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Application of GIS in Smart City

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Abstract

A smart city is a metropolis which integrates information and communication technology (ICT), to boost its operational effectiveness to disseminate information to the general public and enhance the standard of public services as well as the welfare of its residents. At the beginning of the twenty-first century, cities replaced rural areas as the primary place where people lived. With the fact paced growth of population, urbanization too is growing by leaps and bounds. The rapid urbanization led to emergence of the concept of "sustainable urban development". The challenges caused by fast urbanization and population increase in cities necessitated urgent need to modernize existing cities into Smart cities. GIS (Geographical Information System) along with technologies like computer science, information technology, remote sensing, advance multimedia, is playing a vital role in creation of sustainable urban cities. This study explores the role of GIS to enable various stakeholders to access the status of resources across the key areas of smart city initiatives and how it assists in urban planning in developing sustainable urban cities.

Keywords: Smart City, ICT, GIS.

Introduction

In present time one third of the World's population lives in urban areas. The last few decades show a trend of migration from rural to urban population and this will be continue in couple of decades. This type of migration creates the chaotic and congested conditions in urban areas. This type of chaotic and congested cities create new type of problems, like problem with waste management, lack of capitals, air pollution, human health worries, traffic jams, and due to overload weaken, scarce, and aging infrastructures are the basic technical, physical, and material problems. For healthy and safe livable conditions with this type of such fast urban population growth, there is a necessity to develop smart cities in a big manner worldwide. One way to intellectualize a smart city is as a sign of a justifiable and functional city. The Smart City concept is one and only feasible solution looks to the problems generated by this fast growth of urbanization like urban extension, problem with environment, transportation, lacking of energy resources and improvement of citizens' excellence of life. Although there are so many explanations of the Smart City concept given by different persons, but here focus on few of them that present an interesting convergence [1].

Smart City and Smart Community

Since 2008, metropolitan areas have been home to half of the world's population. This is an unstoppable trend that fundamentally alters how cities operate and how metropolitan governance should be set up in order to maintain wealth, allure, human welfare, and sustainable growth. The rapid rise of urbanization gives local governments a lot of authority because it affects the standard of living and services provided to inhabitants. Cities now play a significant role in innovation, development, and economic expansion. A city needs to be appealing to attract highly educated professionals and immigrants. They are the hubs of global trade, major economic centers, producers and suppliers of financial capital, and vital trade hubs for both goods and services. They host significant infrastructure resources and important institutions that support regional growth and the standard of living across the country. Chaos quickly sets in if the city is not properly set up and prepared to handle the strain of an expanding urban population. The community's well-being and prosperity may be adversely affected by a rapid decline in the quality of life, security, the efficiency of citizens' services, economic development, and attractiveness. The idea of a "smart city" appears to hold the answer to addressing issues like urban sprawl, sustainability, and the environment that come with a rapidly expanding urbanization, transportation, public participation, power constraints, enrichment of cultural heritage, quality of life of human being, etc. As smart city concept can be defined with many different definitions (Table 1) some of them are having interesting coverage.

Table 1: Some conceptual definitions of Smart city

Author & Year	Definition
Hall R. E. 2000 [3]	"A city that monitors and integrates conditions of all of its critical infrastructures, including roads, bridges, tunnels, rails, subways, airports, seaports, communications, water, power, even major buildings, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens".
Giffinger Retal. 2007 [2]	"A city well performing in a forward-looking way in economy, people, Governance, mobility, environment, and living, built on the smart combination of endowments and activities of self-decisive, independent and aware citizens".
Lombardi et al. 2009 [9]	"A smart city therefore has smart inhabitants in terms of their educational grade. In addition, the term is referred to the relation between the city Government administration and its citizens. Good governance or smart governance is often referred to as the use of new channels of communication for the citizens, e.g. e-governance or e-democracy".
Harrison C. et al. 2010 [4]	"A city "connecting the physical infrastructure, the IT infrastructure, the social infrastructure, and the business infrastructure to leverage the collective intelligence of the city".

Washburn D. et al. 2010 [5]	"The use of Smart Computing technologies to make the critical infrastructure components and services of a city - which include city administration, education, healthcare, public safety, real estate, transportation, and utilities - more intelligent, interconnected, and efficient".
Nijkamp P. et al. 2011 [10]	"The city is called smart when investments in human and social capital and traditional and modern communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance."
MIT [6]	"cities are systems of systems, and that there are emerging opportunities to introduce digital nervous systems, intelligent responsiveness, and optimization at every level of system integration – from that of individual devices and appliances to that of buildings, and ultimately to that of complete cities and urban regions."
The Forrester Research Institute[7]	"The use of smart computing technologies to make the critical infrastructure components and services of a city more intelligent, interconnected, and efficient."
IBM [8]	"A city is an interconnected system of systems. A dynamic work in progress, with progress as its watchword. A tripod {Infrastructure, operations, people} that relies on strong support for and among each of its pillars, to become a smarter city for all."

According to the IBM and MIT definitions, smart communities or cities are systems of systems connected by ICTs. If a city's administration uses technology to connect and integrate its many systems and eliminate "silos," it will be able to operate more efficiently thanks to the increase in connectedness. The use of technology alone cannot create a wiser city. The many systems that make up the city (such as the waste management system, resource management systems, and transportation systems) must be linked together, and interactions between them must be carefully planned and integrated. ICTs are obviously necessary to transmit a lot of data quickly, but it's also important to utilize all that data effectively to increase productivity. In order to achieve significant improvements in efficiency and in quality of life, as well as to change behavior among citizens, businesses, and the government so that cities can grow in a more sustainable way, we assist the deployment and integration of ICTs, including wireless and broadband connections, advanced analytics software, and intelligent sensors. Being or becoming a smart city is a matter of prosperity, sustainability, and wellbeing for the political and judicial systems, business partners, and residents of the area.

Requirement of Smart City

Urbanization is an indicator of growing economies. Urbanization is inevitable as nations transition from an agricultural to an industrial economy. This is due to the opportunity that urban regions provide for the manufacturing and industrial sectors. If the current urbanization trend

continues, 90% of the world's urban population growth will be in developing nations, with India contributing a sizable portion of that. The GDP is also increased more in urban regions. In India, the urban population makes up around 31% of the total population but 60% of the country's GDP, and in the next 15 years, it will account for 75% of the GDP. India needs to accelerate urbanization at this point, which is the major driver behind successful urban planning. The Indian government took significant action in that area and aimed to build 500 AMRUT cities nationwide in addition to 100 smart cities. "The rate of migration from rural to urban areas is increasing as the benefits of development reach an increasing number of individuals. A new middle class is emerging that wants to improve living conditions. Existing cities would soon become uninhabitable unless new cities are built to accommodate the rapidly growing population. The main problems for which we need to make a city smart are Resource Planning, Growth in population, Globalization, Technical Progress, Changes in geopolitics, Movement of people, Social unrest and inequality among various age groups, Global warming, Energy, food, and water insecurity.

Application of GIS in Planning of Smart City

Smart cities offer a significant chance for growth in the years to come, but they also bring a number of obstacles. Smart city projects are quite complicated since they include both residential and commercial areas that are backed by a strong infrastructure for power, roads, water, drainage, and sewage, creating an almost alive and breathing city. The requirement for a single technological platform to enable integration, coordination, and synergistic functioning of many players in the smart city ecosystem is a crucial success factor. A centralized information system built on a GIS platform offers an IT architecture that combines every stakeholder as well as every process involved in creating a smart city, from inception through planning, development, and maintenance.

GIS technology permits a city to outlook, enquiry and recognize data in many ways. It is very easy to see connections, arrangements and developments in the form of GIS-based maps, information and graphs. GIS assistances to answer questions and solve problems. When noticed in the perspective of geography, a city’s data is rapidly understood and without difficulty shared. GIS technology can be incorporated into any enterprise information system structure of a city. GIS has the distinctive ability to:

a) Incorporate data from numerous sources
b) Present them visually expending geography as a collective element of these a number of data sources,
c) Help understand configurations and connections between these data elements.

Informed decision building enabled by this would be very cooperative while transforming existing cities to smart cities. GIS is also being gradually more used in the construction of Smart, Green Buildings as GIS without difficulty interfaces with BIM(Building Information Modeling)

solutions. Modern developments in 3D GIS and Indoor GIS agree to creation of intellectual and cooperating digital city models that makes it stress-free for the city planners to create "what-if" circumstances. This helps them in accepting short and long term impact of numerous planning conclusions.

GIS Platform for smart City development

A centralized information system based on GIS provides an IT framework for maintaining and deploying data and applications throughout every aspect of the city development life cycle. According to ESRI GIS development life cycle[12] (Fig 1) for smart city contains five stages which are as follows

Acquire: Site selection is done during this step taking into Locate the ideal locations for city expansion, observe legal boundaries, and determine the proper valuation for your present and future properties.

Arrangement & Design: Find problems, then decide on the best fixes. Increase your infrastructure design process's analytics and cost-estimating capabilities by integrating GIS with the majority of design tools, such as Computer Aided Design (CAD) and Building Information Modeling (BIM).

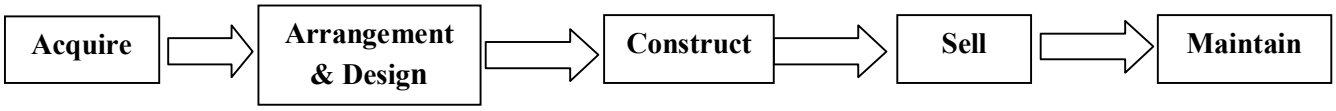

Figure 1: GIS Smart City Development Life Cycle (ESRI)

Construct: Integrate project and financial management software with GIS to better manage projects. GIS can provide a single point of entry for all construction-related documents and files.

Sell: Understand where and how to market city developments, attract buyers and tenants, and improve retention rates. Analyze demographics and market conditions to provide a more accurate picture of a property's suitability to needs.

Maintain: Easily manage disparate assets. Integrate your asset inventory with inspection history and work order management to maintain your critical investments in a cost-effective manner.

While GIS can be used in various areas of a City, some areas where the profits of unique competencies of GIS can be rapidly leveraged are as following table 2:

Table 2.Smart City applications (Src:- GIS for Smart Cities, Esri India 2015 online esri.com/cityengine)

Area	Application
Site Selection & Land Acquisition	GIS can combine and integrate different types of information to help making better decisions and also provides high quality visualization tools that can improve the understanding and enhance decision making capability w.r.t to site identification, valuation and finally selection. By analyzing location data – proximity to road network, fertility of soil, land use, soil bearing capacity, ground water depth, and vulnerability to disasters such as floods, earthquakes - the real estate organizations can arrive at the right property valuation. By analyzing, mapping, and modeling the merits of one site or location over another can be evaluated. In addition, this can also be used for arriving at appropriate market linked compensation to owners based on valuation parameters and in rehabilitation and resettlement planning.
Environmental & Legal Compliance	GIS makes meeting regulatory requirements less time consuming and easier to accomplish by providing a common platform for communication with regulators and public. The existing data can be directly connected to a compliance workflow ensuring adherence. Also, GIS-based graphical outputs can help in quickly generate reports that clearly demonstrate how compliance requirements and building bye-laws are being met.
Planning, Design & Visualization:	Geodesign will be the key framework for conceptualizing and planning for smart cities; it will assist at every stage from project conceptualising to site-analysis, design specifications, stakeholder participation and collaboration, design creation, simulation and evaluation. GIS enables planners to integrate a variety of data from multiple sources like road, sewerage and drinking water and to perform spatial analyses and planning. Utilities can manage and map the location of millions of miles of overhead and underground circuits.
Construction & Project Management	GIS, integrated with project management and financial software provides a comprehensive view of projects and their current status and helps in tracking performance. GIS helps organize all relevant project information, from soil data, and geotechnical studies to planning, environmental studies, engineering drawings, project maps, inventory and asset control.
Sales & Marketing	With GIS, city developers can win over prospective businesses by creating informative sales tools and marketing reports that highlight the economic potential of a new location or future development. For residents, GIS helps in presenting a visual representation of all the information affecting the desirability and value of a property giving them a far more accurate picture of a property's suitability to their needs.
Facility	A GIS-based information system provides a powerful foundation for better

Management (FM)	facility management by generating integrated information that helps make better allocation decisions. GIS can integrate with and extend the current facilities management system. By importing and aggregating into a GIS the geometries and tabular data of the multiple BIM and/or CAD files required to accurately represent the built environment, the efficiencies and power of BIM can be leveraged, extended, and connected in geographic space to other relevant site, neighborhood, municipal, and regional data.
Operations & Reporting:	GIS can track and analyze assets over space and time and provide insight through visualization of information via maps and easy-to-understand reports. It supports creating an operations view that include maps, lists, charts, gauges, and more based on live geographic data defined in a web map or web service. Multiple operation views can be defined to meet the needs of stakeholders focusing on different aspects of the operation. With this ability to integrate disparate information sources into a common operational picture of all facilities, GIS provides greater power to control township operations and positively impact bottom line.

GIS is becoming a crucial factor in the development of new, intelligent applications as a result of the advancements and innovation in geospatial technologies. For the some of the applications As per ESRI India following are the data or Information can be sought with the help of GIS.

Table 3.Smart City applications (Src:- GIS for Smart Cities, Esri India online esri.com/cityengine)

S. No.	Activity	GIS Data to be mined for SMART City planning
1.	Land Use Planning	Parcel catalogue of zoning areas, floodplains, industrialized parks, land uses, plants, green spaces etc.
		Investigation of percentage of land used in each classification, concentration levels by vicinities, threats to suburban conveniences, propinquity to undesirable land uses.
		Modeling of predictable residential, commercial and industrial population progression for land use plan, estimation of land use plan grounded on demographic appearances of neighboring population
2.	Services and Infrastructure	Catalogue of roads, footpaths, bridges and utility linkages with all utility properties
		Characteristic information excluding name, location, condition, most current maintenance
		Exploration of infrastructure conditions by demographic variables such as earnings, population change
		Use of analysis to plan and program proactive preservation and enlargement based on probable future load

3.	Transportation & Solid Waste Management	Identification of bus, MRT and LRT paths, road capability and circumstance, signaling structure tools etc.
		Identification of accident locations
		Identification of sanitation truck courses, measurements, and employment by area
		Identification of landfill and reprocessing sites
		Analysis of prospective capacity strain allowing for development in assured areas
		Analysis of accident patterns by category of site
		Analysis of sanitation truck routing in relation to area pickup needs, routing proficiency, and terminus sites
		Use of analysis to recognize ideal high-density development areas based on standards such as customary transportation capacity
		Use of analysis to identify probable alternative traffic flow tools
		Use of analysis to resolve where recycling curriculums or sites should be positioned
4.	Health	Identify locations of persons with individual health complications (e.g. asthma)
		Spatial, time-series investigation of the spread of disease
		Analysis of connotation of disease with environmental circumstances (e.g. proximity to heavy traffic roads creating pollution)
		Use of analysis to identify possible causes of disease
5.	Law	Catalogue of location of police stations, crimes, arrests, sentenced

Conclusion

Smart cities are technologically advanced urban spaces that use ICT tools and sensors to collect and process specific data. Information derived from this data is used to effectively manage assets, resources and services and to bring efficiency in city-wide operations. Key infrastructure elements of a smart city include adequate water supply, safe power supply, sanitation including waste management, efficient urban mobility and public transport, robust IT connectivity, digitization, affordable housing and good governance for the masses. GIS has evolved as a powerful tool to assist urban and regional planners and policy makers to enhance collaboration in decision making regarding various key infrastructure elements to create innovative, prosperous, civic and sustainable Smart Cities. The convergence of GIS with several other technologies resulted in enhanced levels of accessibility and functionality that helps in better city planning and management. The paper helps to understand the utility of GIS. A smart city's whole life cycle, from site selection, design, and building to use and maintenance, can be supported by GIS. GIS is a perfect technology since it can scale across any area, from a single asset inside a building to a nearly global context linking all parts of the planning and development of a Smart City.

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