Planning for Engineering Projects with the Reference to Application of Environmental Impact Assessment

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Key words: EIA, GIS, Environmental modeling, engineering projects

SUMMARY

In general, the engineering projects produce localized changes to the air, the hydrology, and the land mass. Hence, they will cause various environmental biotic impacts. Therefore, the engineering specifications of the proposed actions should be developed to predict the biotic impacts on the existing physical environmental with some degree of accuracy.

Evaluating the environmental impacts of these projects refers to many sources of data. Overlaying the non-heterogeneous data sources can be implemented and analyzed with the help of the GIS techniques. Such a technology will offer alternatives based on the given data and their weights. Also, it can assess the proposed project site and its environmental context. Moreover, it can derive insights that can help guide project planning and design.

In this paper, the importance of the EIA is presented. Basic characteristics of impacts, steps and methodology of assessments are itemized. The need of the GIS technology for this purpose is highlighted. A case study concerned with the integration between environmental factors – hand in hand with the engineering ones is presented.

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1. INTRODUCTION

The engineering project may have negative effect on the environment. Therefore, the effect of any project on the existing physical environmental should be predicted with degree of reliability and high accuracy. The failure of traditional project appraisal techniques to account for environmental impacts intended for offering a systematic process of identifying the future consequences of a current or proposed action. Such a process is named the Environmental Impact Assessment "EIA".

2. WHAT IS EIA?

The term describes a technique and a process by which information about the environmental effects of a project is collected by the developer. These effects are taken into account by the planning authority in forming their decision on whether the development should go ahead.

The word Environment (Ecological) that refers to ecosystem components (structures and their interaction) while Impact represents the effect of human induced activity on an ecosystem and the expression Assessment is seeking for the analysis and evaluation of impacts.

3. THE NEEDS, AIMS OF THE EIA?

Humans have now become a major driver of global environmental changes. Therefore, environmental models must now incorporate the influence of process associated with human activities. In the former day's, many pioneer engineering projects, were studied only from both the "Cost-Benefit Analysis" and the "Technical Feasibility Factors" points of view and ignoring the side effects which caused significant community concern (Calrk, 1981).

Nowadays, The EIA is needed to ensure the protection of the environment and the natural resources from any unexpected side effects which may be occurred during the process of the projects. Simply, EIA is a study of the effects of a proposed action on the environment, where the term environment includes all aspects of the natural and human effect (El-Raey, 2003)

So, the studies of the EIA act as guide for understanding the likely environmental consequences of new developments and minimize adverse impacts of projects on environment. It will maximize project strategic benefits without sacrificing environmental concerns. Finally, the EIA process will present the results in such a way that engineers can provide answers needed by stakeholders. All of these procedures share the basic concepts of Environmental Impact Assessment (EIA).

In general, the EIA process shares certain aims to:

- Provide decision-makers with analysis of the total environment so that decisions can be made based on as nearly complete and balanced information as possible.
- Assess and present intangible effects that are not adequately addressed by benefit analysis and other technical reports.
- Provide information to the public or a proposal.
- Formalize consideration of alternatives to a proposal being considered in order that the least environmentally harmful means of achieving the given objective can be chosen.
- Improve the design of new developments and safeguard the environment through the application of mitigation and avoidance measures.

4. PRINCIPLES AND CHARACTERISTICS OF EIA

Based on (Gramangis, 1981**)** the scale and significance of potential impacts can be determined by eight main characteristics. These principles are summarized as Participation, Transparency, Certainty, Accountability, Credibility, Cost effectiveness, Flexibility and Practicality. The characteristics are Magnitude (Extension of impact-measurable quantity), Importance or significance (social value), higher order and cumulative effects, reversibility and irreversibility, duration, remedial measures and risks and uncertainty of occurrence.

5. METHODOLOGIES OF ASSESSMENTS

The EIA methodologies are structured mechanism for identification, collection organization and assessment of environmental impact data.
Different methodologies have been adopted in many areas of applications to evaluate the EIA of projects. Each of them has its own characteristics, objectives, advantages and disadvantages
Following is a brief summary for the major applied methodologies:

- Check lists, which register environmental parameters to be investigated for possible impacts.
- Interaction Matrix that correlate cause- effect relationships among specific project activities and impacts. It could be used for identification and evaluation of impacts. No provisions for evaluation of higher order impacts (Morris and Therivel,1995).
- Networks of impacts: It represents a set-up of caused chain of possible impacts which may be triggered by project activities. It requires the analyst to trace out project actions, their primary, secondary and disciplinary sectors
- Computer systems and models: It includes the computer software models which may involve one or more of previously mentioned methodologies.
- Overlays to facilitate the physical and computerized (GIS) overlays have recently been used for modeling and quantitative evaluation of impacts

6. GIS AND ENVIRONMENTAL MODELING

The environmental systems include spatial data relevant to the decisions, analytic tools to process the data in ways meaningful for decision makers, and out put or display functions. Therefore, most of theses systems have spatial dimension.
In addition, these factors are captured through many different sources.
To deal with these non-heterogonous data, it has been found, that the GIS represent the most suitable way to deal, represent and analyze these data sets.
The GIS technology is considered as one of the most efficient ways, it can be defined as "A technology capable of assembling, storing, manipulating, and displaying geographically referenced information i.e. data identified according to their location".
It is used as a powerful tools to be used for scientific investigations, resource management, development planning and as Decision Support System (Keith and el, 2002).
Moreover, GIS links between the location data and their descriptive ones in order to perform a suitable decisions to the selected problem as in Fig [1].

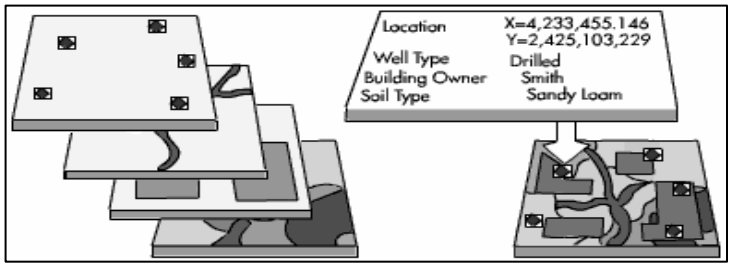

Figure [1] represents the link between the spatial data and their attributes in GIS

7. DATA STRUCTURE

Generally, data can be classified into spatial and descriptive, where the location data "spatial" can be gathered in many ways; surveying techniques, such as field surveying, aerial photogrammetry, remote sensing and GPS technology. They represent the main spatial data sources. These data in a GIS should refer to correct location on the earth's surface where, the operation of transforming coordinates, projecting the data should be implemented for the whole data sets (layers). Descriptive data "attribute" are set of data that collected and stored in forms of tables and the organization of these data are based on the relational database concepts. Joining between the two types of data will guide us to many solution suggestions to the proposed problem.
An essential factor should be studied during the data capture stage, which is referred by the Quality checking process "QC" of the collected data "spatial and attributes".
It goes for the conformance to reality. The following items summarize the main QC process:

- Correctness of whether a real world data item is correctly recorded according to specific data catalogue.
- Completeness of the percentage of data items which are actually in the data set compared with items that should be in it.

- Currency which is specified by the date of survey and the aging rate of the elements in the data set.

8. RESEARCH CAMPUS (UNIVERSITY) - CASE STUDY

In general, the EIA elements varies in limits of many engineering projects (i.e. industrial, highway, electrical projects etc...) are already defined.
For the data to be truly representative the way they are likely to be distributed in time and space with relation to one another should be cleared out, in addition to how dependent are they on one another. Also, how the data are dependent on other attributed part of the system under study should be defined. Through the paper the definition of some necessary elements that should be evaluated in case of dealing with educational institutions is a must this is because of the rapid increment of the number of universities and institutes that are constructed without any EIA (also, there is no guide about such projects).
Accordingly, the main purpose of the paper is to achieve the following:
- Provide planning input to the development of a new and progressive research campus,
- Assess the proposed site and its environmental context;
- Derive insights that can help guide project planning and design.

The main process is going to: identify environmental planning issues, identify data requirements, develop GIS database, conduct environmental assessment and create plan. The case study is going to test a selected site within an island to use this place as a research campus.
The following strategy is going to fulfill the general requirements: highlighting the business objectives, defining the EIA, site development program and site design

9. SITE DESCRIPTION

It is planned to build a research campus where, such a project will improve the community level. At the same time, the negative effect of this project to nature resources at this island should be ensured. Thus many factors should be studied for assessment. The candidate factors are: Topographic constraints slope stability and foundation support, Erosion and sedimentation, water quality, unique terrain features, agricultural farmlands, microclimate conditions, historic, cultural and archeological resources, community services, accessibility, visual quality and noise.

These factors can be itemized as a physical constraints model for
- Potentially unstable slopes, proximity to surface hydrology, winter wind exposure, coastal microclimate influence, landform shading, road noise potential and the proximity to sensitive cultural resources.

While, the natural amenities for
- The solar accessibility, visibility, and the summer breeze exposure.

Also, accessibility to infrastructure defines the ease of use to the
- Major roads, existing rail stations, bus stations and the residential Infrastructure.

10. ANALYSIS

After collecting the necessary data "spatial and attributes", overlaying and weighting them, each of the above factors –related to the environment- started to be evaluated.
The process is executed and customized with the help of the GIS software package "ArcGIS – ArcInfo8.2". Modeling the data was executed based on the following aspects:
- The extension and the geometry of the domain and the time period to which the model is applied,
- The space and the time scales of the model,
- The conceptual model, which is a schematic representation of the essential features of the physical system,
- The parameterization of heterogeneity and anisotropy of the physical system,
- The boundary conditions,
- The kind of sources and sinks.

As shown in Figure (2) represents the layout of the site. Herein, the topography of the proposed site should be studied in order to define the suitability of the site to the project. By using such data type, a contour map can be created. Figures (3a, 3b) show the topography that represents the terrain of the location.
The soil stability and the foundation support represent the second factor that should be studied. Here, the collected data should contain the completely required engineering factors that should be put into consideration during the design process, which should be studied since the site has a unique specification (island). In addition, this factor will help to define the erosion and sedimentation influence and to see the sites which have minimum negative effects of the project. Figure (4) shows the cultivated area and the zones of protections (buffer surrounding it). This represents another factor where the choice of the site should be away from the agricultural regions. The land value is another factor that should be mentioned. In the case study, the institutional projects, this factor plays a significant factor of the site selection decision. Figure (5) represents the irrigation network. Herein, we have to balance between the negative impact of having buildings beside the water network and the positive one to be close to the water sources. Figure (6) explains the existing urban community. This criterion has different impact based on the nature of the proposed project. In the case study, select a site that fulfills the requirement of the civilian community is needed. At the same time the closeness of the project to the urban region, the increasing of the expected noise which is considered as a negative impact of this factor should be specified. Figures (7) represent the infrastructure factors, the streets and the roads which already exist. The site selection should be near to these roads in order to let the way to the institutional project more easier. Figure (8) represents the position of the hospitals in the island. Figure (9) shows the available mosques, this represents another factor where the choice of site should be close to the project. Figure (10) illustrates the position of the post offices which available in the site and also should be closed to the site. Figure (11) illustrates the best position for the project (the brown areas)

11. CONCLUSION

The EIS is a process that tries to balance between the industrial and engineering progress and the protecting the environment "human centers of attention".

It has been found that there are shared behaviors of the factors which are not different with the type of the project such as road accessibility and water resources availability and the rest of the mentioned factors depend on the type of project such as research campus near or not to the cultivated area. Several key environmental issues must be addressed:

- Foothill side development – landscape restoration and soil management as integral part of design approach;
- Careful management of surface drainage and non-point source pollution;
- Careful management of groundwater resources;
- Recycling and careful solid waste management;
- Transportation, housing, community facilities and services issues must be addressed for convenience and energy effectiveness;
- Integrated Peninsula plan is needed to accommodate development and manage environmental resources

In sum and according to the above, the following considerations should be taken into account in applying the community planning and development is a process. Decisions must be made in this process. Better decisions require better information, knowledge, and tools to predict the likely outcome of decision makers. A comprehensive decision support system is needed for better planning. Spatial data should be collected once and maintained at the level where this can be done most effectively. It must be possible to combine seamlessly spatial data from different sources and share it between many users and applications. It is highly recommended to collect spatial data at one level of government to be shared between all the related different organizations. Spatial data needed for good governance should be available on conditions that are not restricting its extensive use. Where, it should be easy to discover which spatial data is available, to evaluate its fitness for purpose and to know which conditions apply for its use. The environmental problems come out of the industrialized world represent a complex problem. That needs a close cooperation between scientists from different fields, public authorities, and industry societies.

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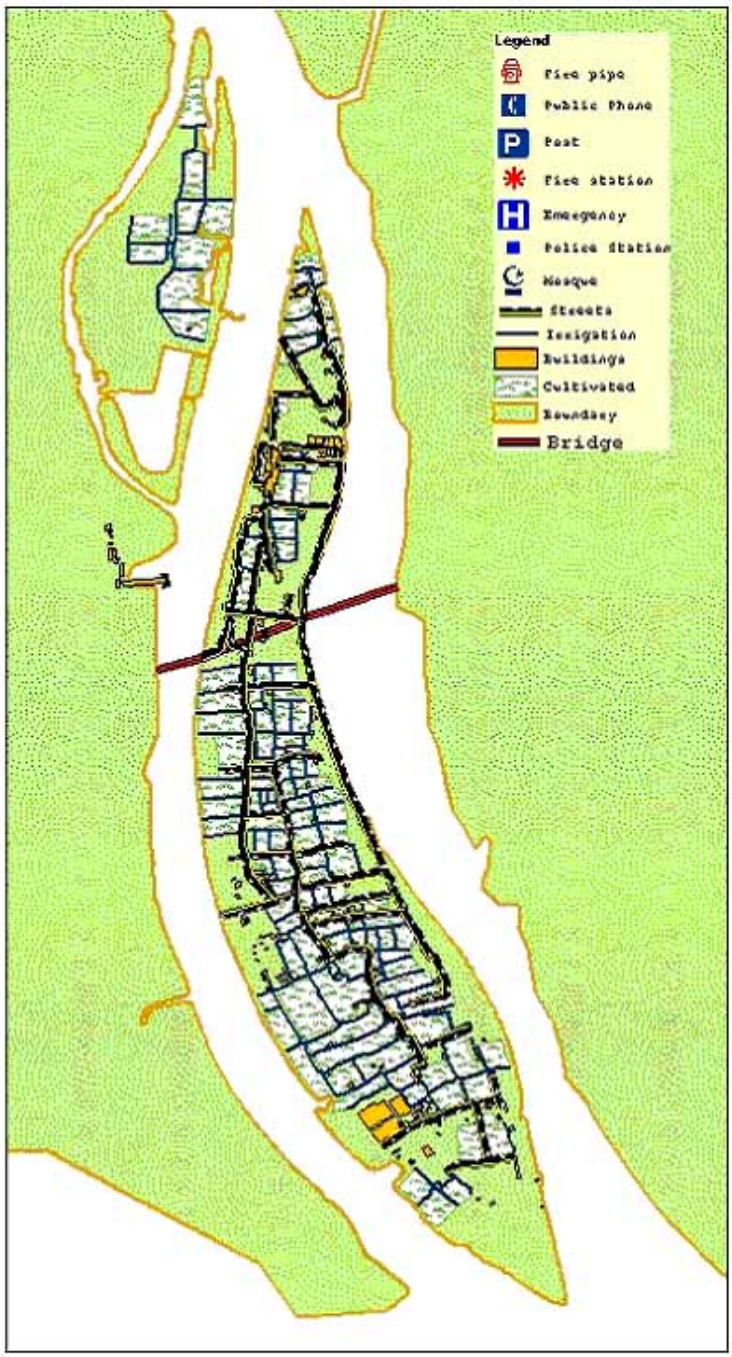

Figure (2) The Layout of the site

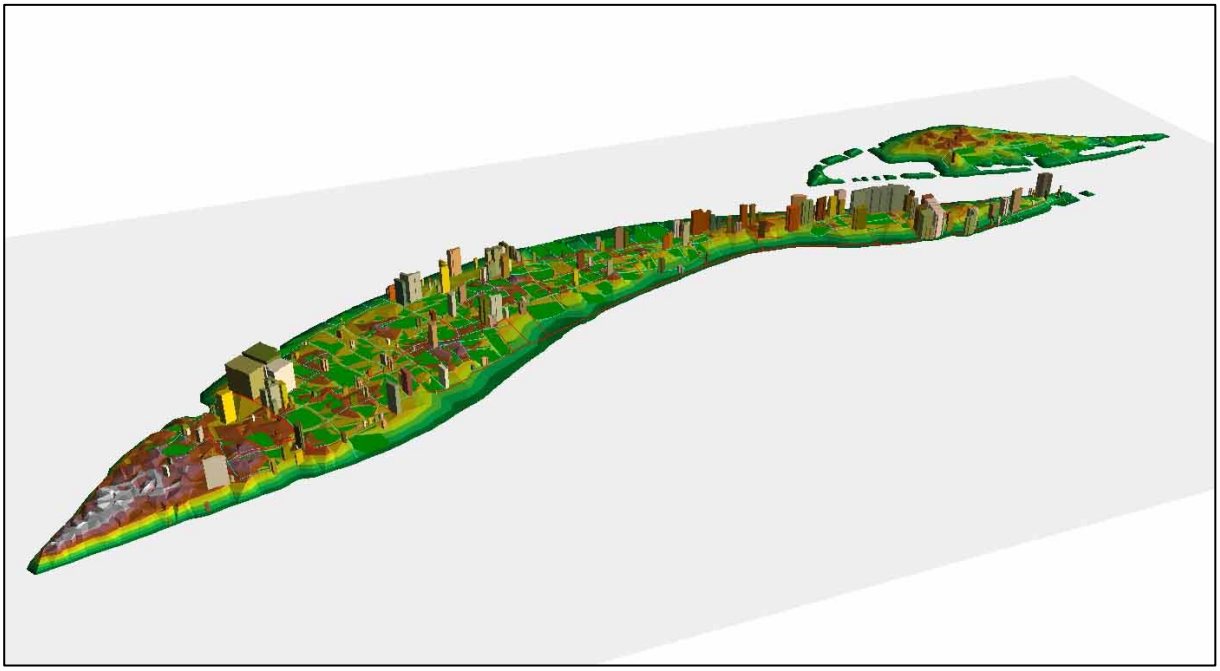

Figure (3-a) 3-D representation to the site

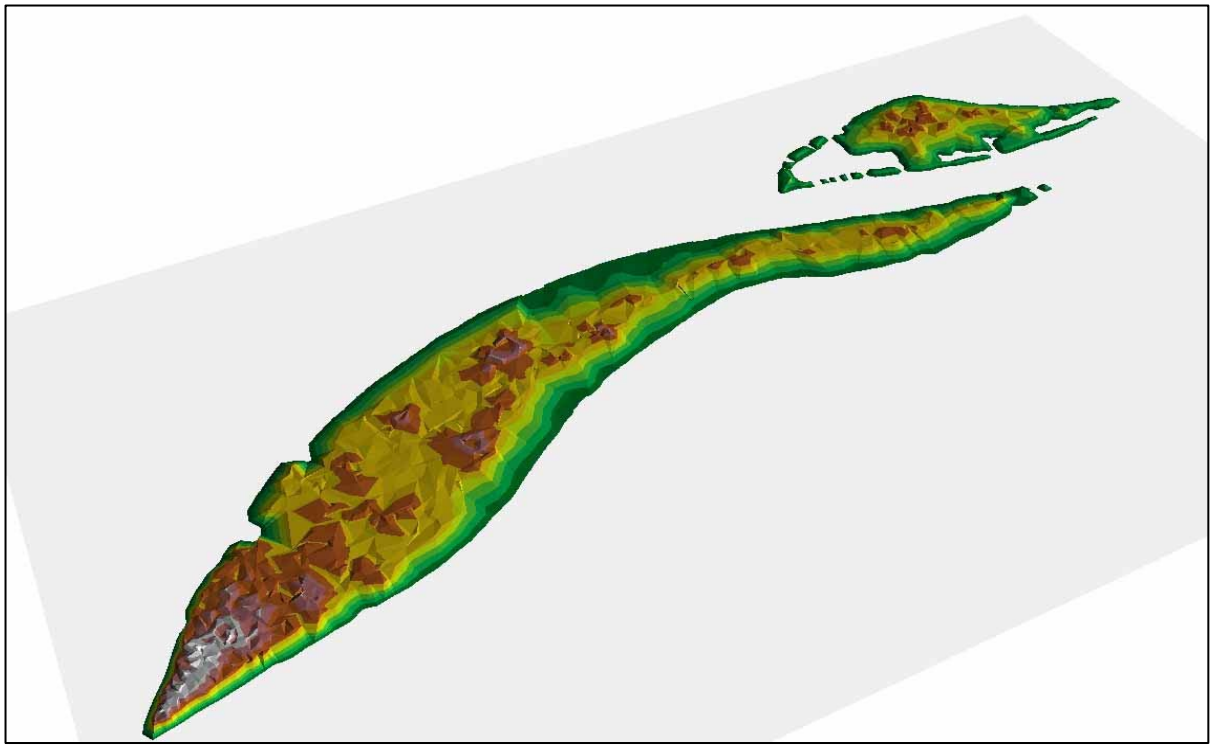

Figure (3-b) A TIN represents the topography of the site

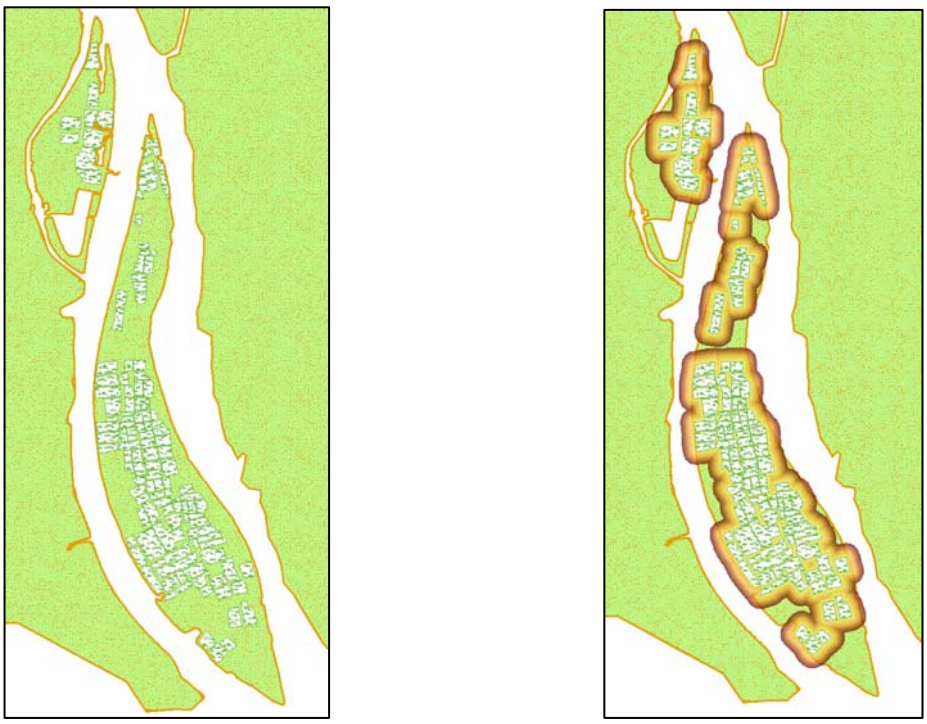

Figure (4) Cultivated area
Buffers surrounding the cultivated area

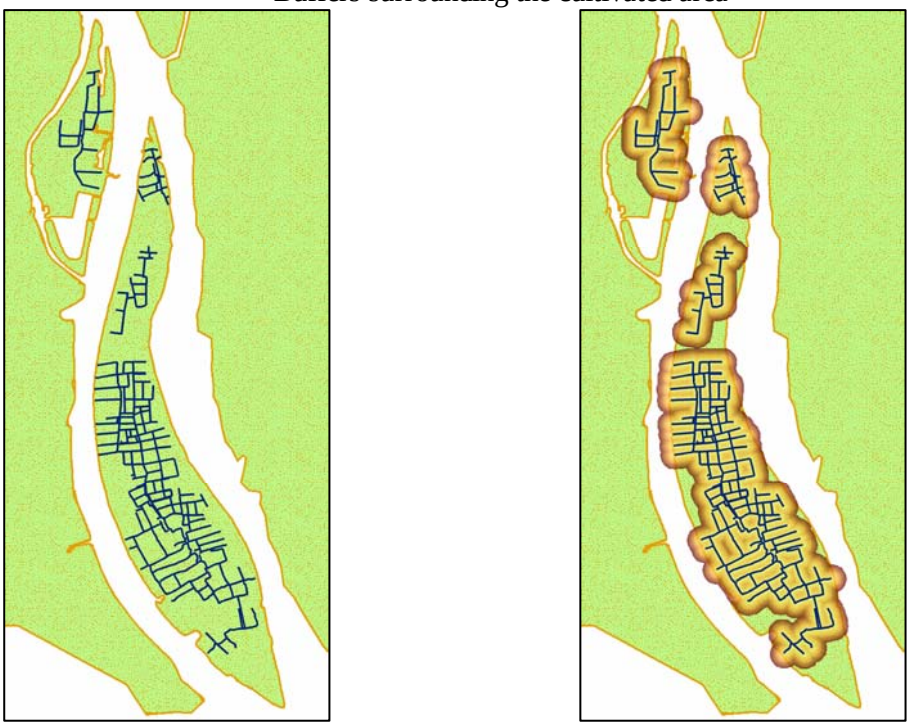

Figure (5) Irrigation network
Buffers surrounding the irrigation network

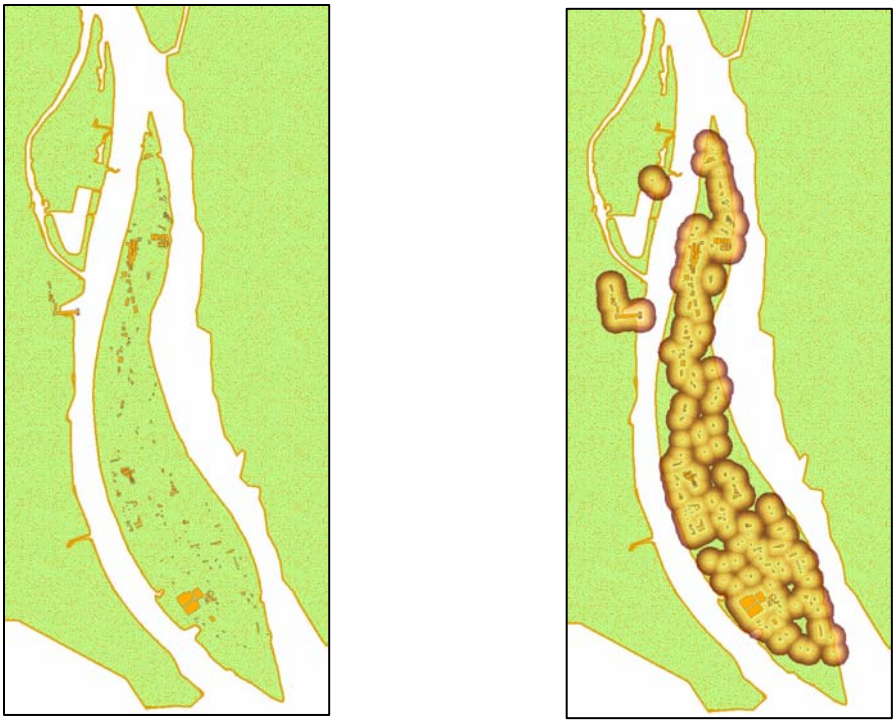

Figure (6) Building zones
Buffer surrounding building zones

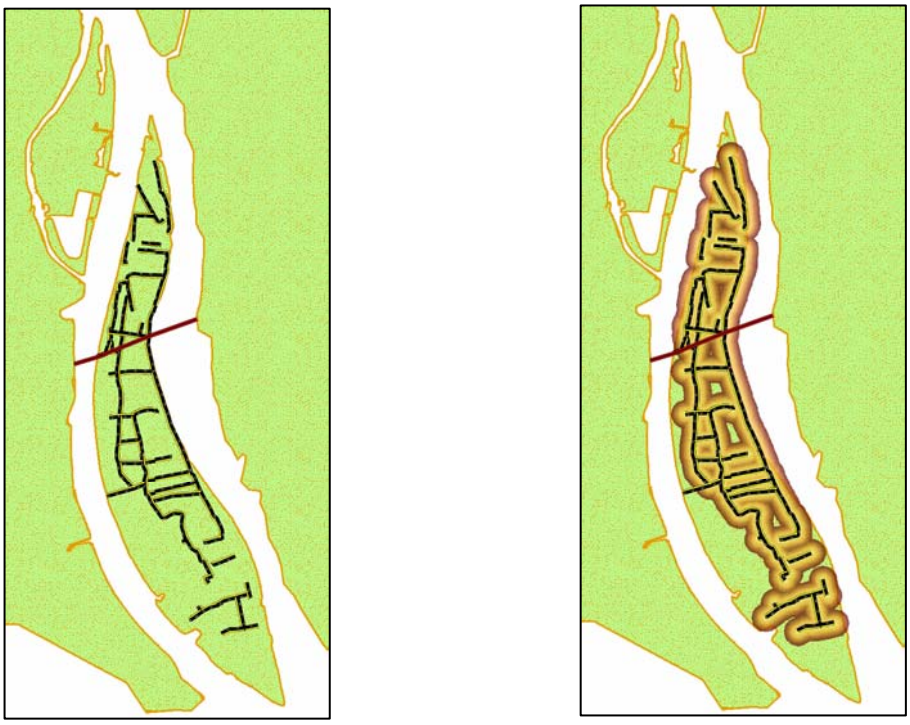

Figure (7) Street Network
Buffers surrounding the street network

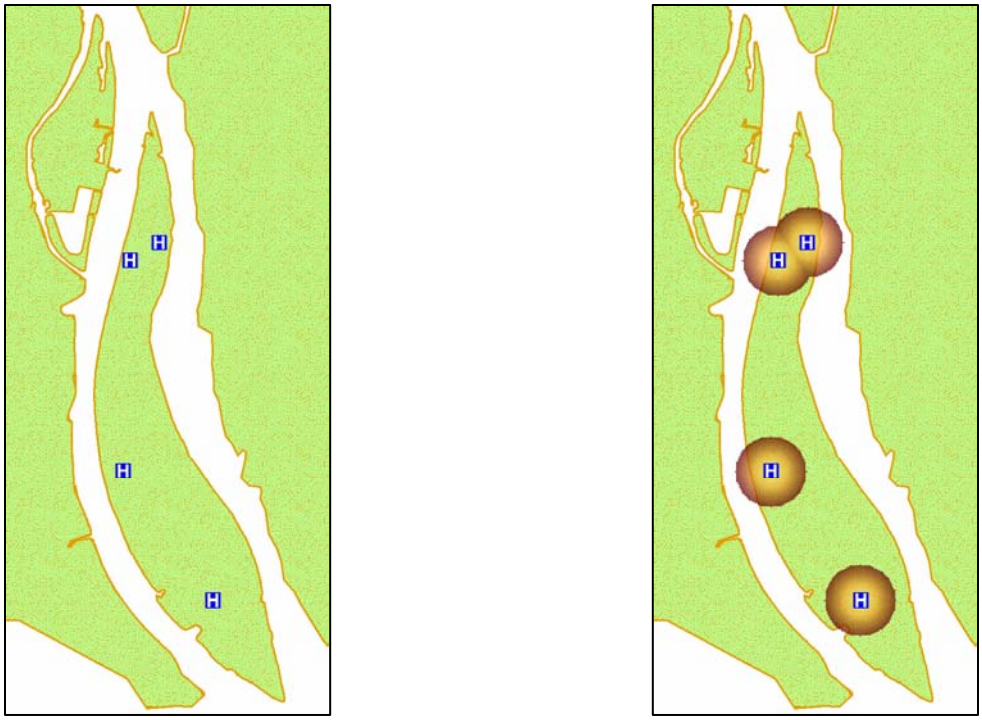

Figure (8) Buffers surrounding the available Hospitals

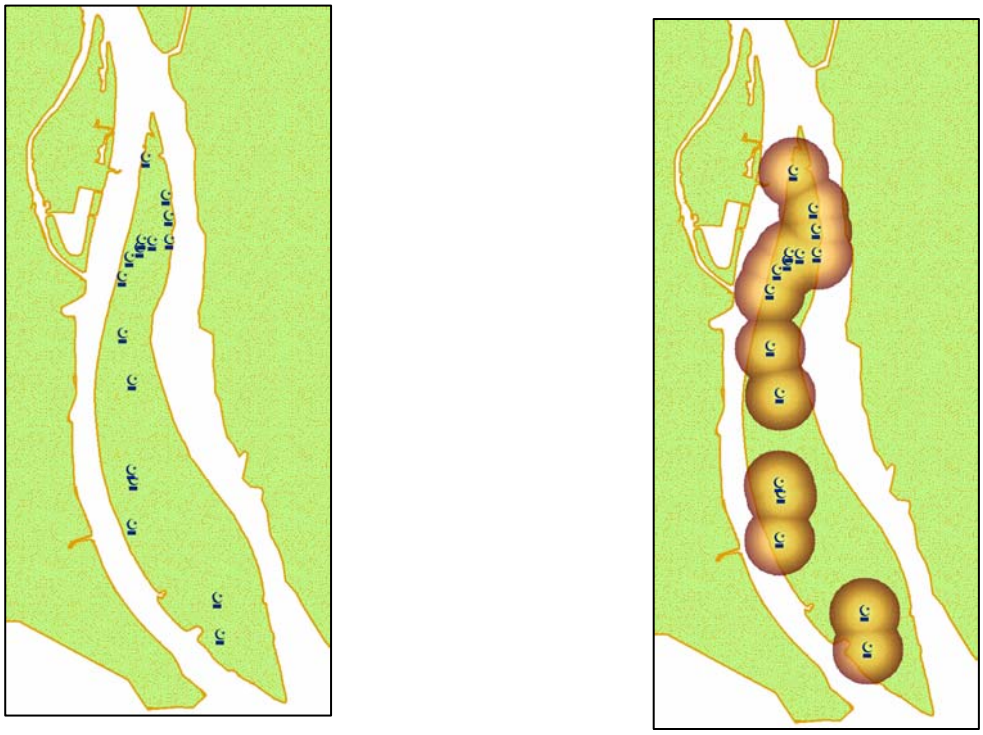

Figure (9) Buffers surrounding the available Mosques

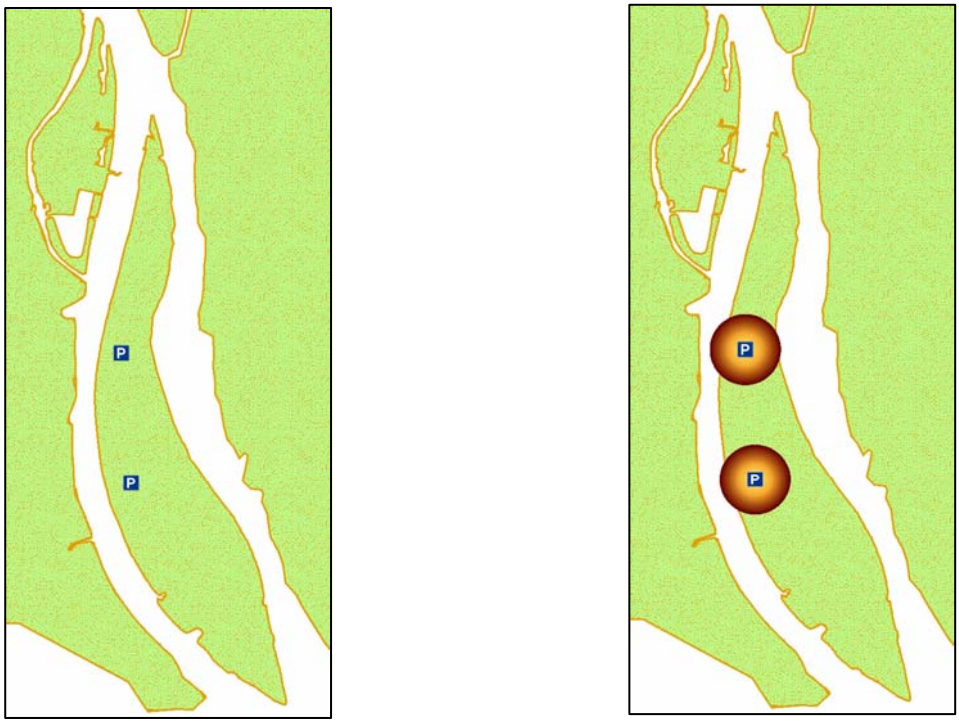

Figure (10) Buffers surrounding the available Post Offices

Figure (11) Final result represents the candidate sites

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