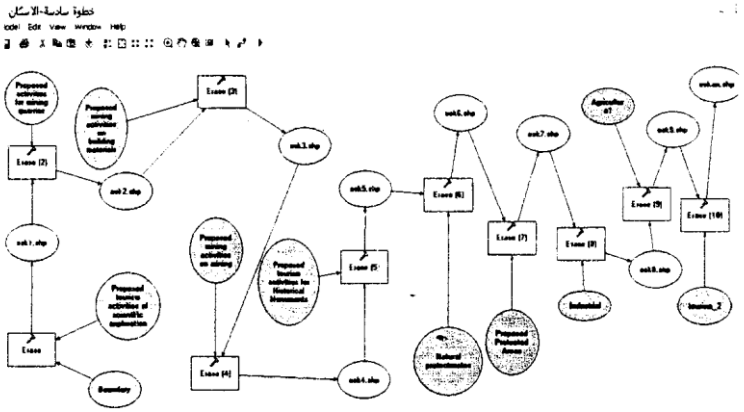


Figure (36): that presents the sixth step which is final for housing area

☒ **Conclusion:**

- Now we can say that we could be able to calcify each piece of land area according to its characteristics and usage, putting into consideration Social, economical and environmental goals, for taking a final and a most suitable decision.
- We must use Geographical information system integrated with the science of fuzzy decision support system to take best results.
- GIS is not only for building layers and drawing maps, but we can use it also as a tool that build models to help decision makers taking decisions

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Appendix I

List of Abbreviations

Abbreviation	The whole word
DSS	Decision Support System
GIS	Geographic Information System
MCDA	Multi Criteria Decision Analysis Spatial Decision Support System Multi-criteria Analysis and GIS for Territory
SDSS	Fuzzy Decision Support System
MAGISTER	Decision Making Process
Fuzzy DSS	Strength Weakness,
DMP	Opportunities, Threats
SWOT	Geographic-Database
Geo-Database	