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## Preface to improve the Environmental Impact Assessment by using Geographic Information System

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**Abstract**

In this abstract I[1] would like to deal with the environmental consequences that threaten the environment which resulted from current human activities and unplanned development. That impact of environment deterioration appears not only on the local level but also on the global one; here the role of Environmental Impact Assessment (EIA) process proved to be a valid tool to improve the relation between man and his environment. Where the EIA role is, to study the impacts on the environment and to try to minimize those impacts; so far many developing countries take EIA process duty to preserve and maintain the environment lately after years of running after economical inflow of money leading to environmental damage and harmful impacts, here I would like to talk about the Egyptian and the Hungarian cases as both started to apply EIA studies at the same time. Meanwhile, the Environmental Impact Statement (EIS)[2] output, sometimes, seems to be weak, unconvincing and ineffective reports, lacking skills and abilities. On the other hand, the need of an analytical tool of analysis in which the Geographic Information System (GIS) seems to be a good mechanism of analysis, which could fill the gap between the theoretical and the spatial conditions of the EIA process.

Therefore, the question is, How to integrate GIS within the EIA process using a developed mechanism of analysis? In order to, improve the implementation of the EIA studies by integrating the GIS within the EIA process using a developed mechanism of analysis in order to achieve accurate results and to raise the efficiency of the EIA studies.

**Key words:** Environmental Impact Assessment (EIA), Environmental Impact Statement (EIS), EIA steps, EIA methods, Geographic Information System (GIS), GIS tools, GIS functions.

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[2] EIS is a document requiring "significantly affecting the quality of the human environment'' A tool for decision making, an EIS describes the positive and negative environmental effects of proposed agency action - and cites alternative actions. See also http://ceq.hss.doe.gov/nepa/regs/nepa/nepaeqia.htm

## Introduction

At the beginning of the second half of the twentieth century and after about more than a century of urbanization explosion in the US and EU, increase of cities' population and decrease of rural population, and the environment suffer from industrialization and economic changes, collectively worked as sources of producing waste, pollution and negative impacts represented in general environment deterioration of land, water and air, as the desertification, destruction of flora and fauna, ozone depletion and global warming.

While in the beginning of the twentieth century the awareness towards environment witnessed more concern, on 1903 the Fauna and Flora international (FFI) was founded to protect the biodiversity in East and South Africa. Later on, the environmental issues take more and more concern, as it was essential to create a tool for decision makers to predict the environmental consequences of any development project. So the Environmental Impact Assessment seems to be the best tool for such purpose as it was formally established in the US in 1969, then spreading worldwide and received a significant advance in Europe with the introduction of the European Community Directive on EIA in 1985, implemented three years later in the UK in 1988. Further stressing on the benefits of EIA, that helps to achieve the objectives of sustainable development, by the Rio Declaration on Environment and Development that was published subsequently the 'Rio Earth Summit' in 1992.

Ending with the establishment of the environmental law as a complex and interlocking body of treaties, conventions, statutes, regulations, and common law that, very broadly, operate to regulate the interaction of humanity and the rest of the biophysical or natural environment, toward the purpose of reducing the impacts of human activity, both on the natural environment and on humanity itself. And the EEA (European Environmental Agency) established in 2009.

In recent years there is more concern about environmental issues all over the world especially in the developed countries. That concern rises up because of current human activities and unplanned development that threaten the environment. Therefore it was necessary to study the environmental impact and to work on minimizing those impacts thus the Environment Impact Assessment (EIA) process proved to be a valid tool to improve the relationship between man and environment.

In order to understand the Environmental Impact Assessment some definitions should be identified.

**Defining Environmental Impact Assessment (EIA), Steps and Methods**

**Environment**

The environment is broadly understood as "our environment is our surroundings, It can be divided into non-living and living components. The Environment provides resources which support life on the earth and which also help in the growth of a relationship of interchange between living organisms and the environment in which they live" (Mayank Kumar)[3]. In which humans play an important role and a unique position because of their exceptional ability to influence and mould the environment.

**Urban Environment (UE)**

Urban environment is considered as the total environment in which urban forestry must operate, the total urban forestry environment includes all the physical (including biological), institutional, social, legal, and political factors that either facilitate or inhibit management. Where the physical urban environment made up of three basic and dynamic elements: trees and related organisms (land or forest), structures (the trappings society) – society – and people, thus all interactions and relationships of these three basic elements and all their appendages took place (Gene W. Grey, 1996).[4]

**Environmental Impact (EI)**

The word impact can be defined as "the effect of one thing upon another" in which can be described in the terms of its magnitude and significance (Gilpin, pg.5, 1995).[5]

So the environmental impact is "the change in an environmental parameters, over a specified period and within a defined area, resulting from a particular activity compared with the situation, which would have occurred had the activity not been initiated" (Wathern, pg.7, 1988)[6], however Wathern (1988) and Glasson et al. (1994) agreed that the environmental systems are not static but change over time even without the influence of man as shown in figure1.

[3] http://www.du.ac.in/course/material/ug/ba/se/01.pdf, by Mayank Kumar - Environment

[4] http://books.google.com/books?id=6Z30UCsRM1EC&pg=PP13&dq=define+urban+environment+%22urban+environment%22&lr=&as_brr=3&sig=ACfU3U1LzyqM0VxYTV7sLOU47B2cRwI99g#PPP13,M1, The Urban Forest, By Gene W. Grey

[5] Gilpin (1995,pg 5) Gilpin, A., 1995, Environmental Impact Assessment cutting edge for the twenty first century, the press syndicate of the university of Cambridge, Cambridge, UK.

[6] Wathern, P., 1988, Environmental Impact theory and practice, Routledge, London, UK.

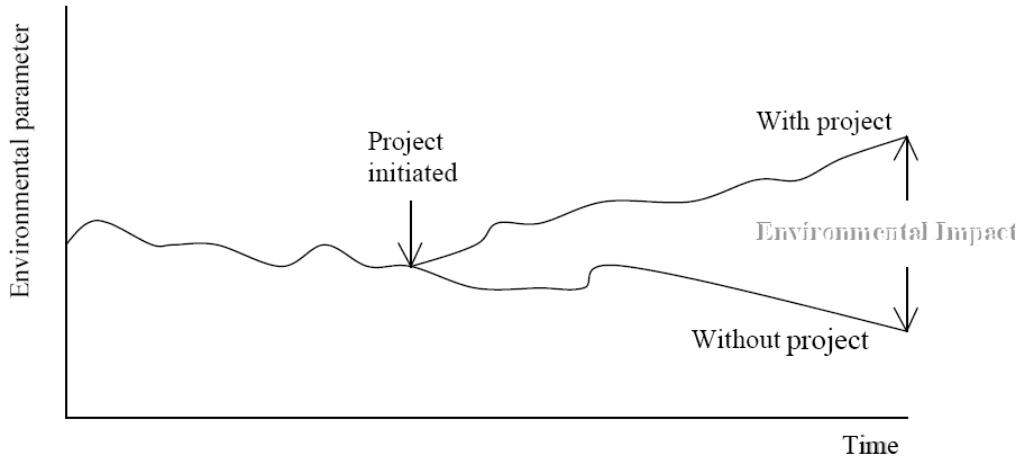


Figure 1, the nature of an environmental impact[7]

**Environmental Assessment (EA)**

Environmental Assessment is defined as a "document containing information in sufficient detail to determine whether a proposal will impose significant adverse impacts on the environment" (Gilpin, pg.5, 1995)[8].

**Environmental Impact Assessment (EIA)**

EIA is a process which aids decision-making to take wise decisions concerning a proposed development action, and assessing all the possible impacts whether positive or negative ones; how they affect the natural environment, which should lead to more rational and structured decision-making whether to proceed with the project or not. It can be described as "a process for identifying the likely consequences for the bio geophysical environment and for man's health and welfare of implementing particular activities and for conveying this information, at a stage when it can be materially affect their decision, to those responsible for sanctioning the proposals" (Wathern, pg.6, 1988)[9]. The EIA can modify and improve project design, ensure efficient resource use, enhance social aspects, identify the measures for monitoring and managing environmental impacts, identify key impacts and measures for mitigating them, inform decision-making and condition-setting, avoid serious and irreversible damage to the environment, and protect human health and safety.

[7] Wathern, P., 1988, Environmental Impact theory and practice, Routledge, London, UK.
[8] Gilpin 1995: pg 5, Gilpin, A., 1995, Environmental Impact Assessment cutting edge for the twenty first century, the press syndicate of the University of Cambridge, Cambridge, UK.
[9] Wathern, 1988:pg 6, Environmental Impact Theory and Practice, Routledge, London, UK.

Thus the EIA aims to assess the overall impact on environment of development projects proposed by the public and private sectors (Glasson, J. Et al., 1994)[10], which presented in the Environmental Impact Statement (EIS) that lacks the spatial location dimension, where weak, unconvincing and ineffective reports come out. That is why it is essential to use an effective integrated mechanism of analysis as an analytical tool that joins the theoretical aspects with spatial aspects of the real world accessing the various data used to carry out the EIA process seeking to give more quality to the EIA studies.

**Environmental Impact Statement (EIS)**

EIS is the final report presented at the final stage of EIA and after the official approval, and can be defined as "the document prepared by a proponent or a developer applicant describing a proposed policy, development, activity, program, or project; alternatives to the proposal; and measures to be adopted to protect the environment"(Gilpin, pg.5, 1995).[11]

**Mitigation measures**

Mitigation measures are actions that are taken to avoid, reduce or compensate for the predicted negative impacts on the environment, while by applying the EIA process theoretically sometimes we get weak EISs.

**EIA Steps**

EIA is "A systematic process to identify and manage the potential environmental effects of a proposed development or activity" (section 4, December 2006)[12], in which its findings are presented in an Environmental Statement (ES). Both of the process and findings inform decision-makers of the likely environmental consequences of the proposals.

The EIA process summed up in gathering data and evaluates effects on a range of technical topic areas that are specified in the legislation, including, air, population, soil, fauna, flora, water, climatic factors, material assets including architectural and archaeological heritage, landscape and the inter-relationships between these factors. Where the evaluation of each of these topic areas linked together provides a whole picture of the effects of the proposal as a whole.

[10] Glasson, J. et al., 1994, Introduction to Environmental Impact Assessment, University College of London, UK.
[11] Gilpin, A., 1995, page 5, Environmental Impact Assessment cutting edge for the twenty first century, the press syndicate of the university of Cambridge, Cambridge, UK
[12] section 4, version 4, December 2006, EIA – Defence Estates, Delivering Estates – solutions to Defence Needs, UK

The EIA process can be split into stages, each of which has a key output in terms of a tangible product, action or decision. These stages are represented in Figure 2.

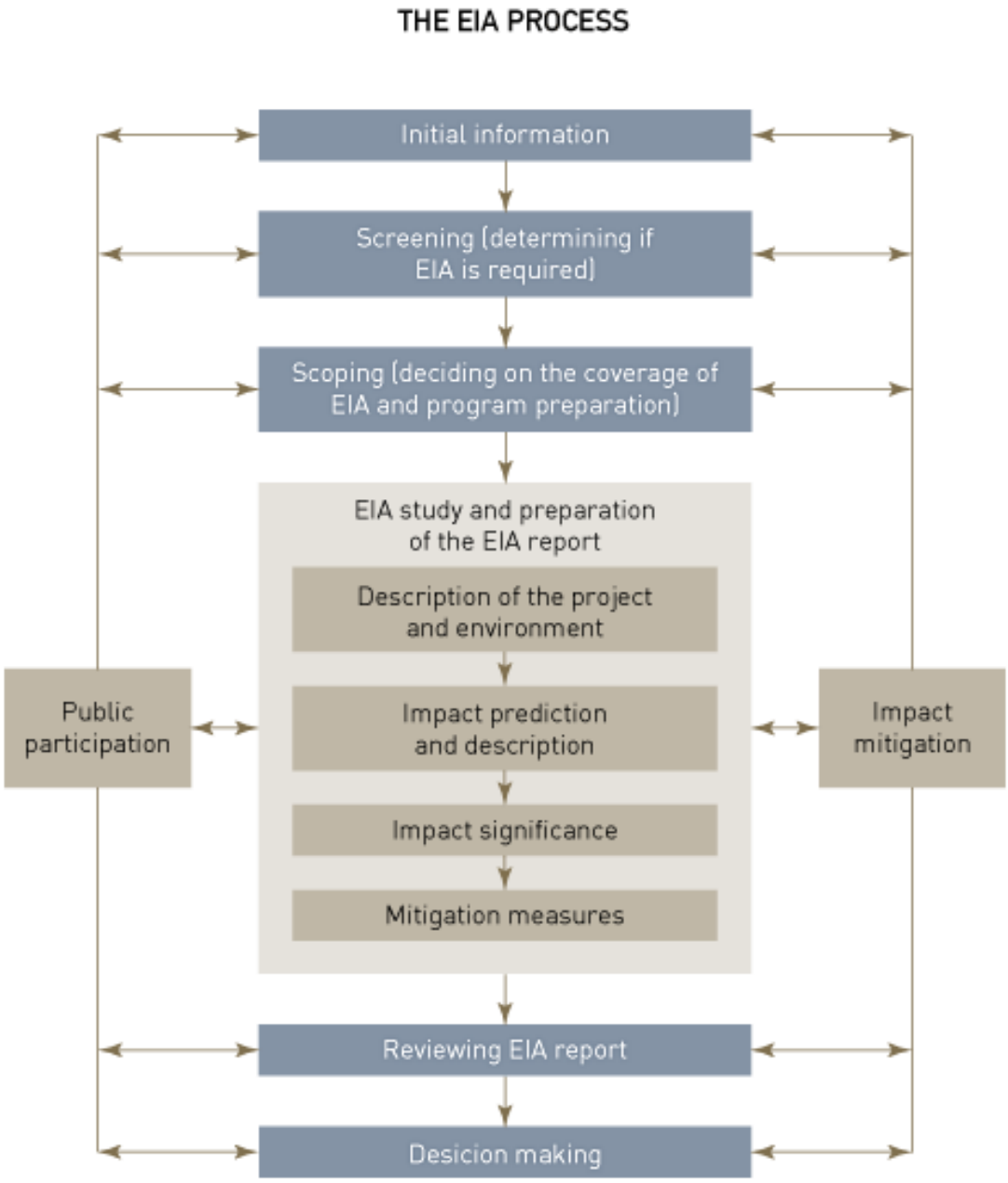


Figure 2, EIA process[13]

Also as following:

1- Screening (is an EIA needed or not?)
2- Scoping (which impacts and issues should be considered?)

[13] www.le.lt/en/main/atom/PAV_nuclear

3- Baseline studies (Assess the value of the baseline environment)
4- Impact prediction (Assessment) (Process of predicting the potential impacts of the project)
5- Mitigation measures (Actions that are taken to avoid, reduce or compensate for the predicted negative impacts on the environment)
6- Monitoring (most important step in EIA, and the way to verify the "effectiveness of mitigation measures and assessing residual impacts").

**EIA methods**

Most of EIA methods used to identify, measure, and assess impacts rely on expert judgments, where experts are heavily involved in all aspects of the assessment. EIA methods range from simple to complex, which require different data types and formats. In order to choose an effective EIA method it must be able to do:

- Organize a large mass of heterogeneous data.
- Allow summarization of data.
- Aggregate the data into smaller sets with least loss of information; and
- Display the raw data and the derived information in a direct and relevant fashion.

There are many methods of EIA that will be discussed below:

1- Ad Hoc method

Ad Hoc methods is alike a systematic analysis of a problem as if a team of experts assembled for a short time to carry out an EIA

2- Methods for Organizing and Presenting Information

There are three different methods of organizing and presenting data used by EIA which are checklists, scale & weights, and matrices.

3- Networks

4- Spatially based methods

There are two spatially based methods for EIA even by using overlaying method or Geographic Information System method. The first method is generally used, moreover the GIS method is not that proudly used as it needs more time and expertise to manage the data and information used, also to avoid bias data and errors.

GIS can be used in the EIA process through three different types of approach, firstly can be used before the EIA process starts, secondly it can be integrated within the EIA process, and thirdly it can be used in parallel with the EIA process.[14]

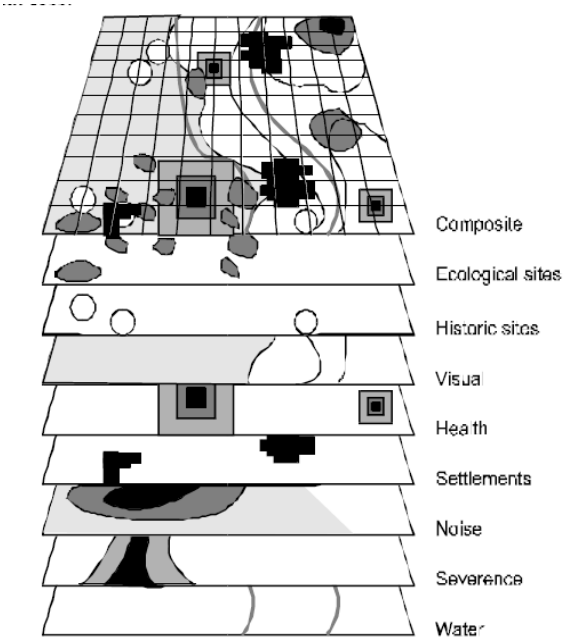


Figure 3, example of overlay method (source: Wathern, 1988).[15]

**Investigating EIA in Egypt and Hungary**

**EIA in Egypt, Egyptian Environmental Affairs Agency (EEAA)**

On 1994 for the Protection of the Environment, about ten years later after the European Community directive on EIA, the Egyptian Environmental Affairs Agency (EEAA) was restructured with the new mandate to substitute the institution initially established in 1982, at the central level.

In June 1997, the responsibility of Egypt's first full time Minister of State for Environmental Affairs was assigned. Egypt in holds the role of EIA seriously as for any implemented new projects, the investors are obliged to make an EIA studies and handle an EIS report to the Agency. Also, all development projects are categorized into three categories in reaction of their impacts on environment black, gray and white projects where black projects has the most harmful impacts on the environment and the white projects has the least impact on the environment.

[14] Sadar H., 1998, Environmental Impact Assessment, Canada

[15] Wathern, P. 1988. An introductory guide to EIA. *In:* P. Wathern (ed.). Environmental Impact Assessment: Theory and Practice. Unwin Hyman, Boston, MA. 332 pp.

The main aims of the Egyptian Agency can be mentioned shortly in:

- Formulating environmental policies.
- Preparing the necessary plans for Environmental protection and Environmental development projects,
- promoting environmental relations between Egypt and other States
- Preparing state of the environment studies and formulating the national plan for environmental protection and related projects.
- Implementing pilot projects for the preservation of natural resources and the protection of the environment against pollution.[16]

**EIA in Hungary, Ministry of Rural Development (Környezetvédelmi és Vízügyi Minisztérium)**

On 1998, had witnessed a change of the government of housing and construction and the regional development duties were transferred to the Ministry of Agriculture and Rural Development while heritage conservation tasks were moved to the Ministry of National Cultural Heritage. At this time when the Ministry of Environment Protection was established.

In 2002 the Ministry went through a transformation again as water affairs were transferred from the Ministry for Transport, Communication and Water to the Ministry of Environment and Water.

While the main aims of the Hungarian Ministry can be mentioned in the following: :

1. Environmental and water authorities, national park managements – attend to the first degree tasks of the authorities.
2. Environment and nature protection second degree tasks of the authorities are carried out by the National Environment and Water Authority.
3. Realization of a liberal program which is based on environmental conscience and sustainable development
4. Encouraging green thought to penetrate the conscience and actions of every political - economical decision maker and every citizen of Hungary (green portfolio)
5. Implementing environmental education and development of ecological sustainability.[17]

[16] **http://www.eeaa.gov.eg/English/main/about.asp**
[17] **http://www.kvvm.gov.hu/index.php?lang=2**

From both experiences, the Egyptian and the Hungarian governmental have taken charge of protecting the environment so seriously by using implementing EIA process to limit environmental damage and deterioration, but commonly facing a problem.

**Common problem**

The problem can be identified as the gap between the theoretical and applicable studies of EIA studies, as EIS reports Lack the spatial location dimension; resulting in weak, unconvincing and ineffective reports, while the spatial location dimension needs an effective integrated mechanism of analysis as an analytical tool that links the theoretical aspects of environmental conservation and protection with spatial aspects of the real world. Also, to access the various data used to carry out the EIA process seeking to give more quality to the EIA studies.

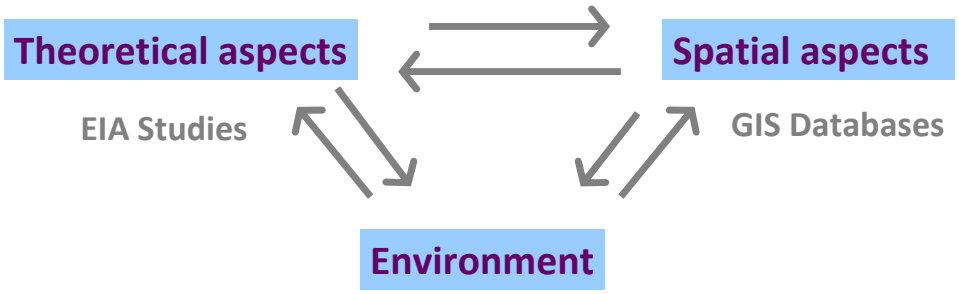


Figure 4, proposed system to integrate EIA and GIS

Finally the problem can be stated as the "Lack of an effective integrated mechanism of analysis to introduce the various data used to carry out the EIA process, which results in low quality of the EIA studies". Now, it worth to know what GIS is and what are the tools and functions in order to achieve a successful GIS.

**Defining GIS, tools and functions**

GIS is "a computer system capable of capturing, storing, analyzing, and displaying geographically referenced information; that is, data identified according to location. Practitioners also defined GIS as including the procedures, operating personnel, and spatial data that go into the system" (U.S. Geological Survey, 2007).[18]

So GIS can be integrated within EIA process by helping in data capture in the step of Data Collection and the analysis procedure in the step of Mitigation measures and

[18] U.S. Geological Survey, 2007

alternatives, so far it can be used in displaying the data related to spatial location of the project / development.

GIS seems to be a good solution to improve the EIA process and overcome its disabilities; because of the following four main reasons:

- GIS seeks to construct a real world model basing on digital data, which most of EIA methods lack.
- The important role that modelling plays is the ability to analyze trends, identify trends causing factors, reveal different paths to solve a given problem, and indicate decisions' consequences.
- The impacts caused by development plans on the environment can be assessed by integrating land use data, with topographic and geologic information using GIS (ADB, December 1997)[19].
- GIS can be used in determining optimal ways for communications, irrigation, and road maintenance, connecting various databases through network modelling, and applying statistical analysis of features.

**GIS functions**

In order to seek the required tasks from the GIS, there are several functions needed to achieve better maintain of geospatial data sharing, exchanging, revision, updating, and analyze more easier, to improve productivity of the GIS staff saving more money and time and better decisions could be taken, as listed below (J. Sogoh).[20]

**A. Data input:**

**B. Data storage, data maintenance and data output**

**C. Query**

Query is used for spatial searching, joining, and overlay. There are two kinds of query spatial query and attribute query.

**D. Generating features**

It is the ability to create new features and to add them to the database. Generated functions should allow features to be defined easily, with no limit on the number of new features that can be added to the database or on the number of points in any position, where names or codes can be attached to new features.

[19] ADB, Asian Development Bank, EIA for developing countries in Asia, volume 1, December 1997, http://www.adb.org/Documents/Books/Environment_Impact/

[20] J. Sogoh, FUNCTIONS OF GIS, Kenya Institute of Surveying and Mapping

**E. Manipulating features**

Manipulation of features has many functions that can be mentioned shortly in:

- Classification of attributes, as a process of grouping features with similar values or attributes into classes.
- Conflate, conflation aligns the lines in one dataset with those in another and then transfers the attributes of one dataset to the other.
- Subdivide area, the ability to split an area to a set of rules.

**F. Spatial analysis**

It is process of answering questions related to the interaction of spatial relationships between multiple datasets (Afifi, S.M., June 2007).[21]

**G. Modeling**

"Modeling may refer to an abstract (or actual) representation of an object or system from a particular viewpoint.". Also Benders argues that modeling means to make prototype, design, and representation of something. That means model is a simplification to -a part of- the real world. Model is an abstraction or simplification of real world (Benders 1996).[22]

During modeling, semantic gap has to be reduced to minimum. "A semantic gap is the difference between a thing being modeled and the model's representation of that thing" (Enth, 2007). Models with a low semantic gap produce good realistic results, while models with a high semantic may give inaccurate or even complete nonsense results.[23]

Models could be categorized into two categories. The first is physical models, which let people get visual knowledge about real world. The second category is mental models which cannot be touched and is related to procedures to be taken by a set of rules or experiences. A visit to a restaurant is an example often used; using a mental map, we do all the actions (Singh, 2003).[24]

**Keys to achieve successful GIS**

In order to get successful GIS some points should be taken into consideration.

- Data Input, as the cost of data input will occupy about 80 % of the total cost in GIS, More attention should be given to selection and classification of required geospatial

[21] Afifi, S.M., June 2007, M.Sc. Urban Growth Modeling, Ain Shams University, Urban Planning Department, Cairo, Egypt.
[22] Benders R. 1996. Models and modelling. INTERACTIVE SIMULATION OF ELECTRICITY DEMAND AND PRODUCTION, Groningen.NL, University Groningen.
[23] Enth 2007, [online] URL:.http://everything2.com/index.pl?node_id=1166593, Access date: 03/06/2007
[24] Singh, A. 2003, MODELLING LAND USE LAND COVER CHANGES USING CELLULAR AUTOMATA IN A GEO-SPATIAL ENVIRONMENT, Msc. ITC, Netherlands

data for the project taking into consideration of the digitizing method. It is not only about data but also Maintaining of Database on the long run.

- Customizing Software, as the existing GIS software provided by vendors are not enough for practical applications, the users should develop customized software or solution for the problem by building a model and programming an application package.
- Data Sharing is one of the important keys to minimize the total cost of data input.
- Lack of vision so the objectives, targets and goals of a GIS project should be settled.
- Lack of support by decision makers, which can be gotten rid of by using EIA as it is already a decision maker's tool to maintain environment.
- Lack of System Analysis, digital approach with GIS in replacement of the existing analog approach based on manual works is sometimes not acceptable in the existing conventional system.
- Lack of Expertise, improper selection and misuse of GIS hardware and software very often occur due to lack of expertise. Professional consultants or experts should be invited to evaluate the plan.
- Lack of Access for User's, There would be very few users if the training for users is not well organized and not provided with a well organized manual.[25]

**Conclusion**

According to the previous issues which have been mentioned, and in order to improve EIA studies. The integrated approach pointed out seems to be the best alternative as it is the best way to give a direct feedback of any error in the EIA process faster than the third method which the user might be lost between the two compound systems working in parallel (EIA and GIS). While in the integrated approach, the chance for EIA to lead as it is already a decision making tool is bigger.

So far, the need of a developed mechanism of analysis in order to achieve accurate results and to raise the efficiency of the EIA studies, there are other three objectives which need to be achieved in sequence. The first objective is to Design a methodology of analysis (to analyze data collected). The second objective is to get accurate results to assist predicting of impacts then design the appropriate mitigation measures to reduce, avoid or prevent those impacts. The third one is to develop an effective policy instrument to assist decision makers in decision making process.

[25] ESRI, ArcGIS practical exercise book.

Based on the previous objectives, the last objective is to observe some recommendations concerning further research in Environmental Impact Assessment (EIA) with Geographic Information System (GIS).

So far , the issue can not be limited with this preface as it needs more research and effort to be done in order to integrate GIS with the EIA process which is relevant to be a master research topic by itself.

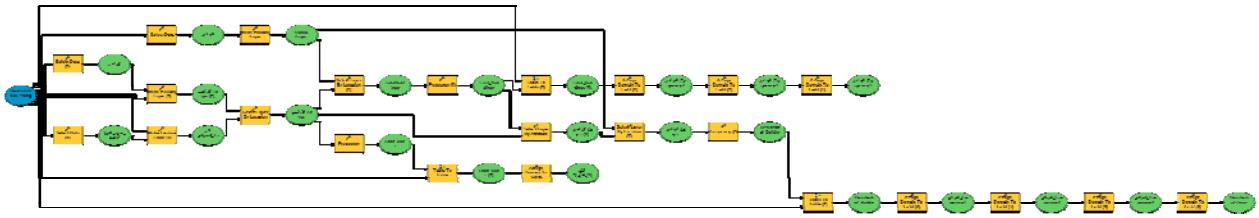

Figure 5, an example of a designed model of GIS[26]

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