Applications of Geographic Information System (GIS)

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Abstract- *The development of GIS over time is proportional to the wide general development of the computer science. The development of Geographic Information Systems has advanced the geographical information systems as we know them today. Geographic Information Systems (GIS) are a set that consists of equipment, software, databases which contain a satisfactory collection, storage, information, management, analysis and presentation of all types of geographic information. The paper summarizes and describes the applications of GIS in urban planning, transportation, health care, safe site selection, project management and tourism. The purpose of this paper is to provide an introduction to geographic information systems (GIS) and a research framework for future information systems researchers.*

Keywords- GIS, Site selection, Urban planning, Transportation, Health care.

I. INTRODUCTION

A Geographic Information System (GIS) is a system of computer software, hardware and data, personnel that make it possible to enter, manipulate, analyze, and present data, and the information that is tied to a location on the earth's surface. This system comprises of Software, Hardware, Data, and Personnel that make it possible to enter, manipulate, analyze and present information that is tied to a location on the earth's surface (Bansal, 2012). GIS is a system that combines technology, software, and data to capture, manage, analyze and display all types of geographically linked data . GIS has the capability to manage large volumes of spatial data from a variety of sources. It efficiently stores, retrieves, analyzes and displays information according to user defined specification (Siddique *et al.* 1996). Within the realm of geographic information technologies, there are three major components: Geographic Information Systems (GIS), Global Positioning Systems (GPS), and Remote Sensing (RS).

1.2 Components of GIS

A working GIS integrates these five key components: hardware, software, data, people, and methods.

Hardware

Hardware is the computer on which a GIS operates. Today, GIS runs on a wide range of hardware types, from centralized computer servers to desktop computers used in standalone or networked configurations.

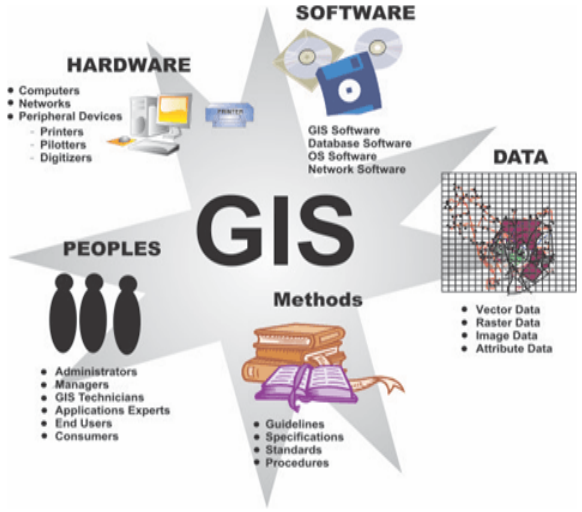

Figure 1.1: Components of GIS
Source: Adapted from Ali, 2020

Software

GIS software provides the functions and tools needed to store, analyze, and display geographic information. Key software components are: A database management system (DBMS), tools for the input and manipulation of geographic information, tools that support geographic query, analysis, and visualization, a graphical user interface (GUI) for easy access to tools.

People

GIS technology is of limited value without the people who manage the system and to develop plans for applying it. GIS users range from technical specialists who design and maintain the system, to those who use it to help them do their everyday work.

Methods

A successful GIS operates according to a well-designed plan and business rules, which are the models and operating practices unique to each organization.

Data

Maybe the most important component of a GIS is the data. Geographic data and related tabular data can be collected in-house or bought from a commercial data provider. Most GIS employ a DBMS to create and maintain a database to help organize and manage data. The data that a GIS operates on consists of any data bearing a definable relationship to space, including any data about things and events that occur in nature. At one time this consisted of hard-copy data, like traditional cartographic maps, surveyor's logs, demographic statistics, geographic reports, and descriptions from the field. Advances in spatial data collection, classification, and accuracy have allowed more and more standard digital base-maps to become available at different scales.

1.3 GIS in Urban Planning

One of the reasons why GIS is important in urban planning is the ability to better understand current needs for a city, and then design to fulfill those needs. By processing geospatial data from satellite imaging, aerial photography and remote sensors, users gain a detailed perspective on land and infrastructure. As urban populations grow and spread the importance of GIS lies in its ability to pull together the vast amounts of information necessary to balance competing priorities and solve complicated problems, such as optimizing new building placement or determining the feasibility of a waste disposal site. GIS technology empowers urban planners with enhanced visibility into data. They monitor fluctuations over time, evaluate the feasibility of proposed projects and predict their effects on the environment. GIS software can also show all relevant stakeholders exactly what the changes on the ground will look like to help them make better decisions. For example, GIS software may generate visualizations of an area's current environmental conditions and allow users to draw comparisons between the anticipated results of proposed development plans (ESRI, 2011).

Urban planners in both the public and private sector employ data-driven methods to address a wide array of issues that have long-term implications for communities and the surrounding landscape. Some of the common applications for GIS include: Review and analysis of plans for development, checks on regulatory compliance, review of environmental impact. Preservation of historic sites, regional planning beyond the borders of a city or town, mapping the delivery of utilities and planning for service interruptions. By performing land use analyses, planners can guide new developments to areas that are less prone to damage from natural disasters (Chandra *et al*. 2008).

1.4 GIS in Safe site selection of building in Hilly region

Safe site selection (SSS) largely depends upon compiling, analyzing, and refining the information of an area where a building is likely to be located. The locational and topographical aspects of an area located in hilly regions play a major role in safe site selection, but are generally neglected in traditional and CAD-based systems used for site selection. Architects and engineers select a site based on their judgment, knowledge, and experience, but issues related to site safety are generally ignored. Site selection, as one of the key principles of building planning, plays an important role and has a huge impact on the design of a proposed building (Cheng *et al*., 2007).

Safe site selection in hilly regions needs to consider aspects such as landslides, slope stability, topography, and drainage in addition to ensuring minimum adverse impact on the fragile environment. These considerations also have a strong impact during the construction stage (NBC, 2005). Furthermore, architects and engineers need spatial information about the neighborhood of a building to know its dependence on existing facilities/utilities. Such dependence cannot be easily modeled in the absence of GIS. The use of GIS allows for viewing and analyzing the effects of locating a proposed facility in the neighborhood of existing facilities/utilities (Tardie *et al.,* 2003). Karan and Ardeshir (2008) suggested that GIS is an effective tool for safety assessment and for quantifying various hazards linked with construction sites.

1.5 GIS in Transportation

Geographical Information System (GIS) are becoming more widely used in transportation planning agencies, especially among metropolitan transportation organizations. Many more authorities are now able to use GIS for Highways and transport management, due to falling costs and GIS increasing overfriendliness. GIS offer transport planners a medium for storing and analyzing data on population densities, land uses, travel behavior, bridge inventories, pavement condition surveys, geometry design inventories, and other data collection and maintenance activities etc. The use of GIS in transportation is widespread. The major areas of applications include highway maintenance, traffic modeling, accident analysis, and route planning (Meyer, 2016).

Highway maintenance management is a critical issue, which can be better harnessed using GIS. Authorities in many developed countries now actively use GIS for highways and transport management, mainly due to the benefits of falling costs and increasing ease.GIS technology allows transportation maintenance and inspection crews to save time when collecting and updating information from remote locations. By using GPS and GIS-enabled devices, field crews accurately collect information from the field and seamlessly update corporate databases located in the office in real time. Through GIS technology, officials can track resources and assets in real time, allowing a quick response to any event that requires immediate attention (Olba, 2006)

Traffic accidents are one of the more important national and international issues, and their consequences are important for the political, economic and social level in a country. GIS delivers powerful spatial analytics, allowing the authorities to discover patterns and gain intelligence to better understand travel behaviors and perform accident analysis. GIS significantly helps in accident analysis and leads to a reduction in the number of accidents on roads as well (Xie, *et al,*. 2008).

GIS data can also be transformed into functional road models for large-scale traffic simulation. GIS data can model road networks around the world as polylines with attributes. Roadmaps from the GIS database can be extrapolated to automatically create geometrically correct and topologically consistent 3D models of large-scale road networks to be readily used in a real-time traffic simulation, interactive visualization of the virtual world, and autonomous vehicle navigation. The resulting model representation could also provide important road features for traffic simulations, including smoothly connected ramps, highways, overpasses, legal merge zones, and intersections (Meyer, 2016).

Route planning is an important application within transportation. Hurdles on routes can lead to unnecessary delays and losses. It is in favor of all businesses and people to know in advance which route is the best to follow. This knowledge can help in saving time and essentially gaining the best cost/benefit ratio. GIS-based systems quickly provide and analyze essential economic, demographic and cost estimates for planning new routes. It helps in analyzing existing routes, collecting data and informing the riders of change to routes (Farooq, 2018).

1.6 GIS in Project Management

GIS can be used for Progress monitoring system in construction, 3-D data analysis, comparison of data, construction scheduling and progress control with 3-D visualization. A GIS does in fact create high quality maps that communicate considerable amounts of information in an efficient and attention-getting manner. 3-D visualization allows the construction manager to view the construction activities during any stage of the construction process. GIS can be integrated with project Management for construction progress visualization and an integrated information system (Palve, 2013).

1.7 GIS in Health Care

The planning of domiciliary care provision is one of the most active applications of GIS. A Geographic Information System is able to organize all the routes that a health care professional has to follow and it can take into account other parameters, too. On the other side, private health services could arrange their extension plan and promote their services. They even make predictions about some services that are in great demand in specific locations. Generally, GIS application areas might be applied towards Strategic Planning, Research and Evaluation, emergency preparedness and both response and location of health care services, too (Smith et al., 2007). Geographic Information Systems provides a tremendous convenience for health care providers as regards the organization and the management of these services. Hence, the organization and coordination of various services would be easier and more efficient. The healthcare provider may direct quickly and efficiently the patient to suitable health care services (Najafabdi *et al*., 2009). Geographic Information Systems provide us with the exact location of specific medical equipment and how somebody may gain the fastest access to it. It is important an insurance institution, when it is requested by the insured, know the nearby location where the insured could gain access to a CT scanner (Smith *et al.,* 2007).

Water, heavy metals and other chemicals pollute the drinking water worldwide. Thus, serious health problems are caused due to the fact that the water can carry a number of microorganisms which put equally the public health at risk. Similarly, the applications of GIS, here, can depict the drinking water by region. Also, these applications could provide some additional information about the texture of the water (Briggs et al, 2000). The ground as well as soil contamination might also cause serious health problems within a population. It is very important the soil texture with all the additional chemical information be recorded. This is another field in which GIS have found application (Joseph et al., 2014).

Studies have shown that cardiovascular events, including heart and stroke deaths are associated with gaseous

pollutants and especially with air pollution. GIS can display gaseous pollutants and particulates and even their dispersion and transport (Foley, 2002).

Mental disorders appear to be spreading across all countries, societies and nations regardless of the population's socioeconomic level. It is estimated that 20-25% of the population will face a mental illness at some point in their lives (WHO, 2001) Mental disorders are one of the most common causes of disability among all diseases. Some of these mental illnesses are quite intertwined with environmental changes or disasters and changes in land-use such as urbanization (Albrecht *et al.,* 2007). It is manifested that the geographical representation of these data would be a valuable tool for healthcare professionals to both treat and prevent mental illness. The accessibility of mental health services as well as general health is one of the most common types of research that is based on GIS. Geographical factors such as the distance may have an influence over the use of mental health services and the long distance between healthcare systems and patients reduces the rate that patients used to visit to these departments (Lopez *et al*., 2012). GIS can analyze and portray accurately the distribution of mental health services and they could explain the reasons why the accessibility in healthcare services is affected. Except for the geographical distribution, other studies on mental health have also used GIS to correlate mental health and geographical variables such as the individual's residence (Zhang *et al.,* 2011). Mental health data regarding accessibility, mental illnesses, ethnicity and educational level of the population using these services can be joined together by GIS.

1.8 River Crossing Site Selection for Bridges:

The important geotechnical consideration is the stability of slope leading down to and up from the water crossing. It is advisable to collect historical data on erosion and sedimentation. On the basis of these information asses the amount of river channel contraction, degree of curvature of river bend, nature of bed and bank materials including the flood flow and the flow depth, all these can be done in GIS within estimated time and accurately (Lemmens, 2011). This information has been often used for river crossing site selection for bridges.

II. CONCLUSION

An application of GIS is not just limited to above fields but it has, applications in various other fields. GIS integrates all kinds of information and applications with a geographic component into one manageable system. Therefore, a benefit of GIS applications is their ability to integrate and analyze all spatial data to support a decision-making process. A GIS system has to be built up within an organization. The integration capability of GIS technology empowers organizations to make better and informed decision based on all relevant factors.

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