3D CITY MODEL ENABLED E-GOVERNANCE FOR SUSTAINABLE URBANIZATION

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Abstract

India is poised to have nearly fifty per cent of its population in urban areas in next decade. Large scale urbanization brings the need to plan and develop urban areas in a systematic manner, invest in infrastructure and improve the quality of life in our cities. For the sustainable development of India and in order to successfully address the related challenges, it is crucial to modernize the governance system (Integrated thinking, planning and decision-making processes).

In this paper to enable e-governance for sustainable urbanization we introduce GIS mapping and analysis followed by 3D City Modelling. 3D city model basically a computerized or digital three-dimensional representation (3D) of our urban environment (City) that provides complete visual representation of a city and integrates all information regarding spatial objects over, on or under the surface of the earth.

The objective of this paper is first to understand the extent, trend and pattern of urbanization by using GIS mapping and analysis function on well-known GIS platform: ArcGIS, and then integrate this analyzed geospatial information with a comprehensive 3D city model that will be certainly on the basis of digital elevation models, orthophotos, survey maps, architecture models which are increasingly available in an up-to-date, area-wide and high quality manner for the whole urban area. The integration of these different data sources and the city model can be used for a wide range of applications and therefore be helpful for making urban planning and administration processes more up to date and transparent.

Key Words: 3D City Model, E-Governance, Sustainability, Urbanization, GIS.

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1. Introduction

1.1 3D City Modeling

3D city models are becoming more and more popular in commerce and public administration. The efficient creation of 3D models, ranging from single landmarks up to whole cities, has received increasing interest from last few years. 3D Modeling is the technical art that lets an artist to develop a virtual representation of any three-dimensional object and involves combining and shaping such simple objects into more complex ones that ultimately used to represent them digitally. 3D City Model is a computerized or digital three-dimensional representation (3D) of our urban environment (City). 3D City Model provides 3-Dimensional visual representation of a city that integrate all information regarding spatial objects over, on or under the surface of the earth.

3D city models can help planners, urban developers, government officials and other participants to understand the realistic and vivid view of the existing buildings, trees, roads, terrain, infrastructures and neighbouring environment (Zlatanova et al., 2000). Analysis of traffic flow, pedestrian patterns, zoning, land-use and special restrictions can enable the planners to make more useful, sustainable and far-sighted plans for the future development of the cities. 3D city models are also very useful in urban design, site location analysis, emergency facilities planning, new town planning, urban growth management, and regulation of urban sprawl.

Figure1. 3D city Models

Modeling Methods: Several methods are currently used to create 3D city models (Wolf, 1999). The simplest is to extrude building footprints from 2D maps to a given height based on building attributes. A 3D terrain model is usually added to provide the landscape context for the buildings. Most GIS systems support this method but the 3D city model that is generated does not contain detailed information, such as facade geometry or textures, and the height of the buildings may not be very accurate. To overcome the problem of inaccurate building height data, photogrammetry or laser scanning methods have been developed to capture 3D city models from aerial images or airborne laserscan images (LiDAR).

Photogrammetric method: Photogrammetry is the art, science and technology of obtaining reliable information about physical objects and the environment through processes of recording, measuring and interpreting photographic images and patterns of recorded radiant electromagnetic energy and other phenomena (Wolf and Dewitt, 2000).The Photogrammetric method is proven and provides exact and definite interpretation results (Gruen et al., 1999).

Laser scanning method from airplanes or mobile vehicle: LiDAR is one of the most important breakthroughs in Optical Remote Sensing technologies. LiDAR is an acronym for "Light Detection and Ranging." It is the active Remote Sensing technology that can find the range and other information about a particular distant object by the means of measuring the properties of scattered lights. LiDAR Survey facilitates the acquisition of data of thousand points within a fraction of a second

accurately. The laser scanner method provides a large quantity of unstructured elements it cannot be used optimally for achieving the interpretation processing (Ackermann et al., 1999).

1.2 Urbanization

The world is undergoing the largest wave of urban growth in history. More than one half of the world population lives now in urban areas (UNFPA. 2007), and virtually all countries of the world are becoming increasingly urbanized. In 2008, for the first time in history, more than half of the world's population will be living in towns and cities. By 2030 this number will swell to almost 5 billion, with urban growth concentrated in Africa and Asia. Urbanization refers to a process in which an increasing proportion of an entire population lives in cities and the suburbs of cities. Urbanization is an index of transformation from traditional rural economies to modern industrial one. It is a progressive concentration of population in urban unit.

Urban expansion in India will happen at a speed quite unlike anything the country or the world has seen before. By 2030, 40.76 per cent of India's population will be living in urban areas compared to about 28.4 per cent now. High rate of urban population growth is a cause of concern among India's urban and town planners for efficient urban planning. Therefore, there is an urgent need to adopt modern technology like 3D city Modeling that will be certainly on the basis of geospatial database, DEMs (digital elevation models), orthophotos, survey maps, architecture models which are increasingly available in an up-to-date, area-wide and high quality manner for the whole urban area and allow us to collect lot of physical data rather easily, with speed and on repetitive basis, and together with GIS helps us to analyze the data spatially, offering possibilities of generating various options (modeling), thereby optimizing the whole planning process.

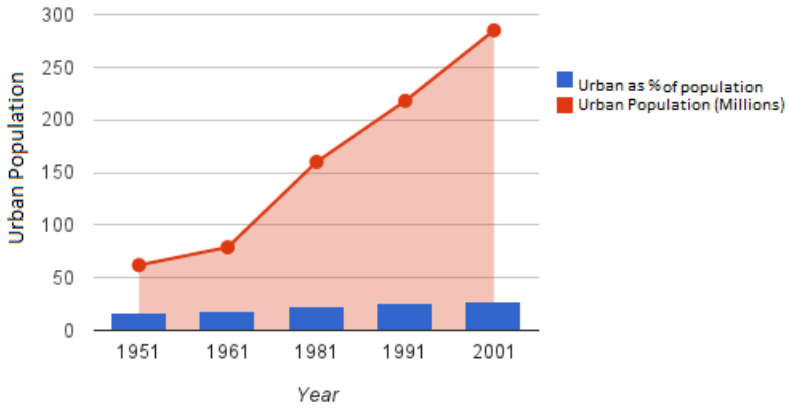

Figure2. Statistical outline of INDIA, 1951-2001
Source: National Commission on Urbanization (NCU).

1.3 E-governance

E-governance is the application of information & communication technologies to transform the efficiency, effectiveness, transparency and accountability of informational & transactional exchanges with in government, between govt. & govt. agencies of National, State, Municipal & Local levels, citizen & businesses, and to empower citizens through access & use of information (UN, 2008). E-governance presents challenges and opportunities to transform both the mechanics of government, and the nature of governance itself.

Today, India is emerging as an economic tiger, inspite of the global meltdown, but this growth is meaningless till the time it is inclusive, sustainable and encompasses the poorest of the poor. The success of eGovernance initiatives is determined by

efficient delivery of citizen centric services and better access to knowledge and information. 3D city models increase our ability to analyze and assess spatial phenomena and process, and would support modern, e-governance processes. Integration and use of 3D city model based applications into urban management practice can support governments to achieve good urban governance, i.e. sustainability, subsidiary, equity, efficiency, transparency and accountability, civic engagement and citizenship, and security.

2. Sustainable Urbanization

"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

There are many definitions of sustainable development, including this landmark one from Brundtland Commission: World Commission on Environment and Development's (Oxford: Oxford University Press, 1987): The concept of sustainable development is rooted in this sort of systems thinking, a system that connects space; and a system that connects time. Sustainability adds new dimensions to urbanization. Sustainable urbanization is the maximization of economic efficiency in the use of resources including air, water and soil, maintaining natural resource stocks at or above their present level, ensuring social equity in the distribution of development benefits and costs, and avoidance of unnecessary foreclosure of future development options.

3D city models are one of the new tools for sustainable city development. The major challenge is the vast amount of Space data (data for underlying area) to be collected, processed and visualised. However, keeping the resulting model up-to-date is another challenge. Updating requires the introduction of a suitable concept of Time in the model. This Space and Time Data together allow representation of historic and current status of the city as well as future scenarios. Processes provide the connection between different points in time. Processes also change the appearance of the city and need to be represented in the model for change detection.

3. Three Pillar Basic Model

This is one of the most well-known models created using the three dimensions -Economy, Environment and Society. (Doran et al, 2012). (Figure 3): The diagram shows three interlocking circles with the triangle of environmental (conservation), economic (growth), and social (equity) dimensions. Sustainable Development is modeled on these three pillars. This model is called 'three pillars' or 'three circles model'.

1. Economic component includes public administration and economic actors. It covers governance models, urban regeneration, open data, big data, bandwidth, mobility, cloud computing, security, business intelligence, etc.
2. Environmental component includes resources and managerial infrastructures. It covers water, air, energy and waste management, public and alternative transportation, geographical information, green buildings, green spaces, smart growth, climate change measurement, etc.
4. Social component includes citizens. It covers community life, urban mediation, participatory democracy, social innovation, human-scale cities, civic participation, proximity services, etc.
5. The three components of the proposed Model are needed in order to create an innovative, prosperous, civic and sustainable Smart City.

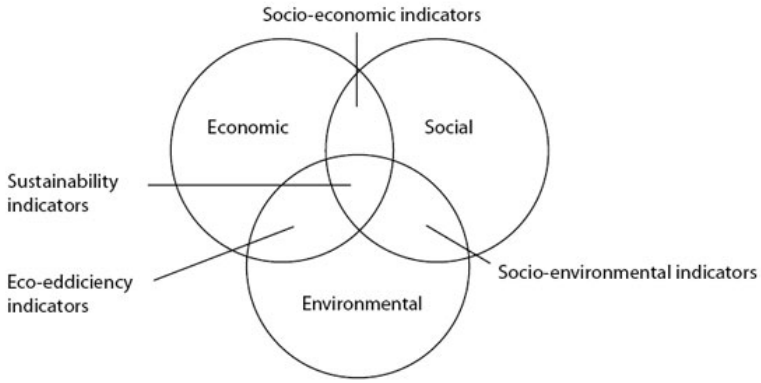

Figure3. Three Pillar Basic Model

4. Methodology based on ArcGIS and 3D City Modeling

Stable and real time data acquisition tools like Satellite, Helicopter, Surveillance Cameras, UAV, LIDAR and different on site sensors are used to collect satellite images, Arial photographs, point cloud, site plan, base map or site survey data. To generate the three dimensional or spatiotemporal models from the collected data, data is to be pre-processed and information in the 3 classes (Elevation, Image and feature) is rearranged. These collected Digital Imagery and dimensional information is put in the well organized database management system where unimportant and redundant information is omitted. Now this information is evaluated to get Facade/ Texture dataset, and Basic geometric model. Level of detail is set according to the required depth and by using 3D Modeling library with obtained facade/texture on basic geometric model a detailed 3D model for the underlying area is rendered by 3D Modeling Engine.

An indicator helps to understand where we are, which way we are going and how far we are from our goal. In order to measure the comparative level of sustainability accurately, sustainability indicators ought to be carefully selected. On the theoretical front, indicators should relate to sustainability and represent all necessary sustainability domains (i.e., economic, environmental, social, and also governance). For the present study, the sustainability issues concerning urban systems have been divided into broad groups of indicators, viz., economic, social, environmental and governance systems.

- Economic Sustainability—Capture the current as well as the dynamic economic strength of an urban system which occurs when development, which moves towards social and environmental sustainability, is financially feasible.
- Social Sustainability—Social sustainability refers to the sustenance of basic human needs such as nutrition and shelter; human freedoms, including political rights, economic facilities, social opportunities, and protective security; and human development, which expands social, economic, cultural, and political choices and leads to equity sustainability, productivity, and empowerment (Magis, et al., 2007).
- Environmental Sustainability—Assess the conformation of economic development to environmental standards.
- Governance Sustainability—Measure the extent and effectiveness of government in creating opportunities like employment, financial resources, community services and support, etc.

3D Modeling Engine: Core working unit that execute the collected information, generate a basic geometric model, fetch the facade/texture information to generate view dependent 3D model of the underlying area and further use the layered (spatial and non spatial) contents to analyze it as per the demand of sustainability assessment managers is known as 3D Modeling Engine. This Engine has a definite class of functions among them some can be summarized as:

- Geological analysis and Geological Space division
- View control
- 3D scene management
- Impact assessment and analysis
- View dependent 3D modeling
- Dynamic shading
- Symbol Management
- Environmental Effects

Geographic Information System (GIS) is an integral part of 3D Engine that involve spatial, temporal and attributes information to act as a decision support tool. It keeps information in different layers and generates various combinations pertaining to the requirement of the decision making. In the recent times, arcGIS has emerged as an effective tool for e-governance since, geo-spatial data and socio-economic information need to be amalgamated for the better decision making in handling a irregular urbanization or to plan for managing urban development in a better way. arcGIS combines layers of information on various themes to enable the managers to take the most appropriate decisions under the given circumstances.

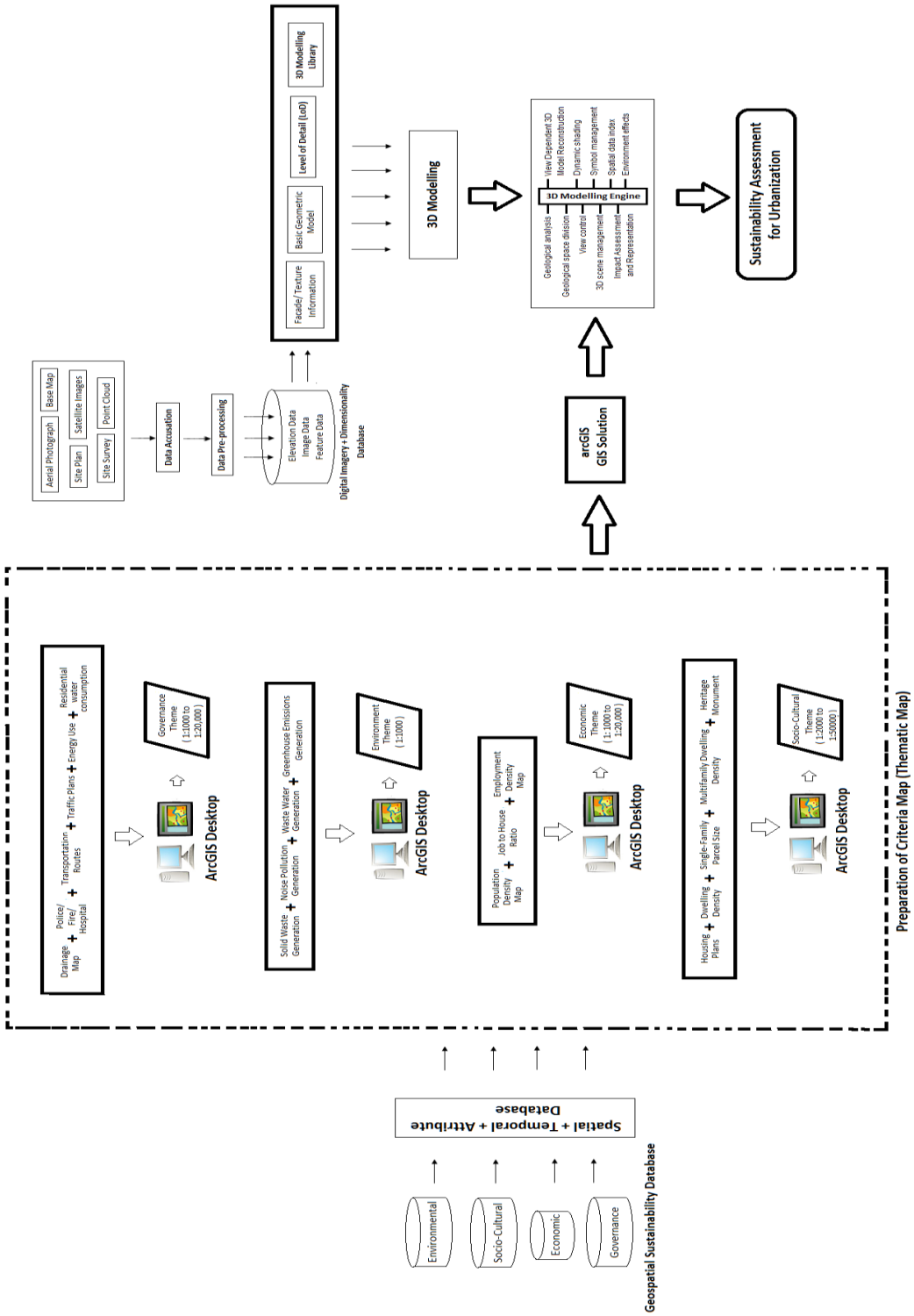

Figure4. Methodology for Sustainability Assessment

Conclusion

In the perspective of a sustainable development, cities ought to be studied in a comprehensive manner taking into account many interrelations between various urban issues. This can be achieved by identifying and extracting the knowledge underlying in related data and 3D City Models. The challenges for sustaining a city infrastructure are enormous. However, 3D City Modeling can help to address many of these. In this paper first a decision support framework is prepared with spatial, temporal and attribute information showing sustainability index of the city and than a 3D city Engine is proposed which is used to model and visualize the integrated dimensions to facilitate the achievement of sustainability, in particular urban context.

The implementation of e-collaboration and e-participation platforms based on virtual 3D city models could support efficient workflows, data exchange, and data reuse between governments and citizens as well as between government and the private sector. And it could raise transparency and accountability in environmental planning and ultimately foster civic engagement. Moreover e-government services could be defined that would support the continuous update and enhancement of 3D city models.

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