

## **Role of Remote Sensing and Geographical Information System in Environmental Impact Assessment of Developmental Projects for Environmental Management**

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### **Abstract:**

The fast growth in population, urbanization, change in land use pattern in developing countries have resulted in damage of historical, biological, archeological, aesthetic, visual impacts and pollution in land, water, air and noise. There are needs of a tool which can be capable of complex analysis and produce an alternative plan. Therefore Remote Sensing and Geographical Information System (GIS) are the latest technologies or support system or tool which will produce much more accurate results and perform various geographic analyses even in complex situations. Environmental Impact Assessment (EIA) is a less accurate and time consuming because it has more dependant and independent variables which have to be taken in to account such as Land use, land price, population density, socio-economic level, road accessibility, railway accessibility, air quality, ground water quality, noise level, biological content, historical value, archeological and visual importance etc. Remote Sensing and GIS technique is more comfortable, easy and accurate and complete the EIA of any proposed developmental activity in less time. EIA require reports of potential impacts of any proposed activities. By utilizing GIS modeling tools, potential impacts can be predicted and included in the management and monitoring programs. GIS and remote sensing could be used in environmental monitoring for Land use / Land cover analysis, wetland assessment and ground water modeling, habitat mapping, disaster management etc. Thus, Remote Sensing and GIS techniques play a significant role in Environment Impact Assessment process for the proper management of environment.

Keywords: Environmental Impact Assessment, Developmental Projects, GIS and remote sensing

### **Introduction**

EIA is a management tool to be carried out before any project or major activity to ensure that it will not in any way harm the environment on a short term or long term basis. Any developmental project requires not only the analysis of the need of such a project involved but, it requires a consideration and assessment of the effect of a proposed development on the environment. The purpose of environment impact process is to identifying the potential beneficial and adverse impacts of development projects on the environment in to account environmental, social, cultural, and aesthetic considerations. Any development requires not only the analysis of the need of such a project, but most important, it requires a consideration and detailed assessment of the effect of a proposed development on the environment. The environment impact process is the purpose of identifying the potential beneficial and adverse impacts of development projects on the environment in account with environmental, social, cultural and aesthetic issues. EIA is carried out before any project or major activity to ensure that it will not harm the environment on a short term or long term basis (Murthy & Patra 2005). In recent years, major developmental activities projects have encountered difficulties because insufficient account has been taken of their relationship with the surrounding environment. (Singh, 2002) environment impact assessment is a precautionary measure for preventing the possible harms of a development project for maintaining the balance between environment and development the Government of

India issued an Environment Impact Assessment Notification on January 27, 1994. Environmental impact assessment (EIA) is a tool to ensure sustainable development through the evaluation of impacts arising from a major activity (policy, plan, program, or project) that are likely to have significant environmental effects. It is anticipatory, participatory and systematic in nature. (Glasson et al., 1994). slight modifications are needed to make the EIA viable and less costly (Beauregard, 1987), MOEF, 2006 Environment Impact Assessment Authority (SEIAA), to be constituted by the Central Government in consultation with the State Government or the Union territory Administration concerned under sub-section (3) of section 3 of the Environment (Protection) Act, 1986 for the purpose of this notification. EIA has become a requirement in more than 100 countries (Barker & Wood, 1999). Normal procedure of EIA cannot be applied to small scale industries (Arquiaga et al., 1992). EIA process concentrates on problems, conflicts and natural resource constraints which might affect the viability of a project. It predicts how the developmental project can harm to people, their livelihoods and the other nearby developmental activities. It is a planning tool, decision-making. The objective of EIA is to mitigate the environmental problems at an early stage of project planning and design (Tyagi & Singh, 2014). Some projects have been found unsustainable due to resource depletion. Others have abandoned because of public opposition, unforeseen costs, held liable for damages to natural resources and even been the cause of disastrous accidents. (Singh, 2007) Environmental Impact Assessment is one of the tools to satisfy this need involves the systematic identification and evaluation of the impacts on the environment caused by a proposed project. (Kumar & Kumar, 2014) Environmental Impact Assessment is a study of the effect of a proposed mining project, plan or program on the environment. All of these considerations are necessary for determination of the viability of a project and to decide if a project should be granted environmental clearance. EIA potential role in attaining sustainable development objectives was recognized during the 1992 Earth Summit held in Rio de Janeiro. Environmental impact assessment is an analysis of the changes in physical, bio-physical, and socio-economic characteristics of the environment from a proposed project to ensure sustainable development.

### ***EIA process in India***

The role for EIA was formally recognized with an earth summit held at Rio conference in 1992. Principle 17 of the Rio declaration states that – “EIA as a national instrument shall be undertaken for the proposed activities that are likely to have significant adverse impact on the environment and are subject to a decision of a competent national authority”. In India the developmental projects till as recently as the 1980s were implemented with very little or no environmental concerns. The environmental issues began when a national committee on environmental planning and coordination was set up under the 4th five year plan (1969-1978). Till 1980, the subjects of environment and forests were the concern of the Dept of Science and Technology and Ministry of Agriculture respectively. Later, the issues were attended by the Dept of Environment in 1980. This was then upgraded to the Ministry of Environment & Forest in 1985. In 1980, clearance of large projects from the environmental angle became an administrative requirement to the extent that the planning commission and the central investment board sought proof of such clearance before according financial sanction. A major legislative measures for the purpose of environmental clearance was in 1994 when specific notification was issued under section 3 and rule 5 of the environment protection Act , 1986 called the “Environment impact Assessment Notification 1994”. The first step in seeking environmental clearance for a development project is to determine what statutory legislations apply to the particular project. The MOEF has brought out several notifications restricting the development of industries in specified ecologically sensitive areas. In addition there are also draft rules framed for the sitting of industries. Environmental clearance for development projects can be obtained either at the state level or at the central level depending on certain criteria concerning the characteristics of the project. However, (regardless of where the final environmental clearance is obtained from), for most projects the consent must first be taken from the state pollution control board or pollution control committees in the case of union territories.

### Some Projects require Environmental Clearance

1. Nuclear Power such as Heavy Water Plants, nuclear fuel complex.
2. River Valley projects
3. Ports, Airports
4. Petroleum Refineries.
5. Chemical Fertilizers
6. Petrochemical complexes Bulk drugs and pharmaceuticals.
7. Exploration for oil and gas
8. Synthetic Rubber.
9. Asbestos products.
10. Hydrocyanic acid
11. Primary metallurgical industries
12. Integrated paint complex
13. Viscose Staple fiber
14. Storage batteries
15. All tourism projects between 200m—500 meters
16. Thermal Power Plants.
17. Mining projects
18. Highway Projects
19. Forest areas.
20. Distilleries.
21. Pulp, paper and newsprint.
22. Dyes.
23. Cement.
24. Electroplating

### ***History of EIA***

Before the First World War, rapid industrialization and urbanization in western countries was causing loss of natural resources. This continued to the period after the Second World War giving rise to concerns for pollution, quality of life and environmental stress. In early 60s, people realized the projects they were undertaking were affecting the environment, resources, raw materials and people. As a result, pressure groups formed with the aim of getting a tool that can be used to safeguard the environment in any development. The USA decided to respond to these issues and established a National Environmental Policy Act in 1970 to consider its goal in terms of environmental protection. The USA became the first country to enact legislation on EIA. This was the first time that EIA became the official tool to be used to protect the environment. The United Nations Conference on the Environment in Stockholm in 1972 and subsequent conventions formalized EIA. At present, all developed countries have environmental laws whereas most of the developing countries are still adopting it (Lee, 1995). On 27 January 1994, the Union Ministry of Environment and Forests, Government of India, under the Environmental Protection Act 1986, formulated an EIA notification making Environmental Clearance mandatory for expansion or modernization of any activity or for setting up new projects listed in Schedule 1 of the notification.

### ***Types of EIA***

It is important to recognize that there is a general principle of assessment that applies to EIA, and to other assessment processes. There are several other processes that relate closely to the review of environmental impacts that may result from a proposed project. Different types of Impact assessment is as listed below

The following are well recognized processes:

1. Social Impact Assessment
2. Risk Assessment
3. Life Cycle Analysis
4. Energy Analysis
5. Health Impact Assessment
6. Regulatory Impact Assessment
7. Species Impact Assessment
8. Technology Assessment
9. Economic Assessment
10. Cumulative Impact Assessment
11. Strategic Environmental Assessment
12. Integrated Impact Assessment
13. Climate Impact Assessment
14. Demographic Impact Assessment
15. Development Impact Assessment
16. Ecological Impact Assessment
17. Economic and Fiscal Impact Assessment
18. Environmental Auditing
19. Environmental Impact Assessment
20. Environmental Impact Assessment
21. Environmental Management Systems
22. Health Impact Assessment
23. Project Evaluation
24. Public Consultation
25. Public Participation
26. Risk Assessment
27. Social Impact Assessment
28. Strategic Impact Assessment
29. Technology Assessment

#### *EIA Process*

The process of EIA includes several steps listed below-

**(a) Screening:** EIA process kicks off with project screening. Screening is done to determine whether or not a proposal should be subject to EIA and if so, at what level of detail. The output of the screening process is often a document called an Initial Environmental Examination or Evaluation (IEE).

**(b) Scoping:** The aim of EIA is not to carry out exhaustive studies on all environmental impacts for all projects. Scoping is used to identify the key issues of concern at an early stage in the planning process (Ahmed & Sammy, 1987).

**(c) Baseline data collection:** The term "baseline" refers to the collection of background information related to biophysical, social and economic settings proposed project area.

**(d) Impact analysis and prediction:** Predicting the magnitude of a development likely impacts and evaluating their significance is core of environmental assessment process (Morris & Therivel, 1995).

**(e) Analysis of alternatives:** Analysis of alternative is done to establish the preferred or most environmentally sound, financially feasible and benign option for achieving project objectives.

**(f) Mitigation and impact management:** Mitigation is done to avoid, minimize or offset predicted adverse impacts for environmental management plan or system.

**(g) Environmental Management Plan (EMP):** An Environmental Management Plan (EMP) is a detailed plan and schedule of measures necessary to minimize, mitigate, etc. any potential environmental impacts identified by the EIA (World Bank, 1999). Once the EIA the significant impacts have been identified, it is necessary to prepare an Environmental Management Plan.

**(h) Environmental Monitoring:** Environmental monitoring is the measurement of environmental indicators over time within a particular geographic area. Monitoring should focus on the most significant impacts identified in the EIA.

**(i) Environmental Impact Statement (EIS):** The final EIA report is referred to as an Environmental Impact Statement (EIS). Most national environmental laws have specified what the content of EIS should have.

**(j) Decision making:** At each stage of EIA, decisions are made. These decisions influence the final decisions made about the EIA. The EIS is submitted to designate authority for scrutiny before the final decision.

**(k) Effective EIA follow-up:** In practice, an EMP, which is submitted with the EIS report, should be used during implementation and operation of the project. The link between EIA process and project implementation stage is often weak especially in developing countries (Welford, 1996).

**(l) Public hearing and involvement:** After the completion of EIA report the law requires that the public must be informed and consulted on the proposed development after the completion of EIA report.

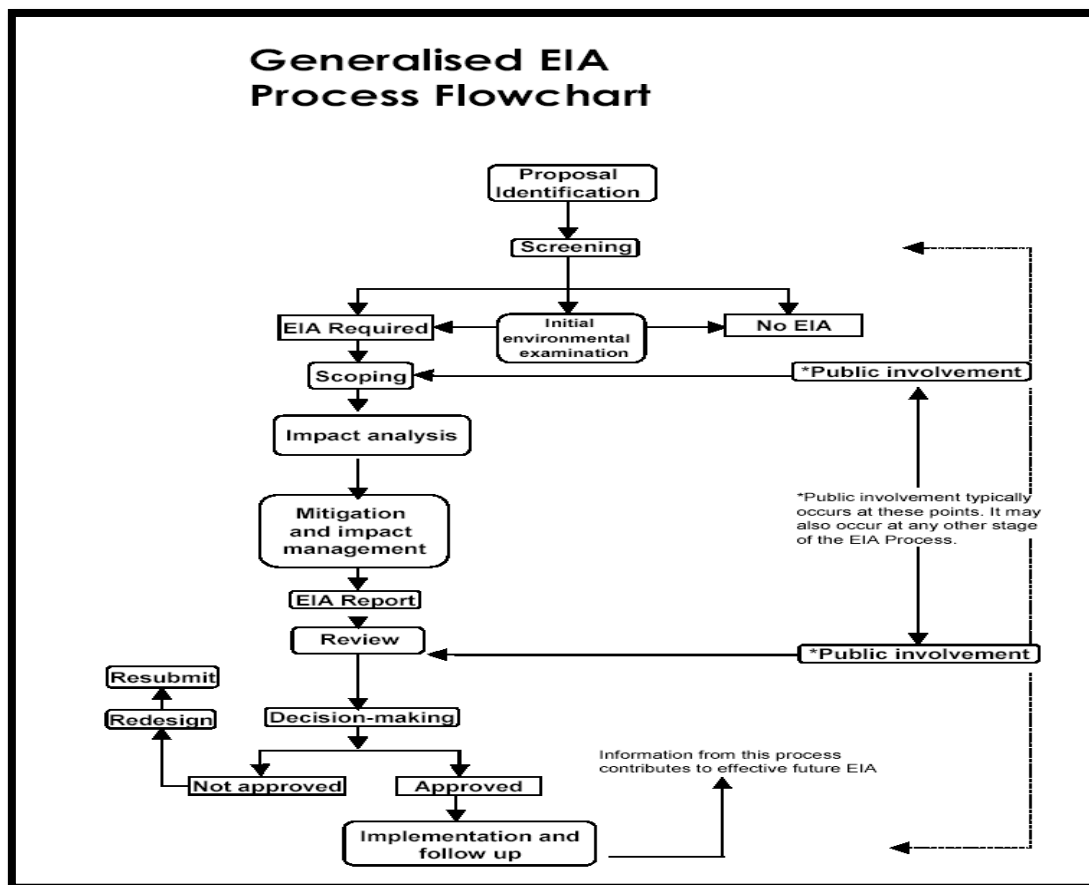


FIGURE 1: Generalized EIA Process Flow-Chart



### ***Remote Sensing***

Remote Sensing is defined as- “ the science and art of acquiring information (spectral, spatial, and temporal) about material objects, area, or phenomenon, without coming into physical contact with the objects, or area, or phenomenon under investigation”. In recent years, remote sensing technology has proved to be of great importance in acquiring data for effective resources management and can be applied to coastal environment monitoring and management (Ramachandran, 1993; Ramachandran *et.al.*, 1997). Recent advancement in RS technology are of great importance in acquiring data in more efficient way which is beneficial in quick change detection and effective resource management. Remote sensing technology may be divided into three phases: (i) data collection from a sensor mounted on a platform eg. a satellite; (ii) data handling; (iii) data interpretation which end up in producing some thematic maps of the investigated surfaces. Data acquired by RS is interpreted with the help of GIS software's.

### ***Geographical Information System***

A Geographical Information System is a system of hardware, software and procedures to facilitate the management, manipulation, analysis, modeling, representation, display of geo data to solve complex problems regarding planning and management of resources. Functions of GIS include data entry, display, management, information retrieval and analysis. A geographic information system captures, stores, analyses, manages and presents data, which is linked to locations or having spatial distribution. Any GIS application and/or operation contains five essential elements: data acquisition; preprocessing; data management; manipulation and analysis; and product generation (Star and Estes, 1990; Antenucci, et al., 1991 & Canter, et al.,1994).

It is a computer-based system that provides four sets of capabilities to handle geo-reference data, such are:

1. data capture: graphic data include digitization and attribute data
2. keyed-in loaded from existing data files
3. data storage and manipulation: file management and editing
4. data analysis: database query, spatial analysis and modeling
5. data display: maps and reports

This is quite simply because this type of data calls for the utilisation of GIS capabilities and when one considers that GIS is becoming simpler to use and much cheaper to buy, it is hard to imagine a future for environmental monitoring systems without it (Schroeter and Olsen, 1996). A GIS can manage different data types occupying the same geographic space. The GIS software for database management provides users with the means to define the contents of a database, insert new data, delete old data, identify database contents and modify the contents of the database (Star and Estes, 1990). The major advantage of GIS is that it can read and analyze different layers of spatial information in the form of maps and satellite images easily and allows identifying the spatial relationships. Thus, it is software used for storing, retrieving and presenting both spatial and non-spatial data in an efficient, quick, and structured way.

Geographical Information System (GIS), is composition of traditional sciences, contemporary science and technology. GIS is a tool for management, manipulation, analysis, modeling, representation of geographical information recorded with the help of RS. Data entry, data display, data management, information retrieval, and analysis are the functions of GIS. In GIS software's geo-referenced data is analyzed in four steps captures, stores, analyses, manages, and presents data, which is linked to locations or having spatial distribution . It is a computer-based system that provides four sets of competence to handle geo-reference data like data capture (digitized, converted from existing data), data storage and manipulation, data analysis (database query, spatial analysis and modeling), and data display (maps and reports).

Data acquisition refers to the process of identifying and collecting the data required for the application. After data acquisition, the methods used to covert a dataset into a suitable format for input into the GIS is known as pre-processing. Data format conversion, such as digitization of maps and printed records and recording this data into a computer database, is the key step in preprocessing. Preprocessing also contains map

projection, data reduction and generalization, error detection, and interpolation. Generally, data sets are manipulated before and after entering into the computer in such a way that they are mentioned to a common geodetic coordinate (e.g. Universal Transverse Mercator (UTM)), orientation and scale.

There are many GIS software's as per your needs e.g; ERDAS, ArcView, ArcGIS, SWAT, which allow developers to add dynamic mapping, improves image quality, overlapping etc (Ormsby et al., 2010). The datasets can be manipulated as needed by the analysis. Some of the operations used in data manipulation are analogous to those used in pre-processing. Many types of analyses are feasible within a GIS; among these are mathematical combinations of layers, Boolean operations and, with external programs using the GIS as a database, complex simulations. Final output of GIS is fully classified map or image which is easy to understand and pass minimum noise.

### ***Advantages of GIS***

On the basis of GIS, the digital data base has been developed stage can also be used in future and any related information can be extracted conveniently and efficiently. New information overlaps can also be maps with newly defined user condition. The other advantages of using GIS for resources investigation can be summarized as follows:

- ✓ GIS is a powerful tool for handling data collected from a variety of sources at different scales and resolution.
- ✓ Large quantities of data can be stored, maintained and retrieved with a greater speed and low cost.
- ✓ GIS is able to manipulate and integrate different types of data in a single analysis, which is an impossible task.
- ✓ It can perform complex spatial analysis providing both qualitative and quantitative results.
- ✓ GIS is extremely helpful in planning scenarios, decision models and interactive processes.
- ✓ Remotely sensed data used for resource mapping, monitoring and management.

### ***Remote Sensing and Geographical Information System in EIA***

Geographical Information System (GIS) is a computer based system which can be used to store, integrate, analyze, and display spatial and non spatial data for undertaking an EIA study. The first GIS system was evolved in the late sixties, and by mid seventies, it was used for EIA. Overlay technique method is one of the main methods of analysis in GIS. In 1972, a computerized version of the GIS technique was used for siting of power lines and roads (Munn, 1975). First GIS (Canada GIS or CGIS) was used for EIA in the late 1970s for the preparation of an EIS for a dam on the river Thames. GIS processes are related to environment for considering the spatial properties of the housing projects. Most of the environmental issues can be handled properly with the use of GIS techniques (Schaller, 1990). Due to the evolution of computer technology, and their graphic capabilities, GIS's have become more users friendly and powerful. The availability and quality of digital spatial data sets have improved for routine analysis (Batty, 1993).

GIS is widely utilized in EIA of housing projects, however, its use is largely limited to the fundamental GIS functions such as map production, classic overlay or buffering (Joao, 1998). The use of GIS in EIA process is common for scoping in terms of time and money relative to the time and budgets allocated for EIA preparation, and especially for scoping studies. The key advantage of GIS for EIA is its ability to perform spatial analysis and modeling (Joao and Fonseca, 1996) for future urban growth projections in world's developing and upcoming urban townships.

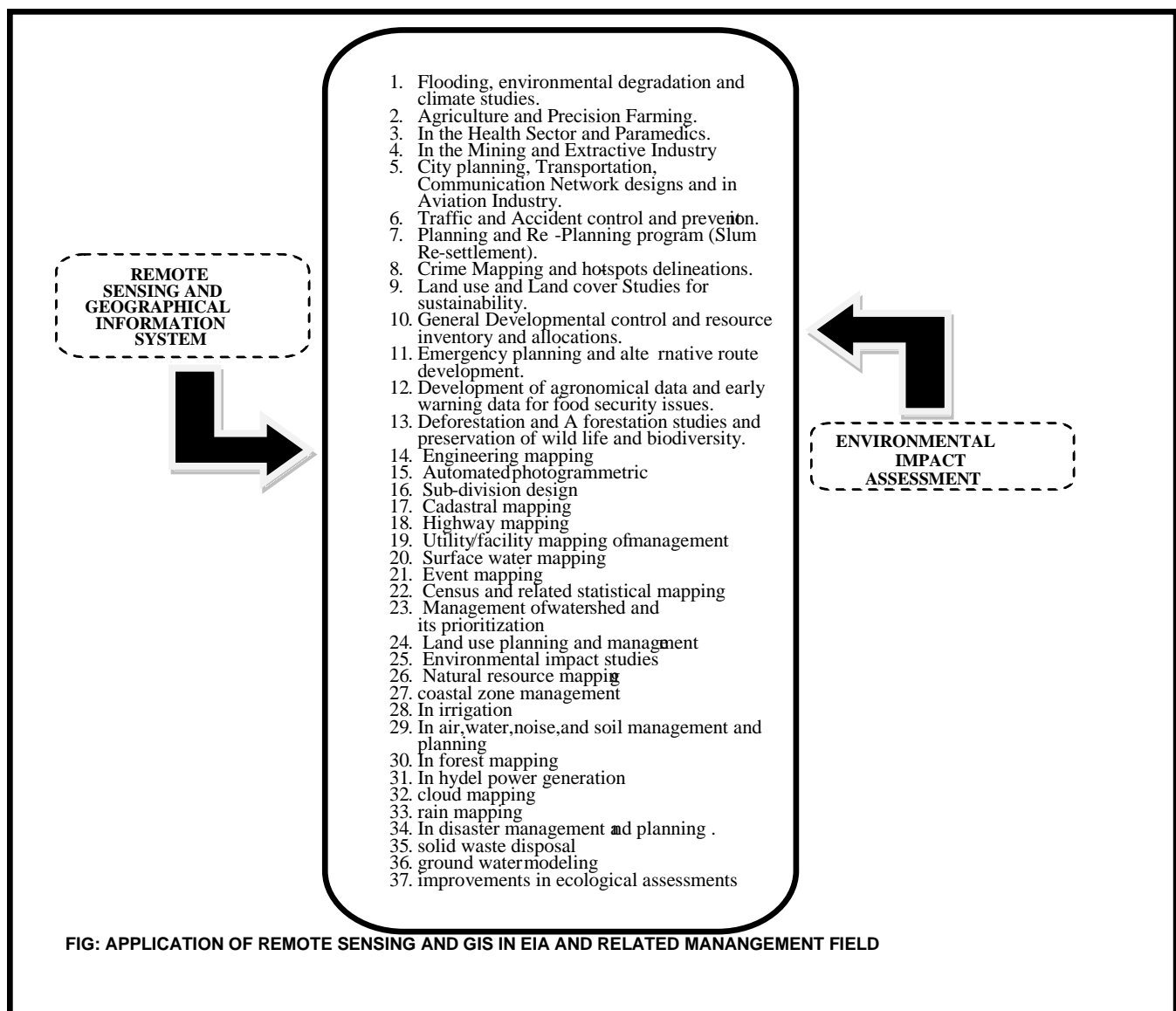
There are several advantages of Remote Sensing and Geographical Information System techniques in EIA which are outlined below:

1. ***Space management*** which is a major issue concerning the provision of limited space to meet housing goals, minimize operating costs and promote an effective and productive environment. The ideal uses of space in successful manner decreases the building's per capita functional costs. There are several cases where GIS is effectively used in the management of spaces for different housing projects.

2. **The suitable site selection** is the primary and essential part of eco-city/housing projects planning. GIS can be utilized to visualize whether a particular site meets the predefined criteria or not. It helps to visualize the spatial interlinks or errors between various factors with that of chosen site for planning. GIS techniques help to generate several important functional maps for the master plan such as the location of the waste management sites, green space, parks and open areas etc.

3. Housing and construction industry is one of the major sources for **Green House Gas (GHG) emission**. Reducing the GHG emission from the construction activities is one of the critical challenging issues in construction industry. So, GIS technique helps in monitoring GHG emission from the construction activities. The maps generated from several sources could be overlaid to prepare the emission scenario and its impact on settlements (Denga et al., 2008).

4. Many applications are enhanced by the use of **3-D spatial information**, such as visualization of planning development proposals, flood predictions, modeling urban sprawl, tourist visit simulations and the design of transportation networks. Some GIS software also predicts the future growth with the help of modeling techniques.



## Conclusion



Environmental Impact Assessment can be defined as the systematic identification and evaluation of the potential impacts (effects) of proposed projects plans, programmes or legislative actions relative to the physical – chemical, biological, cultural and socioeconomic components of the total environment (Canter, 1996). EIA identifies measures also to minimize the adverse impacts to improve the project viability. GIS is an ideal tool for environmental monitoring. GIS is used to a much smaller degree as an active component of environmental monitoring systems. Environmental monitoring and GIS are more closely related. All in all, GIS will be a component of every environmental monitoring system within the next few years. GIS provides a valuable tool for information analysis, automated mapping and data integration. The GIS tools are easy access to large volumes of data. Remote sensing is the technique of deriving information about objects on the surface of the earth without physically coming into contact with them. The use of GIS in EIA process is common for scoping in terms of time and money relative to the time and budgets allocated for EIA preparation and especially for scoping studies. Most of the environmental issues can be handled properly with the use of GIS techniques (Schaller, 1990). The applications of remote sensing and GIS in Environmental Impact Assessments are numerous including environmental impact and compliance studies, site investigations and characterizations, natural resource inventory and management assessments, emergency planning, monitoring, transportation, telecommunication site, route and corridor selection and water and power plant site selection etc.

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