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Implementation of Urban Green Space System using Geo-informatics

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A B S T R A C T

Worsening condition of our urban life such as uncontrolled growth of informal sector, destruction of the environment and abuse of ecological assets like water bodies and stretches of land have rendered cities in India in a regrettable state. A radical change in the development plan of open spaces in India can make it an eco-sensitive and a sustainable, urbanized center. A green space system is an essential ingredient of an urban ecosystem. Green space system planning and construction provides a crucial method for sustainable urban construction in India. Functions of an open space-turned-green space system essentially include protection, productivity, and recreation. This paper proposes sustainable urban green space system planning based on Geographic Information Systems, in order to provide experience for construction of sustainable cities in India. Combining ecological technology, water management systems, wastewater treatment technology and urban slow transport system people can utilize green space systems as an ecological, urban low carbon treatment facility as well as leisure and entertainment facility.

Introduction:

India has been in the interim stage of urbanization since the past decade. High cost of urban transportation, lack of housing for majority of people, inadequate and costly amenities, fragile services, overwhelming real estate thrust and colonization of land in urban development make Indian cities an arduous place to live in. Urbanization has also led to severe environmental and ecological problems like increased air and water pollution, local climate alteration and a major reduction in natural vegetation cover. The character of growth in most Indian towns and cities is anarchic. The archetype of past development cannot be used as a pattern for the future. All Indian cities are challenged with the issue of preserving quality of the environment without hampering development. It creates a demand for environment protection, control of hazardous activities and provisions of recreational facilities in Indian cities.

Sustainable development is defined as: "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs." -The World Commission on Environment and Development. With the overwhelming tide of urbanization, how to keep sustainable development is growing to be an important problem. There has to be a shift of focus in planning, from a single-objective paradigm of recreation, to a multi-objective process of environmental protection and natural conservation (sustainable).

Urban green space systems are a significant reflection for urban life as well as ecology. Urban open spatial information system, supported by fast-going computer technology and spatial information technology, can help to acquire real-time spatial information of a certain region, get analysis of the information, develop simulation of urban open space system, and then make predictions and of the urban ecological environment outcome brought about by socio-economic development of urban open space system.

In this paper, the theory and technological basis of green space system planning is explored, the approaches of green space system planning for a sustainable city are studied and the steps of sustainable green space system planning based on Geographic

Information System (GIS) and Spatialization are proposed in order to provide a theoretical basis and reference for developing a sustainable city in India.

Geo-Informatics and Urban Open Space:

A. Geo-Informatics

Geoinformatics is described as the science and technology dealing with the structure and character of spatial information, its capture, classification, storage, processing, portrayal and dissemination, including the infrastructure necessary to secure optimal use of this information. Research in this field is used to support global and local environmental and energy and security programs. Many fields benefit from geo-informatics, including urban planning and land use management. The importance of the spatial dimension in assessing, monitoring and modeling various issues and problems related to sustainable management of natural resources is recognized all over the world.

Spatial Information technology includes Remote Sensing, (RS), Geographical Information System (GIS) and Global Positioning System (GPS). It is the technology which obtains manages and analyzes spatial information. Using remote sensing technology, people can obtain long distances without contact and with quick access to various features of the ground in real time information. The advantage of RS is short cycle, broad field of vision, rich information, and timing positioning observation; With the help of GIS people can acquire, store, manage, analyze, display, and make use of the spatial data from the whole or part of the earth's surface. GIS can relate the spatial data and the attribute data together, and provide users with the spatial retrieval and analysis capabilities; GPS can provide information of anytime, anywhere, three-dimensional position, three-dimensional velocity, and precise time to global users.

Spatial information technology involves not only collection of data, but emphasizes on earth spatial information processing, measurement, analysis and management, storage and display. Spatial information technology of the whole living environment has is characterized by the objectivity of information acquisition, information positioning accuracy, flexible information management, and spatial information analysis.

The technique of RS, GIS and GPS integration is a trend of modern spatial information technology development. The united technology system of the GPS provides remote sensing for earth's observed information with accurate real-time location information and ground elevation model. RS, GPS and GIS integration leads to the geo-information system with access to accurate positioning ability of current remote sensing information. RS, GPS, and GIS integrated technology will eventually create the new ground for three-dimensional information and geocoding image real-time/ near real-time information acquisition and processing system, and form an information processing process which is fast and highly accurate.

Spatial data refers to data related to spatial location and spatial relationship. Databases are a computer data management technology of wide application range. The GIS database is a key supporting technology of GIS. GIS databases store information about the world as a collection of layers that can be linked together by a common locational component such as latitude and longitude, a postal zip code, etc. These geographic references allow you to locate features on the earth's surface for analysis of patterns and trends. Dozens of map layers can be arrayed to display information. Social, resource, environmental, and economic data can make up of greater spatial information database relying on GIS database. Space database is mainly responsible for constructing service network system of collection, input, management, analysis, distribution, feedback, and decision making information material about resource, environment, society and economy. Many countries and regions (Including the NSDI- National Spatial Data Information, India) have established their own spatial database, but have difficulty in sharing the database because of the difference in technology platform. The difficulty is especially outstanding in GIS database. To realize the sharing of GIS databases, specialists have proposed that we can realize interoperability of spatial data by constructing distributed multi-spatial database system, and then achieve sharing of spatial information.

B. Urban open space and Urban open space system:

Urban open space refers to open space objects outside the urban architecture substances. They include many kinds of spaces like green area, river or lake water bodies, idle space to be built, and not to be built, agricultural, and forestry space, mountains, beaches and so on. They are responsible for many different functions such as diverse lifestyles, activities, natural growth and representing ground landscape and restricting infinite expansion in city. They are important space vectors for urban construction to reflect ecological idea and to promote urban sustainable development. They are the spatial basis of harmonious coexistence for humans and the environment within the urban territory, and a space conditioner to improve urban structure and function. The construction of a modern, urban, and open space system stems from the ideological basis of ecological concept coupled with urbanization. It is an embodiment of ecological planning and ideological design. It wasn't until 1887 in England that the idea of urban open space came into being in a modern sense, and since then it has been interpreted and applied in different angles and for different purposes. Research of urban open (green) spaces is in accord with sustainable development, with

multiple objectives and functions of the ecological, recreational, cultural and aesthetic aspects.

Urban open space systems are an aggregation of all kinds of landscapes, morphology and its constituent elements. They can be classified as green open space subsystems and grey open space subsystems, the former including green area, landscape gardens and water bodies, and the latter including internal transportation space, external transportation space and un-afforestation idle land. Urban open space systems support and overlap mutually with urban ecological systems, economic systems, and social systems, and all of these constitute urban giant systems.

Greenways:

Greenways are linear open spaces such as canals and scenic roads that are set along riversides, hillsides or valleys, converted to a recreational use along the railways. The full word "Greenway", "Green" is defined as forests, riversides, natural spaces like wild life, "way" as a route or an axis. Two words together are depicted as greenway or an axis integrated with landscape. There are bicycle passages, wild life routes, improved water sides or a river far from a city or pedestrian axes forested along a bay. A greenway is basically a green space network that links open spaces with artificially built ecological green corridors. They are a general term of showing linear consistency, linking open and green spaces and providing development into urban texture. It is an essential component of a sustainable urban system planning strategy. Greenway ideology reviews India's urban planning, land utilization coupled with green space system planning. Natural greenways include natural open spaces, patches, rivers, lakes, wetlands, mountains, grasslands, etc.

Sustainable Green Space System Planning Combined With Spatial Information Technology:

Logic Design:

Urban open spatial information system includes two primary subjects namely **Special Subject subsystem** and **Applied Information subsystem**. Special subject subsystem is mainly used to manage and apply some particular subject, then return the new-acquired information to the urban open spatial information system database, and make necessary updates and maintenance. The special subject subsystem is composed of two secondary subsystems, namely **Green open space subsystem** and **Grey open space subsystem**. The Green open space subsystem further involves three subsystems, namely Green area subsystem, Landscape gardens subsystem, and the Water body subsystem. The grey open space subsystem involves 4 subsystems, namely External transportation space, Internal transportation space, Square, Un-afforestation idle land.

Green area information subsystem can be used to handle information data in urban open space related to green areas. It can help in making a layout and plan to green area in urban open spaces, and then make a forecast about the ecological consequences to urban open space system. Even the urban giant system can make valuable consultation to urban green area information subsystem for urban open space design. The landscape gardens information subsystem is used to handle information data related to landscape gardens, analyze all possibilities of landscape gardens planning and ecological influence by its modification, in order to make consultation for urban landscape gardens design. Water body information subsystem is used to analyze water body quality and its influence on open space environment quality, and then make some predication about their possible variation and influence in the next session according to current data, in order to offer information and assistance for water bodies of all kinds. External transportation spatial information subsystem can be used to make predictions and layout analysis in inner-cities when the city is confronted with new external transportation project, and then make prediction about possible consequences on the basis of current information.

Internal transportation spatial information system is to reference scheme and related analysis for the internal transportation layout in future on the basis of analysis of current transportation communication lines conditions. Square information system is used to analyze reasonability of square layout in open space, then try to offer its demand information and make reference scheme.

Un-afforestation idle land information system is used to analyze all of its possible applications based on analysis of information data.

Applied information subsystems are used to offer inquiry and arithmetic operation related to urban open space system to users on the basis of integration of all components. It can get the effect of one or more factor's layouts on urban open space system by further integration and analysis of arithmetic operation of special subject. Next, it can predict the influence on other factors, urban open space system and even urban giant system and all their ecological responses by its layout variation and socio-economic change. The final inquiry outcome and arithmetic outcome can be output as image. With the help of extensive distribution of clients in urban open spatial information system, the public can understand all kinds of information of open space within their city, and can make sense of the influence by some on-going construction in open space, and all in all, improve the enthusiasm of the public to urban construction.

WINDOWS family or domestic LINUX operating system are usually adopted for systematic software of urban open spatial information system, and

applied software always be ERDAS, ARC/INFO series, CAD, and MAPGIS series software.

Database design:

Database is the core part of urban open spatial information system. It affects the system application, maintenance and management, and data update directly. The fundamental requirements of databases are non-redundant structure definition of data volume (the structure, inter-relationship, and subordination of data elements should be kept unchanging when redundant data is inserted, modified, and deleted), data independence, maintenance of data security, guaranty of the correctness, effectiveness, and compatibility (logically) of the data, having the ability of constant to expand and update.

Urban open spatial information systems include socio-economic information, spatial information, metadata, and other information data. The socio-economic information system is non-spatial attribute data, and is mainly composed of socio-economic and cultural data of the open space about the city. Spatial information comprises mainly special information and subsidiary attribute date of topographic maps, administrative region map, transportation maps, and spatial distribution maps of all kinds of ground objects, also including data processed by remote sensing image. Metadata is data about data, concerning quality, content, condition, and other features of data, and it is of great importance in data sharing. All databases can be boiled down to GIS basic database, metadata database, and integrated information database. The data management mode is spatial information by GIS, attribute data by DBMS, and they can be associated by key fields. The designed database must provide for data editing operation and construction of topological relations, registration of the plane coordinate, parameters setting of projection, inter-conversion with state coordinate system, data edge matching problem and other related problems.

System functional module design

Systems should contain functions like data input, query and search of graphic or attribute information, data processing and analysis, coordinates change and projection conversion, display and output of graphics and charts and data update and so on. It also should involve special subject applications and auxiliary business management functions suited for different special subject subsystem.

System user interface design

User interface design should reflect principles of friendliness, convenience and speed of operation. It must adopt localized menu-based user interface so that the user can realize corresponding function merely by some simple operations. To be specific, on the interface like system maintenance, management and operation, data input and modification module for database maintenance and management, data query module, graphic query module, and output of arithmetic result including graphic print module should be available. User oriented query interface reduces database maintenance and management module, and its data output function is simple.

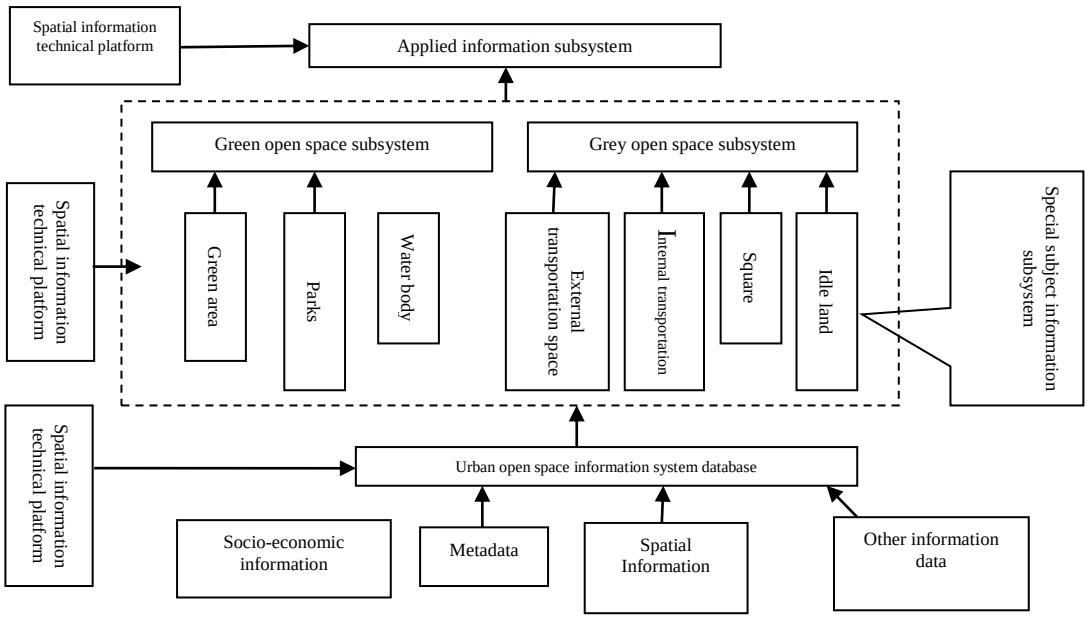

Figure: 1. The structure of urban open spatial information system

Sustainable Green Space System Planning Combined With Geographic Information System (Gis):

Based on existing research, design of a sustainable green space system planning framework combined with Geographical Information System (GIS) is proposed. A basic step-wise approach can be followed for the same.

Step 1: Identifying areas suitable for a green space system

The areas suitable for a green space system are the ones regarded as protected areas and ones that are planned and priority areas for protection. This step requires Geographical Information System (GIS) technology.

Sub-step 1: Identify the existing protected areas for green space system:

To identify such areas as parks, green lands, rivers, and significant historic and cultural sites which are already deemed as protected.

Sub-step 2: Identify the planned and priority areas for protection:

To identify the areas which have not been legally protected yet but critical to the protection and sustainable development. They may be parks, green lands, rivers, river banks, wetlands, and historic and cultural sites. Most of the data obtained in this step is in a format that can be imported to be utilized on a different platform, whilst some of it required some pre-processing.

Step 2: Overlay the areas identified

This step is required to obtain a composite map marking the existing protected areas and the planned and priority areas for protection. Through this we could make a map that presents all the identified existing protected areas and planned and priority areas for protection and thus narrow down our scope of vision to concentrate only on a specific piece of land to work upon

Step 3: Create the green space system
Propose a new green space system.

In this step, the spatial data acquired in the first step is imported into a vector-based GIS system for analysis. Each output raster is multiplied by the weight values of the corresponding factors pertaining to the specific environment in scrutiny and is overlaid using the GIS overlay tool. As a result, a green space system suitability map is constructed through the overlay.

Step 4: Vision the framework of a regional green space system network

This shows the picture of the framework of a regional green space system network to be incorporated in the future.

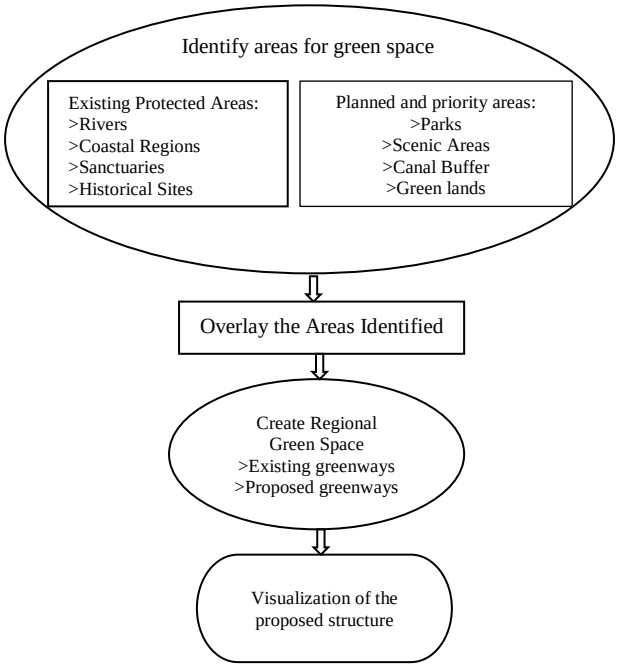

Figure: 2. Framework for green space planning with GIS

Green Space System Planning and Sustainable Development:

The green space system design as an approach for sustainable urban development needs to possess ease of understanding, realization and should be readily adopted by local governments in order to implement metropolitan greenways in India. A few of the major impacts green space system planning will have on our life are listed below.

A. Green space system provide ecological protection:

As the protection facility of urban ecology, Green space system could protect animals, plants, grassland ecological system, wetland ecological system and forestry ecological system. Greenways can be powerful shapers of our urban form if put to correct use meticulously. They work as an adaptive urban landscape form, evolving from axes, boulevards, parkways, and trail-oriented recreational greenways, into multi objective greenways that address recreation, beautification, such areas as wildlife habitats, promoting urban damage reduction, enhancing water quality, providing a resource for outdoor activities, a basis for research in educational fields and other giant urban infrastructure objectives.

B. Green space systems provide overall sustainable development:

Urban green spaces not only play an important role for the environment but also contribute to social, economic, recreational, cultural and visual aspects and commercial developments in cities.

The social aspects include diversity of land uses, contribution to health and active life styles in cities, opportunities to interact and expand social network and a playground for children leading to their the social, mental and physical development. From the planning aspects, urban green spaces include business, retail, leisure development, tourism development and the good planning of urban green spaces can play a role as a visual delight, a medium of noise protection and a place for commuting via well-designed networks within the park and with the other areas (greenways). Most importantly the ecological perspective, urban green spaces work as a facilitator to reduce the impact of human activities by absorbing pollutants and releasing oxygen into the atmosphere, contributing to the maintenance of a healthy urban environment with clean air, water and soil and preserving the local natural and cultural heritage with a diversity of urban wildlife and urban green resources.

C. Green space system reduce carbon footprint for sustainable development

The urban planning of slow traffic systems can be integrated with green space system planning. This can be done by constructing fitness facilities and walking, running, and cycling lanes incorporated within a greenway. This thus provides a green traffic way as well as an outdoor leisure facility for citizens. Urban greening can reduce air pollutants directly when dust and smoke particles are trapped by vegetation. Research has shown that in average, 85% of air pollution in a park can be filtered.

D. Impact on Human Health

People who are exposed to natural environment, their level of stress is much lower as compared to people who were exposed to urban environment. A research conducted in Swedish cities showed that the more time people spend outdoors in urban green spaces, the less they are affected by stress. In the same research, patients in a hospital whose rooms were facing a park had a 10% faster recovery and needed 50% milder pain relieving medication as compared to patients whose rooms were facing a building wall.

This is a clear indication that urban green spaces can increase the physical and psychological wellbeing of urban citizens. Certainly, improvements in air quality due to vegetation have a positive impact on physical health with obvious benefits such as decrease in respiratory illnesses. The connection between people and nature is important for everyday enjoyment, work productivity and general mental health.

Conclusion:

The two biggest contradictions in urbanization were contradictions between development and environmental protection and contradictions between population growth and land resource constraints. The green space system not only has functions of protection, productive, and recreational, but also has economic potential. It provides an effective way to solve many urban problems, such as environmental degradation, shortage of land resources, water resources pollution, etc. Green space system planning will effectively construct urban green ecological network, improve urban environment, and motivate urban sustainable development.

Green space system has ecological functions, which make it an important part of urban ecosystem.

Many biologists have recognized that green corridors play an important role in the protection of urban biodiversity. In addition, urban green corridor also have other functions, such as alleviate the urban heat island effect, the change of wind speed and direction, prevent sand, water conservation and increased rainfall, etc. Conducting a suitability study of green space system planning with Spatial Information and Geographic Information System (GIS), in order to provide a data base and analysis tools for green space system planning; combining ecological technology, storm water and flood management system and domestic wastewater treatment technology.

People use green space system as an ecological treatment facility of managing the urban storm water, flood and urban domestic

wastewater to achieve economic environmental benefits; combining urban slow walking system, take green space system as urban low carbon facility as well as leisure and entertainment park facility, such as supplying pedestrian ways, bicycle lanes to realize green walking for residents, reducing the usage of automobiles, energies, lowering the carbon- emission and supplying an environment for outdoor sports and entertainment activities for residents.

Most importantly, green space system planning and construction is an important way to achieve sustainable development. Geographic Information System (GIS) can provide useful suitability analysis. Planning and thoughtful design can guide the urban special layout and development, and modern geo-informatics technology can help to construct cities that achieve complete environment sustainability in India. In the pursuit to establish environmental sustainability and sustainable management of urban green spaces, the local authorities should maintain a database of actual and potential green spaces graded according to landscape and ecological values. This would help in developing a management plan. A conservation plan should be prepared to protect the urban green spaces enclaves from intrusion by other land uses and to ensure that the natural ingredients of flora, fauna, landforms, soil and water continue to flourish. Urban green spaces management plans should be in place early before the inception of the design process.

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