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REVIEW ARTICLE

GEOINFORMATICS ROLE IN URBAN PLANNING PROCESS

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ABSTRACT

Urbanization is a key to transform from traditional rural economies to modern industrial one which concentrates population in urban unit. At present, India is among the countries with low level of urbanization. During the last fifty years, Indian population has grown two and a half times whereas urban India has increased nearly five times. In 2001, 306.9 million Indians were living in nearly 3,700 towns and cities across the country, and is expected to increase to over 400 million by 2011 and 533 million by 2021. Most urban settlements are characterized by shortfalls in stock housing and water supply, urban encroachments in extreme area, inadequate sewerage, traffic congestion, pollution, poverty and social unrest making urban governance a difficult task to maintain healthy urban environment. High rate of urban population growth is of concern among India's urban and town planners for efficient urban planning. Therefore, there is an urgent need to adopt modern technology of remote sensing which includes both aerial as well as satellite based systems which allows collecting lot of physical data easily on repetitive basis with speed. Along with this, GIS helps to analyze the data spatially, generate various modeling thereby optimizing the whole planning process. These information systems makes the overall planning process effective and meaningful by offering interpretation of spatial data with other socio-economic data.

INTRODUCTION

Resources allocation and decision making in planning is a widely accepted way to handle complex problems. The world's majority of population is in urban environments and hence, information on its internal composition and dynamics is essential to enable maintenance of certain standards of living. Data on the availability of urban land cover is important to policy makers, particularly for town planners as they monitor impact of planning policies, direction of urban growth, and the development progress. Urban land cover in metropolitan areas continually changes over time and space; hence local government must be able to update their database to reflect current land use, and the data gathered require a great deal of time, effort and money. According to (Patkar, 2003), remote sensing can provide an important source of data for urban land use/land cover mapping and environmental monitoring which has received attention from urban planners and scientists including geographers. A numbers of significant studies were made for environmental quality management, and hence various techniques are applied for mapping urban land use/land cover which helps in encroaching urban problems of smaller magnitude. To handle complex problems of resource allocation and decision-making planning is the solution which involves use of collective intelligence and foresight to chart direction, order harmony and make progress in public activities relating to human environment and overall development. Support from organization is necessary to provide more effective and meaningful direction for better planning and development. Hence there is a need for a suitable information system in all planning and developmental activities for both urban and rural areas. According to (Carlson and Arthur, 2000), present urban areas are described as expansive regions that are interconnected in a dendritic fashion. The positive aspects of urbanization have often been overruled by decline in the physical environment and quality of life caused by the widening gap between supply and demand for basic services and infrastructure.

Urbanization is inevitable, when pressure on land is high agriculture incomes is low and population increases are excessive, as that in developing countries of the world. It has been one of the principal manifestations as well as an engine of change. The 21st century is the urban transition for human society, and being not controlled it is responsible for several problems leading to substandard living environment, acute problems of drinking water, noise and air pollution, disposal of waste, traffic congestion etc. To minimize these environmental degradations, technological development in the related fields has to address the problems caused by rapid urbanization for fruitful development. The modern technology of remote sensing includes both aerial as well as satellite based systems which collects physical data on repetitive basis with speed along with GIS helps us to analyze the data

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spatially generating various modeling, thereby optimizing the whole planning process. To make planning process effective and meaningful, these information systems offer interpretation of physical data with other socio-economic data. Therefore, it is essential to know about the characteristics and capabilities of these remote sensing data products available to urban and regional planners.

Applications of Remote sensing and GIS in urban planning

According to (Sokhi and Rashid, 1999), in India the complexity of urban development is so dramatic that it demands immediate attention and physical planning of the cities and towns. The dynamic nature of urban environmental necessitates both macro and micro level analysis, thus making it necessary for policy makers to integrate remote sensing with urban planning and management. New methods are required for dealing with metropolis as the traditional approaches and technique designed for towns and cities are proved to be inadequate tools. At present for urban studies, digital and multispectral images acquired by EOS and other sensors are used unlike the previous years where maps and land survey records from 1960 to 70 were used for urban studies. The trend of using remotely sensed data in urban studies began with first-generation satellite sensors such as Landsat MSS and was followed by a number of second generation satellites: Landsat TM, ETM+ and SPOT. The recent advent of a third generation of very high spatial resolution (5m/pixel) satellite sensors is stimulating. The high resolution PAN and LISS III merged data may be used together effectively for urban applications. Data from IRS P-6 satellites with sensors on board especially LISS IV Mono and Multispectral (MX) with 5.8 m/pixel spatial resolution is very useful for intensive urban studies.

With its advanced technology, remote sensing has brought miracle in the availability of higher resolution satellite imageries. They include IRS-P6 Resourcesat image with 5.8 m resolution in multispectral mode, IRS-1D Pan image with 5.8 m resolution, Cartosat-I image of 2.5 m resolution with stereo capabilities, Cartosat-II with 0.5 m, IKONOS imageries of Space Imaging with 4 m in multispectral mode and 1 m in panchromatic mode, Quickbird imagery of Digital Globe with 61 cm resolution in panchromatic mode and so on. These high resolutions of sensors provide a new methodology in the application with newly raised technical restrictions. Apart from cartographic applications, IRS-1D LISS IV (P-6) data will be of great use in cadastral mapping and updating terrain visualization, generation of a national topographic database, utilities planning and other GIS applications needed for urban areas. The satellite will provide cadastral level information up to a 1:5,000 scale, and will be useful for making 2-5 m contour map (NRSA, 2005).

The output of a remote sensing system is usually an image representing the scene being observed however, digital image processing and modeling are required to extract relevant information from the image. Suitable techniques are to be adopted for a given theme, depending on the requirement of specific problem. Since remote sensing may not provide all the information needed for a full fledged assessment, many other spatial attributes from various sources are needed to be integrated with its data. This task is performed through GIS technique which is a computer assisted system for capture, storage, retrieval, analysis and display of spatial data and nonspatial attribute data. The data which can be of the form locational (such as latitudes/longitudes) or tabular (attribute) can be derived from alternative sources such as survey data, geographical/topographical/aerial maps or archived data. Data which can be GIS techniques are playing significant role in facilitating integration of multi-layer spatial information with statistical attribute data to arrive at alternate developmental scenarios.

Remote Sensing and GIS technology in the planning process

1) Since information and maps are in digital format, correlating various layers of information about a feature from satellite imagery, planning maps and revenue maps is feasible with the help of image processing software like ERDAS Imagine, ENVI and PCI Geomatica, ILWIS. Valuable information for planning, implementation and management of urban areas is provided by the super imposed maps in GIS software like Map info, Arc View, Auto CAD Map, Arc GIS and IGIS etc.
2) Remote Sensing techniques are useful for change detection analysis, and selection of sites for specific facilities such as hospital, restaurants, solid waste disposal and industry. An attempt has been made to demonstrate the potentials of remote sensing techniques in base, land use and land cover mapping, urban change detection and mapping, urban infrastructure and utilities mapping, urban population estimation, management etc.
3) Digitization of planning base maps and various layout plans has facilitated updating base maps wherever changes have taken place in terms of land development. As digital maps are scale free they provide flexibility such as superimposition of any two digital maps which are on two different scales is feasible. This capability of digital maps facilitates insertion of fresh survey or modified maps into existing base maps. Similarly superimposition of revenue maps on base maps with reasonable accuracy is of great advantage compared to manually done jobs.

Aerial photographs and satellite imagery data in Urban Studies

For a long time aerial photographs have been employed as a tool in urban analysis, and it is used in city planning in India. It is used for generation of base maps and other thematic maps for urban areas as it is cost and time effective and reliable. It provides wealth of information pertaining to land features, land use, built up areas, city structure, and physical aspects of environment that improves the effectiveness of city and town planning in India. Various types of cameras and sensors; black and white, color, color infrared are used for aerial photography. Because of its security concerns, the use of photogrammetric techniques was confined to smaller cities. They are not useful in large metropolitan areas. India was dependent on photogrammetry for providing information for urban planning purposes till March 17, 1988 when it launched its first satellite (IRS-1A) equipped with LISS-I sensor acquiring 72.5

m/pixel data, thereby application of remotely sensed data in urban and regional planning processes gained momentum. LISS-I which gathered data in four spectral bands (0.45 µm - 0.86 µm) was mainly used for broad land use, land cover, and urban sprawl mapping. The IRS-1C and 1D satellites launched in 2003, carrying LISS-III and LISS-IV sensor with spatial resolutions of 23.5 m/pixel and 5.8 m/pixel using Landsat MSS optical bands (0.52 µm- 0.86 µm) have contributed to the effectiveness of urban planning and management. Early experiments with the first generation satellites found the data very useful for mapping large urban parcels and urban extensions. The development of Landsat TM data with 30 m/pixel spatial resolution has helped in mapping Level-II urban land use classes. The salient features of different satellite sensors and the extractable levels of urban information which require higher spatial resolution. Consistency in at least one stage of data collection, the rapidity of survey and small number of skilled workers required at the data collection stage are the advantages of remote sensing methods over tactile methods based on ground survey. Unlike the previous data sources, the direct use of satellite imagery ensures that a minimum of interpretation is carried out by others. If it is collected especially for the purpose of survey, then the client will be able to specify time and environmental conditions which are best for his purposes. For obtaining accurate land use data, the following points should be considered:

Scale of photography, geometric fidelity, contrast, sharpness, resolving power of film, waveband used, photographic or digital format of imagery. Consistency of relationship between form and function, degree of multiple use, the amount of ground control, imagery changes of land use. Interpretation skill, use of stereoscopic techniques used by user etc.

Table 1. Recent Remote Sensing Satellites/Sensors and its Application in Urban Studies

Platform and Sensor System	Spatial resolute (m. pixel)	Year of operation	Mapping scale	Extractable Information
IKONOS	1	1999	1:4,000	Cadastral map
Quickbird	0.61	2001	1:2,000	detailed information extraction for urban planning and infrastructure Mapping.
RESOURCESAT-I (LISS-IV)	5.8	2003	1:10,000 1:4,000	Monitoring the urban growth. Inventory of land-use, land-cover.
CARTOSAT-1	2.5	2005	1:4,000	Large scale cartographic work and DM generation,
CARTOSAT-2A	1	2008	1:1,000	cartographic applications at cadastral level urban and
CARTOSAT-2B	Better then 1	2010	1:2,000	rural infrastructure development and management.

Global Positioning System (GPS) in urban planning:

The Global Positioning System (GPS) has led to a revolution in the land surveying profession. The GPS technology is being employed in a variety of urban surveying applications while the technology is still evolving. At present there are only nationally accepted procedures/methodologies for performing static GPS surveys. Newer methodologies have been identified, e g., pseudostatic and fast/rapid static, for which procedures are just beginning to be developed and universally accepted. As the cost of hardware continues to decrease, surveyors will discover the benefits associated with employing the GPS technology in a variety of urban survey operations. Since the technology and its applications are still evolving, the land surveyor must keep abreast of these evolutionary changes. GPS is not the solution to all urban survey problems, but can probably aid urban survey practices in proportion to the time put into understanding it.

Requirements for Urban Planners

Apart from topographical mapping, planners look forward to remote sensing technology to provide information on existing land use and their periodic updating and monitoring. With appropriate technique and methodology the same data products can be used to:

Slum detection, monitoring and updating, space usage surveys in city centers, using repetitive coverage for updating and monitoring, Study of open/vacant space, Study trend of urban growth/sprawl, Study of urban morphology, population estimation and other physical aspects of urban environment, Study of transportation system and important aspects in both static and dynamic mode and Site suitability and catchments area analysis. In complex urban areas where relatively small size and complex spatial patterns of the component scene elements are restricted to use low-resolution space borne sensors, high spatial resolution satellite data are beneficial. These new images thus increase the amount of information attainable on urban form at local level.

Urban Land Use Classification Criteria

Classification is an activity of sub-dividing a group of objects in two or more groups, i.e. to arrange objects into classes according to some system or principle which can be based on activity, economic function, physical appearance, or simple land cover. The guidelines are:

It is suitable for using remotely sensed data obtained at different time periods. The system should be applicable over a large area covering both city core and its surroundings. Classification should be flexible and easier to understand. The minimum interpretation accuracy and reliability in the identification of land use should be about 85 percent. The nomenclature, definition and framework should be compatible with existing terminologies adopted in planning agencies. Aggregation of similar or multiple land use classes should be possible at different levels of requirement and must be mutually exclusive. It must be based upon quantitative criteria wherever required.

Urban Land Use Delineation

Using classification process, the detailed observations of the purposes into groups are arranged. There are different perspectives in this process which tends to be subjective, even after using objective numerical approach. There is no logical reason to expect that one detailed inventory should be adequate for more than a short time since land use and land cover patterns changes with the demand for natural resources.

Challenges and Issues

While using remote sensing data many problems arise during interpretation of different urban land use/land cover features, in which cloud patches on satellite data is of importance. Another problem in remote sensing data depending upon urban building size and spectral contrast with the surrounding area is that some buildings in urban area may be identified, while others may not. On the other hand, while individual houses cannot be always being identified, groups of houses and city blocks can often be delineated and interpreted in satellite images. Thus, urban remote sensing must be able to provide planners with certain key, data sets that are pertinent to urban studies, notably:

The location and extent of urban area, the nature and spatial distribution of different land use categories within urban areas, the primary transportation networks and related infrastructure. Census related statistics and socio-economic indicators. The 3 -D structure of urban areas for telecommunications (inter-visibility) and environmental Impact Assessment (EIA) studies; and the ability to monitor changes in these features over time and space.

Institutional, Financial, and Technical Limitations

Inadequate funds to acquire and upgrade periodically the hardware and software. Limitation on availability and digitization of certain data products. Inability to procure digital data products and carry out surveys for collection of attributed data. Lack of appropriate base maps necessary for micro-level and utility planning. Absence of a dedicated team that would continue for a reasonable period to establish GIS database. Lack of support to young GIS professionals by the peers who feel threatened. Rigidity in work culture not encouraging experimentation that is so vital for GIS implementation.

The following urban issues are analysed by using Geoinformatics

1) Social Infrastructure

In most Indian cities, the municipal bodies have primary responsibility to cater to the basic needs of the citizen by providing required essential services and infrastructure facilities. But there is a tremendous strain on the delivery of these basic services since last century where the developing world has seen an extraordinary increase in their population size. A major concern of municipalities in developing countries is the limited access to urban services of larger parts of the city population.

Equitable distribution is becoming the centre of concern in planning the infrastructure facilities which basically include banks, post-office, schools, medical facilities. For each facility the proposed indicators are: (a) Number of facility/Total population of the ward. (b) Number of facility/Total area of the ward.

2) Analysis of Urban Environment

Greenery in cities exist as semi-natural areas, managed parks and gardens, supplemented by scattered vegetated pockets associated with roads and incidental locations. Embodying the garden city concept advocated by Ebenezer Howard (1898) and the large urban park idea expounded by Frederick Law Olmsted in US (Wilson, 1989), public green spaces have been increasingly designated in cities since 1 880s to counteract environmental impacts of urban expansion and intensification. Planting notably trees, have a wide range of environmental benefits, and urban green spaces often accommodate varied assemblages of flora and small animals, providing readily accessible site with natural ingredients.

3) Land Use in the Core Area

From monitoring point of view, information about land use may not be sufficient for city administrators and planners in congested core areas, it should be visualized. In the absence of suitable large scale maps for such detailed studies, the principal use of very high resolution IKONOS satellite data provide a base for the survey/ recording of various activities in the field. Quantitative determination of space use allows understanding the distribution pattern of various activities and functional characteristics within urban fabric, which is useful for quantifying the stress on existing infrastructure.

4) Analysis of Location Suitability

A number of workers have identified various criteria including soils, hydrology, topography, vegetation, climate, existing built up areas, transportation route etc. to find out suitable sites for development activities. The most commonly technique for suitability analysis is weighted suitability method which is more complex; to bias the weighting the aspect scales should first be normalized that is used in the same numerical range. Such a scale can accommodate qualitative and quantitative data but it needs qualified professionals. The next step is assigning the weight factors which are often based on a mixture of implicit knowledge, personal experience and individual values that are usually called professional judgment.

5) Analysis of Travel Route model

Physical infrastructure of an urban centre comprises of transportation, water supply, electric power supply, sewage in which transportation system is one of the keys to rapid modernization, particularly in developing countries. Irrespective of whether roads act as a catalyst or play a passive role for development, it is necessary to work out a

judicious plan to avoid congestion, pollution and cost. The main objective of studies using Remote Sensing and GIS techniques is to analyze the network of tourist places considering time and cost which could be helpful for other cities.

6) Land range in Urban area

As the population growth increases the pressure on the land, the non urban land is converted into urban areas which ultimately influence the land use pattern of urban centre. In urban planning knowledge of the patterns and intensity of land use is relevant but its preparation inventory by conventional method is expensive and time consuming. The advantage of satellite imagery interpretation in terms of accuracy, timeliness and cost is indisputable in comparison to conventional methods.

7) Analyzing Urban Sprawl and Growth Trends by change detection

Since satellite based remote sensing systems have unique capability to provide repetitive coverage it is most suitable for monitoring and updating of urban expansion by using very high resolution multi-temporal remote sensing data especially for town and country planning. The role of remote sensing in the case of green / open spaces mapping and analysis has become important for managing and maintaining old and degraded spaces. However, remote sensing can supplement or partially replace tedious ground survey methods which have limitations as whole area may not be accessed in one go and information collected may not be accurate. Remote sensing not only provides spatial data but also allows us to compare temporal variations in it which is essential for green/open spaces management.

8) Analyzing Urban Hydrology

Indian city face problems of insufficient water for domestic and industrial purposes, poor water quality and inadequate urban storm water run of disposal. The remote sensing techniques are also being applied in obtaining information pertaining to surface water quality parameters, soils, drainage, land use, ground water and slope of catchment are water sheds relevant to carry run of and water estimation studies.

Conclusion

Remote Sensing and GIS is capable of extracting urban land cover information with robust results. Satellite remote sensing with its repetitive and synoptic viewing capabilities, as well as multispectral capabilities, is a powerful tool for mapping and monitoring the ecological changes in the urban core and in the peripheral land use planning, which helps in reducing unplanned urban sprawl and the associated loss of natural surrounding and biodiversity. On the other hand, incorporation of land use transportation models, network analysis, simulations of urban activities to evaluate different urban development alternatives in the GIS framework needs to be explored for more advantage. From this information, land use planning, community facilities planning, transport planning, and environmental planning can be benefited. For urban managers and policy makers, rapid development in city poses several challenges including problems associated with urbanization. Meeting these challenges requires access to timely and reliable information. In urban planning profession Indian cities will have to compete with others to attract investment and, therefore, issues like quality of infrastructure, energy efficient services provision and environmental conditions in a city besides economic stability would play a significant part in such competition.

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