Remote Sensing & GIS Use in Trends of Urbanization and Regional Planning

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ABSTRACT *Urbanization is a dynamic system in which development and changes are prominent features, Which implies population growth and changes in primary, secondary and tertiary sector in the economy. Urban population is increasing day by day due to natural increase in population and migration from rural areas and the impact is bound to have on urban areas in terms of infrastructure, environment, water supply and other vital resources. For organized way of planning and monitoring the implementation of Physical urban and regional plans high resolution satellite imagery is the potential solution. Now the Remote Sensing data is widely used in urban as well as regional planning, infrastructure planning mainly telecommunication and transport network planning , highway development, accessibility to market area development in terms of catchment and population built-up area density. This paper sketches out the Urbanization modal for the future development of Urban and Regional Planning.*

Keywords: *Development, dynamic, migration, resolution*

Introduction

Planning and information are closely linked. Information is needed to assist decision making in planning activities. The monitoring of urban development may result in new planning actions. Information is considered as one of the important element of settlement planning & activities crucial for the economic, social and environmental advancement of all countries. There have been continuous efforts to improve the database for planning and development of any human settlement. Still serious problems regarding availability and organization of data especially in developing countries are persisting. New technology based on aerial photographs, satellite data products and computer techniques is found to be very useful and has got potential to generate desired database for planning. Settlements are being spatially located. Thus, these are geographical in nature. Geographic information at settlement level is used for plan preparation, monitoring & forecasting changes, planning services, managing resources, protecting the public, developing properties, etc.

Progressive globalisation and liberalization of economies will lead to extensive and in depth interaction between various parts of the world cutting across state and national boundaries. The communication revolution with increasing ease of transmitting data in voice, hardcopy visual and digital formats across the globe will further strengthen these ties, opening up of the possibilities of particular specialized communities interacting with other specific parts of the globe. Ready access to world market demands and trends coupled with flexible manufacturing schedules will enable these communities to make, buy, sell or hold commodities, services and cultural objects in quick response to this data. Over last three decades the steady growth in information technology has provided planners and other related professionals with new tools to process, analyze and present spatial data. One set of such tools is known as Geographic Information System (GIS) that means a particular form of Information System applied to geographical data. A Geographic Information System uses geographically referenced data as well as non-spatial data and includes operations that support spatial analysis. In this context GIS can be broadly described as a system of hardware, software and procedures designed to support, capture, manage, manipulate, analyze, integrate, retrieval, update and display of spatially referenced data for solving complex planning and management problems.

Maps for centuries have been an important means for storing, analyzing and communicating information about geographical phenomena. The GIS is systematic procedures for automatically doing what maps have been doing for centuries. However, the base of the GIS is a data file from which maps can be made, whereas the map file itself is the traditional database. The data base manipulation techniques, which include various analytical functions and data processing function, which can be performed on spatial, automated data. Since Remote Sensing Satellites provides continuous image once the database is created in

GIS environment, which allows updating and results can be obtained in less time and used for decision making.

Objectives

The aims of establishing digital information systems are numerous and depend on their applications. However, a few aims are listed below irrespective of applications. They are :

- Efficiency Improvement
- Enabling new Possibilities

Efficiency Improvement

Typically data in a GIS is captured and stored once and used for different applications. In analogy information system (conventional mapping) and early digital systems – the same data – was collected several times for different applications. The initial effort for data capture is reduced as well as for the updating of the same data. Besides all users consult the same data avoiding interpretation differences and other ambiguities.

Enabling new Possibilities

Applications using analogy graphical data do not enable certain type of processes because too much data is involved, for example:

- Map design is the cartographer's job. His skill and knowledge result in a certain design. No alternatives were studied or created because that would be too expensive to do.
- Assigning the quality information to individual objects is not possible in conventional mapping in contrary to the digital equivalent that allows continuous quality control of each data item separately and also in conjunction to each other whether it is for the initial data capture or for updating of data.

The advantage of Remote Sensing data:

- It provides reliable data at regular intervals
- It provides base data that is built-up area information and location
- It provides and use land cover information
- It provides base for plan monitoring and implementation

The advantage of GIS:

The GIS is widely used in Urban/Regional Planning is wide because of following advantages over traditional system of keeping maps.

- Data is maintained in a physical compact data files
- Large amount of data can be maintained and extracted at will with great speed
- Various computerized software modules/tools allow for variety/type of manipulation, including map measurement, map overlay, transformation and geographic design and data manipulation
- Graphic and non-graphic information can be merged and manipulated simultaneously in a related manner

The limitations

- Both the techniques required manpower
- Investment in Hardware and Software
- Time consuming and problems in initial stages of GIS data base design and creation
- Changing data formats and software, which will create problem in merging old data with new data
- Storage environment

Retrospective

Before making any development exercise the first task, both from planning point of view and statutory requirement , is to prepare or obtain a reliable accurate and up to-date base map of respective city and its region for which plan is being prepared. Data is collected from conventional source and data was analyzed in conventional forms for preparation of Development Plan/Regional Plan. Area estimation was done through plan meter and grid method. The conventional secondary data sources are mentioned below.

- Census of India Publications
- Tabular data from various planning agencies
- Old Municipal property maps

- Land use details from land revenue records
- Municipality/village parcel maps from Land Records office
- Old published Gazettes and other publication
- Maps prepared from other planning agencies like PWD, Public health, power, etc.
- NATMO Maps
- City guide and tourist maps
- Specified field survey
- Topographical maps of Survey of India

The shortcoming of above data source is not up to date and survey year is different for each data source which creates complication in data compilation. Data inaccuracy is incorporated due to mechanical mode of adjustments of maps. In absence of latest survey sheets, employing the field survey to record land use or any other details for planning purpose is difficult. Thus, the task of plan preparation takes longer time. By the time plan is approved lot of development takes place, which creates problem in implementation. To speed up the process of data collection, satellite images were not up to the level of users in urban planning. The base map was prepared from available map source and land use inventory was carried by field survey method or from revenue records. The colour maps and single column area table were made for analysis. Plan document contained more of tables and less of spatial details.

For few cities one time digital data was prepared and used for preparation of thematic map plots.

Prospective

So far conventional source data have been the major input for generation of base maps for preparation of development plans. Of late the emerging techniques of aerial photography and remote sensing are being used increasingly for generation of base maps and updating of existing base maps in conjunction with conventional collateral data and limited field survey. The innovative techniques of survey are

- Conventional aerial photography and Photogrammetry
- Digital Photogrammetry
- High-resolution satellite image survey
- Use of GPS and GIS

Now, IRS Cartosat-2 satellite provides 1-meter resolution of the panchromatic data enables planners to distinguish ground features as small as 1-meter. The accuracy and interoperability of the imagery makes ideal for mapping analysis.

To increase the public participation web based packages are expected. The web is best available mechanism for providing the general public with route for direct involvement in the planning process and access to relevant data including.

- Access to relevant spatial and non-spatial information in a multi-media format (text, graphics, maps, photographs, video, animation and sound);
- Access to relevant planning tools (including GIS) via intuitive and user-friendly interfaces such that little or no prior training is required;
- Access to problem-specific data for use with the above; and
- Formal and informal mechanisms for communication with other users for the exchange of ideas, feedback and comparison of decisions made without the social and psychological barriers normally associated with more formal channels such as open planning meeting and written/telephone correspondence

The other area will be Multimedia planning Technologies in Planning where it is possible to manipulate and display the following types of data:

- Text of infinitely variable size and structure;
- Still images, like bitmaps and raster, either generated or captured and digitized;
- Still and animated computer-generated graphics;
- Audio, whether synthesized or captured and replayed sound; and
- Video or moving frames

Multimedia software applications are computer tools based on the simultaneous display and processing of several types of multimedia data. These tools allow for interactive exploration of the data. Base information and Plan details should be translated to soft copy form. The working procedures are to be developed to adopt the new approach in planning. Although automated GIS are just beginning to have practical benefits, they have been adapted to many application areas.

Role of Remote Sensing

Remote sensing (RS) data depicts spatial location of various activities and analyzing the linkages between activates, regional plan, development plan and environmental plans are prepared. RS data is immensely used in creating database on following aspects and with GIS data analysis tools, information can be processed as per the planning requirements.

Perspectives Plan/ Development Plan preparation

- Present land use (statutory requirement)
- Infrastructure network (Roads, Railways, and Settlements)
- Hydrological features (River/Stream, lakes)
- Regional level landscape
- Update of base maps
- Urban sprawl, land use change and population growth, and
- Master plan/ Regional plan proposals

Infrastructure Planning

- Road alignment
- Utility planning (STP, garbage dump site selection, water works)
- Road network and connectivity planning
- Growth centre locations

Environmental Planning

Remote sensing data enables mapping of environmental parameters like green cover, surface water bodies and drainage network with other collateral data following are possible to study and to analyse the urban environment.

- Urban land use indicators and Impact assessment
- Development of Urban Information System (UIS)
- Decision Support System (DSS)
- Development of Urban Indicator Observatory (UIO)
- Municipal Information System (MIS)

Scientific Inputs Required for Urban Planning

The present research paper has tried to look into the utility of remote sensing data and scientific methods in solving some of the urban problems. Applying remote sensing technology to urban areas is relatively new and with the advent of high resolution satellite data advances in digital technology, it has gained momentum.

Some of the requirements of urban planners which remote sensing is able to provide are:

- The location and extent of urban areas
- The nature and spatial distribution of different land-use categories
- Primary transportation networks and related infrastructure
- 3-D structure of urban areas
- Ability to monitor changes in these features over a time

Change Detection

Change monitoring, which requires comparison of two images of different times is an important analysis technique for urban studies. The simplest way to detect change in settlements is to visually compare images at two or more different times. Spatiotemporal analysis helps in studying urban sprawl and growth process. The physical changes in distribution of urban activities can be provided. This helps in measuring and monitoring the location and extent of urbanization. Many dimensions of change can be monitored directly through optical and also microwave data. The of a settlement is related to the areal extent of built up area which in turn is related to the size of the population. Algometric growth model and Central Place theory has been extensively used to estimate population on the basis of the built-up area extent.

Haphazard development in urban fringes can be monitored using temporal data. In this era of rapid urbanization, it is vital to a means of monitoring on a global or regional scale. Change detection algorithms include Visual interpretive methods, Post classification comparison, knowledge based visions etc which are mainly applied on multispectral data. Change detection is also carried out through spatial, textural and numerical analysis. e-Cognition is one of the very latest techniques used to delineate urban settlements

which tries to imitate human visual perception and image understanding, the software generates image objects using multi resolution segmentation.

Environment and Transportation Analysis

The environmental impact on urbanization is an important aspect to be included in planning, design and sustainable development of urban areas, for example, slums can be easily and directly identified on satellite imagery. Remotely sensed data and observation are providing new tools for addressing environment related human health problems relevant to human settlements. It is also significant for identifying, measuring, mapping and monitoring characteristics of natural and man-made hazards or disasters. Vulnerability mapping helps in identifying the location which are at risk from hazards. Post disaster analysis, for example, the extent of flooding and related damage can also be assessed. As the cities/towns expand, the encroachment and impact on environment is ever increasing. Degradation of water habitats, higher storm water runoff leading to urban flooding etc are some of the environmental issue very much related to urban development. An indicator used in this regard is the impervious surface area which can be derived from satellite data. Thermal infrared data have been applied in analysis of a wide variety of ecological processes that related directly or indirectly to urban areas. The urban heat island resulting from replacement of natural cover to urban land use can be observed and studied using thermal infrared data. This helps in understanding how urbanization and urban sprawl affect biophysical and land-atmosphere interactions.

The most dynamic element of urban area is the various modes of transportation. Road patterns, its width and alignment can be directly identified and digitized from remote sensing data. A detailed feature/asset inventory of items like dividers, sidewalks, culverts, gutters etc can be prepared from high resolution imagery. Alignment of new roads/rail can be determined in conjunction with parcel and environmental data. Capacity of road intersections, turn lanes can be studied by taking images of same location over a period of time.

Urban Modelling

The thematic database/maps generated needs to be further analysed for various applications. Urban models can be used to support planning, policy and management decisions. Urban simulation is the process through which the plans, polices are tested or their efficiency and impact. Automata models and visualization in urban simulation represent the state-of-the art in modelling of human settlements. Two classes of automata which are significant are Cellular automata (CA) and Multi-agent system (MAS). CA are generally employed for interaction between static units like buildings, parcels, infrastructure objects whereas MAS is used for more fluid like movements. Simple computer animated design models of building have been improved upon by virtual reality models which are capable of supporting application such as urban design, facilities management, environmental analysis, disaster management etc.

Remote sensing analysis in conjunction with urban modelling has potential to provide information needed for planning and management decisions. Planning Support System (PSS) incorporate and integrate different data components such as spatial data sets, GIS, urban models etc. Possible future land development scenarios can also be prepared. The use of scenarios is one of the essential concepts in bridging urban modelling and urban planning and management. A link to planners and the public is provided and communicated via scenarios that are define or explored within a PSS.

Economic Benefits of Remote Sensing & GIS in Urban Application

The use of remote sensing & GIS technology in urban application are being operationalised due its advantages in time, coast benefits, reliability over the traditional ground methods. For any urban application such as urban planning including infrastructure as well as for municipal applications (tax , water supply etc...,) up-to-date maps/geospatial data are required. The traditional method of preparing maps through ground survey has been time consuming and expensive. These maps require timely updation in phase as rapid development takes place in cities like Delhi, Bombay, Hyderabad, Bangalore. Preparation of maps/geospatial data base are essential for preparing Master plans/zonal plans as ground surveys are impractical for such large areas. However, necessary attribute data such as collecting house hold data, utility data are to be carried out by ground based methods.

Scientific Inputs Required for Regional Planning

In the regional setting the decision making process may be said to consist of the following sequential and iterative stages-problem identification, goal/object setting, solution generation, evolution of alternatives, choice of preferred solution, implementation and monitoring with Scientific Inputs,

Description, Prediction and Prescription. Geographical Information System (GIS) has important inputs to make in each of these three scientific fields namely description, prediction and prescription.

Geographical Information System (GIS)

The GIS is define as a computer based technology for producing, capturing, storing, updating, manipulating, organizing, analysing and displaying spatial or geographically referenced information. The GIS combines elements of CAD (Computer Aided Design) data base management, mapping, image processing and statistical analysis. The distinguishing feature which separates spatial analysis from traditional information systems is the use of location for referencing information as an important variable in quantitative analysis. By exploiting the spatial dimension, spatial analysis introduces a new perspective which can greatly enhance decision making and problem solving process..

Use of GIS in Planning

The GIS could be used in each of the planning stages**:**

Problem Identification Stage

This stage requires that the total regional system be described extensively and intensively. The present demand for public goods –both positive i.e., tangible built environment goods produced by direct intervention in the land property markets and negative i.e., legislative and control interventions in public markets to reduce the negative effects of private actions has to be assessed. Once description of this demand is made, it has to be projected into the future. This is where the predictive inputs are required. GIS can be used not only to store geographically referenced data regarding present demand but also to predict or project the same into future through "what if" studies and statistical projection add-ons.

Goal Setting Stage

This stage requires the support of prescriptive tools. Goal setting can be thought of as setting up the boundaries of the planning space in which the possible solution or plans should lie. This can be done by attachment of weights to different market failures or different groups in society. This may be achieved technocratic ally or politically. In both the cases the scientific support required is of a analytical nature so that the aggregation of individual and group preferences into some form a descriptive to a prescriptive activity because there is no value-free way of aggregation individual demand. Prescription is fundamentally concerned with exploring alternative spatial configurations and whether they are explored simply through presentation and discussion of alternatives or through using optimization models. GIS offers many advantages for this essentially spatial analysis.

Plan Generation Stage

Plan generation is more of an art than science because it consists of finding particular solution which more or less lie in the solution space defined by the earlier stage of goal setting. This may be a technocratic exercise by a systematic combination of plan components or a politically guided process of producing alternatives by weighting various goals differently. Either way the scientific support demanded is the same a search of the solution space for feasible alternatives. As already stated above, this is a prescriptive and hence a spatial analysis activity and therefore GIS can be effectively used for this.

Evolution of Alternatives and Final Choice of Solution

This involves selection of a single solution from a set of feasible solutions and can be said to be an optimization process. Again the process may be a technocratic one involving weighted overlay analysis or through political debate where less acceptable solutions are progressively voted out of the solution space and the best possible social welfare solution is adopted. The analytical support required is similar to the earlier stage and therefore GIS may be gainfully employed.

Implementation and Monitoring

Implementation is not a purely administrative process but also a management one requiring constant feedback. The monitoring activity is one of identifying problems in implementation of the plan and the success of the plan in meeting the goals of planning. As such the scientific support required is of the descriptive analysis of positive and negative externalities and the demand of public goods. GIS can thus be gainfully used in this stage too.

Status of GIS and Geographical Data Bases in India and Abroad

There are several geographical data bases being developed in developed countries like the United States [US National Digital Cartographic Data Base – (NDCDB) by the US Geological Survey], Britain [the countrywide Digital Map Data by the Ordinance Survey, and the Department of Employment], Sweden [Geographical Data of Sweden (GSD), National Atlas, GIS], Australia [Land Information System]. These can

be accessed by various user classes such as different government departments, researchers and private businesses.

Development of such computerised geographical Data bases in an essential prerequisite for planning for development an management of regional areas in general and their capitals in particular. Since such large data bases are a capital, manpower and time intensive ventures, it is an activity best suited to the government sphere of action. In India attempts of setting up of such data bases have been taken up by the Census of India, the Digital Mapping Centre of Survey of India, the Department of Science and Technology (Natural Resources Data Management System- NRDMS is being set up for five districts on a pilot basis) the NISSAT (National Information System for Science and Technology), NICNET (National Information Centre Network) and NNRMS (National Natural Resources Management System) are also being set up by various Govt. Department and agencies.

Conclusions

Spatial maps prepared on a 1:10,000/1:5000 scales using High Resolution Satellites (CARTOSAT) data offer an important "Urban Asset" for urban planning and development. Resources information content derived from remotely sensed data has been "proved useful" for the preparation of Regional Perspective Plans. Master Plans/Development Plans and infrastructure plan. In archaeology, remote sensing data found useful in identifying archaeology sites for excavation. Various visual methods and digital techniques are operationally tested for 'data capture' at a higher degree of accuracy and in this respect many "benchmark studies" have been carried out in the country. Urban GIS offers, application driven solutions as a "value addition" for strengthening urban planning and development scenarios. Integration and fusion of satellite derived information with available conventional/ground based data in a GIS environment offers a "valuable outreach" for the success of urban studies. In order to able to fulfil the role of enabler and supporter of positive economic and ecologically sustainable development activities in their regions, the capital cities have to become 'wired' extensively and intensively. They must function as pulsating centres of information collection, manipulation, storage and dissemination. The GIS have a crucial role to play in effective planning, development and management of ecologically sustainable communities especially the state capitals.

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