ISSN : 2454-9150 Special Issue - .inSIGHT'20

Geographic Information System in Civil Engineering

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Abstract - **GIS technology has been in use for over 25 years. It's a proven diary in assisting land managers to correlate and analyze large amounts of spatial and tabular data, leading to scientifically sound land management decisions. Like any tool, GIS isn't appropriate altogether situations. Offices where staff are supportive of GIS technology, in situations where the info are going to be used variety of times for analysis, on-going management activities, planning, or research are the foremost logical candidates for GIS implementation. Hydrological modeling are including river network, rainfall modeling, catchments delineation, rainfall to runoff modeling, and hydrographic and flood modeling for flood depth calculations. Geology and bore log digitization, lineament and geo-morphology mapping, hyper-spectral imagery analysis and enterprise geo-technical software application are developed for the mining, pipeline, and engineering industries. GIS application is developed for natural hazard loss estimation, analysis for disaster planning and disaster loss mitigation, emergency preparedness, and response and recovery. GIS is identified for waste disposal sites also as construction, operation, maintenance, and closure of the repositories. GIS data also are processed and analyses for environmental impact studies and assessment. International companies produced different systems within the field of GIS. The main component of those systems is that the processing software additionally to the specified hardware component of these systems is the processing software in addition to the required hardware.**

Keywords* — *GIS, Technology, Geographic Survey, Civil Engineering, Remote Sensing, Mapping, Disaster Management, Transportation, Geology, Planning, Data.

I. INTRODUCTION

Civil engineering is about developing and sustaining infrastructure. The profession covers many areas of interest and a broad range of experience. As a result, civil engineers work with a voluminous amount of knowledge from a spread of sources. Geographic information system (GIS) is a system which is designed for capturing, storing, manipulating, analyzing, management and presentation of all kinds of geographic data. GIS software is interoperable, supporting the various data formats utilized in the infrastructure life cycle and allowing civil engineers to supply data to varied agencies within the required format while maintaining the data's core integrity.

GIS allows users to look at, understand, question, interpret, and visualize data in some ways that reveal relationships, patterns, and trends within the sort of maps, globes, reports, and charts. Also GIS helps the user to answer questions and solve problems by watching data during a way that's quickly understood and simply shared. GIS technology are often integrated into any enterprise data system framework.

Some of the main objectives of GIS are to -

i. Maximizing the efficiency of designing and deciding.
ii. Integrating information from multiple sources.
iii. Facilitating complex querying and analysis.
iv. Eliminating redundant data and minimizing duplication

II. HISTORY OF GEOGRAPHIC INFORMATION SYSTEM

Map making (representation of geographical information) has evidences to point out independent evolution of maps in several parts of the world. The evidence of mapping comes from Middle East within the sort of Babylonian Clay Tablets as early as 1000 B.C which depicted earth as a flat circular disk.

Around 200 B.C, Eratosthenes calculated the circumference of earth accurately. Later came, Ptolemy and Al-Idrisi who made remarkable contributions within the field of cartography. Following them were Mercator and Newton, their work paved way for the upcoming cartographers and geographers to raised understand the world and therefore the geographical phenomenon.

 DOI : 10.35291/2454-9150.2020.0539

Putting layers of knowledge on series of base maps to research things geographically has been into existence for much longer than the introduction of computers to the geographical world.

The French cartographer Louis-Alexandre Berthier had drawn the maps of the Battle of Yorktown (1781) that contained hinged overlays to point out troop movements.

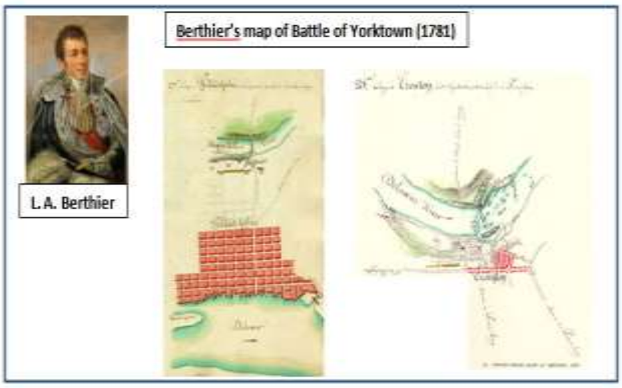

Fig.1 Berthiers Map of Battle of Yorktown

Superimposition of topography, geology, population and traffic flow on an equivalent base map has been shown within the Atlas to Accompany the Second report of Irish Railway Commissioners.

Dr. John Snow showed the locations of death by cholera on a map to trace the source of outbreak of cholera in Central London in September, 1854.

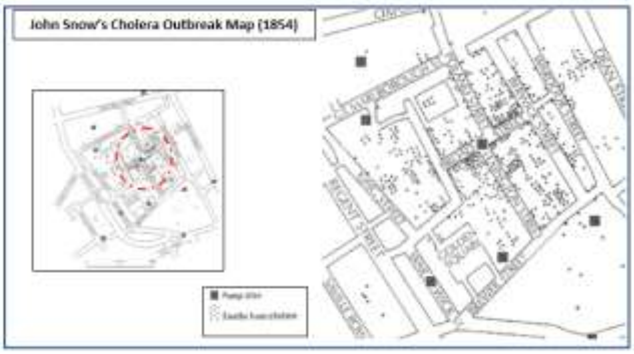

Fig.2 Jhon Snow's Cholera Outbreak Map of Battle of Yorktown

The introduction of computers within the field of geography was a positive step towards understanding and learning the topic better. Change in cartographic analysis thanks to improved graphics, development of theories of spatial processes in economic and social geography, anthropology and regional science, increased social awareness and improvement in education. The integrated transportation plans of Detroit, Chicago during the amount of 1950s and 1960s used information on routes, origin, destination, and time to supply the maps of traffic flow and volume is an example of integration of technology with geographical data.

III. Components of a GIS

Fig.3 Parts of GIS

Hardware: It consists of the equipments and support devices that are required to capture, store process and visualize the geographic information. These include computer with hard disc, digitizers, scanners, printers and plotters etc.

Software: Software is at the guts of a GIS system. The GIS software must have the essential capabilities of knowledge input, storage, transformation, analysis and providing desired outputs. The interfaces might be different for various softwares. The GIS softwares getting used today belong to either of the category –proprietary or open source. ArcGIS by ESRI is that the widely used proprietary GIS software. Others within the same category are MapInfo, Micro station, Geo media etc. the event of open source GIS has provided us with freely available desktop GIS like Quantum, uDIG, GRASS, Map Window GIS etc., GIS softwares.

Data: the info is captured or collected from various sources (such as maps, field observations, photography, satellite imagery etc) and is processed for analysis and presentation. Procedures: These include the methods or ways by which data has got to be input within the system, retrieved, processed, transformed and presented.

People: This component of GIS includes all those individuals (such as programmer, database manager, GIS researcher etc.) who are making the GIS work, and also the individuals who are at the user end using the GIS services, applications and tools.

IV. Early developments in GIS

A. Canada Geographic data system (CGIS)

The earliest GIS, found out in mid 1960s by Roger Tomlinson and colleagues for Canadian Land Inventory.

It was developed as a measuring tool (to measure area), a producer of tabular information instead of a mapping tool.

 DOI : 10.35291/2454-9150.2020.0539

ISSN : 2454-9150 Special Issue - .inSIGHT'20

B. Harvard Laboratory

The Harvard laboratory for special effects and Spatial Analysis was established in 1964 by Howard Fisher at Harvard University.

The GIS packages developed were SYMAP, CALFORM, SYMVU, GRID, POLYVRT, ODYSSEY.

C. Dual Independent Map Encoding (DIME)

Developed by US Bureau of Census in 1967 to conduct the 1970 census of population.

Digital records of all US streets were created to support automatic referencing and aggregation of census records.

D. Environmental Systems Research Institute (ESRI)

Jack Dangermond founded ESRI in 1969 to undertake GIS projects.

In 1981, ESRI launched ArcInfo (major commercial GIS software system) supported vector & electronic database data model.

E. Intergraph Corporation

Jim Meadlock and colleagues formed M&S computing in 1969 which was later renamed as Intergraph.

Global provider of engineering and geospatial software.

Longley et al (2001) have described the amount from1980 to 2000 because the era of commercialization within the field of GIS. The amount marks the establishment of economic GIS industries, research centers, GPS, Open GIS Consortium, Internet GIS products alongside publications on GIS and allied fields. The amount after 2000 is mentioned because the era of exploitation. In 2000, it had been estimated that GIS was getting used by a million core users and five million casual users.

V. METHODOLOGY OF GEOGRAPHICAL INFORMATION SYSTEM ANALYSIS PROCESS

There are five basic analysis process involved in employing a Geographic data system. These five steps are:

Frame The Question - this is often the primary step and it helps to work out what GIS tool is to be used. It's just an easy process. How you frame your question dictates the GIS tools and methods you'll use.

Explore & Prepare Data - this step should be the foremost tedious because during this phase you've got to organize all the info needed for the analysis. You've got to urge your data from the proper and best sources, you furthermore may need to explore your data to work out if it's suitable for the analysis project began. During this phase you furthermore may decide your format and verify that your analysis tool accepts it.

Choose Analysis Methods & Tools - this has got to depend of the frame of the question, as said before the frame of the question will determine which tool to use.

Perform The Analysis - to try to this you create a model and run different scenarios

Examine results; this is often the method of checking the result for accuracy.

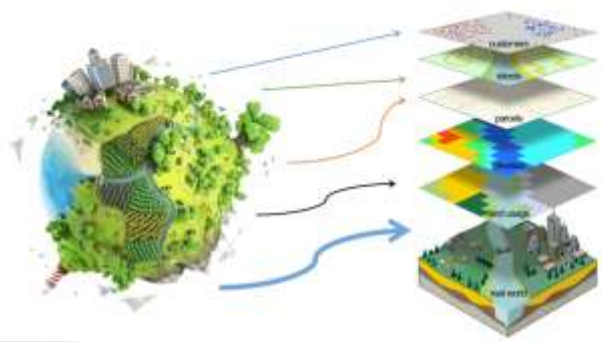

Fig.4 Analysis of GIS

GIS is claimed to be the inspiration of next generation engineering and it is the drive for the event of all sectors.

VI. APPLICATIONS OF GEOGRAPHICAL INFORMATION SYSTEM IN CIVIL ENGINEERING

An advanced data system like GIS plays an important role and is an entire platform in every phase of infrastructure life cycle. Advancement and availability of technology has set new marks for the professionals within the infrastructure development areas. Now more and more professionals are seeking help of those technologically smart and improved information systems like GIS for infrastructure development. Each and each phase of infrastructure life-cycle is greatly affected and enhanced by the enrollment of GIS.

In engineering projects, RS (Remote Sensing) and GIS techniques can become potential and indispensable tools. Various engineering application areas include regional planning and site investigation, terrain mapping and analysis, water resources engineering, city planning and concrete infrastructure development, transportation network analysis, landslide analysis, etc.

Construction it provides the mechanics and management for building new infrastructure including takeoffs; machine control; earth movement; intermediate construction, volume and material, and payment calculations; materials tracking; logistics; schedules; and traffic management.

 DOI : 10.35291/2454-9150.2020.0539

Fig.5 Applications of GIS

These are the subsequent area for using GIS in Civil Engineering.

A. Transportation
B. Watershed analysis
C. Remote sensing
D. Wastewater, storm water and Solid Waste Management
E. Regional Planning and Site Investigations
F. Landslides
G. Terrain Mapping and Analysis
H. Disaster Management

A) Transportation Engineering -

- Location-Allocation

a) Finding a subset of locations from a group of potential or candidate locations that best serve some existing demand so as minimize some cost

b) Locate sites to best serve allocated demand

c) Application areas are warehouse location, nutriment locations, fire stations, and schools.

- Location-Allocation Inputs

a) Customer or demand locations
b) Potential site locations and/or existing facilities
c) Street network or Euclidean distance

- The best sites

a) The optimal allocation of demand locations to those sites
b) Many statistical and summary information that particular allocation

- Synergy between spatial data and analysis

a) Imagine you're a national retailer
b) You would like warehouses to provide your outlets
c) You are doing not wish the warehouses to be quite 1000 km from any outlet

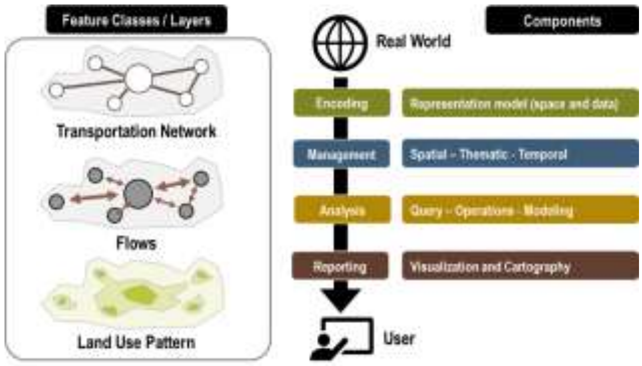

Fig.6 spatial data and analysis in GIS

B) Watershed analysis -

a) Possible to watch the consequences of dam construction.
b) Help in preliminary investigation of impact assessment of dams and rehabilitation.
c) Reservoir sites to store the excess flows in these basins might be identified.

d) The RS based input integrated with ground based information through GIS is beneficial for broad reconnaissance level interpretation of land capability, irrigation suitability, potential land use, water harvesting areas, monitoring the consequences of soil and conservation measures, estimation of run offend sediment yields and monitoring land use change including land degradation.

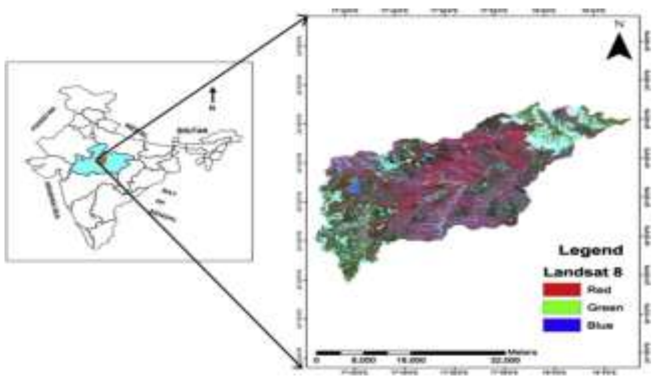

Fig.7 Watershed Analysis by using GIS

C) Remote sensing -

Remote sensing and GIS techniques become potential and indispensable tools for solving many problems of engineering. Remote sensing observations provides data on earth's resources during a spatial format, GIS co-relates

Different sorts of spatial data and their attribute data, so on use them in various fields of engineering.

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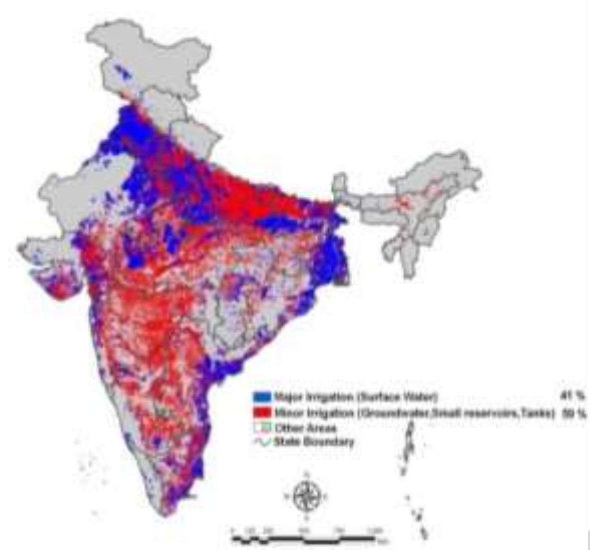

Fig.8 Application of GIS in Remote Sensing

D) Wastewater, storm water and Solid Waste Management

Whether for irrigation, power generation, drinking, manufacturing, or recreation, water is one among our most crucial resources. Image interpretation are often utilized in a spread of the way to assist monitor the standard, quantity of water resources. It's well proven in exploring spring water prospect zones. One such example is Rajiv Gandhi beverage Mission with help of remote sensing and GIS. Sediment pollution is usually clearly depicted on aerial and space images. Materials that form films on the water surface, like oil films, also can be detected through the utilization of aerial and satellite images. Normal colours or ultraviolet aerial photography is usually employed for the detection of oil films on water.

Knowledge of groundwater location is vital for both water system and pollution control analysis. Remote sensing plays an important role in delineating potential areas of groundwater occurrence for detailed exploration, thus reducing the value and time involved in groundwater exploration. Potential spring water areas can't be seen on satellite images directly. The clue to the groundwater search is that the incontrovertible fact that sub-surface geological elements forming aquifers have almost invariable surface expressions, which may be detected by remote sensing techniques (Joseph, 2005). Satellite data provide information about geomorphic features, structures, land uses and rock types (in a couple of cases) indicating the presence of groundwater.

Fig.9 Application of GIS in Solid Waste Management

E) Regional Planning and Site Investigations

Site investigations generally require topographic and geologic considerations. Remote sensing data permits such an assessment. Just in case of dam site investigation, information on topography is important. Geological consideration involves the various soil and rock types and physical properties.

In selecting river-crossing sites for bridges and pipelines, a crucial consideration is that the stability of slopes leading right down to and up from the water crossing. Such slopes include riverbanks, terrace faces and valley wall. History of river erosion and sedimentation would give clues needed for locating the sites where scour is probably going to occur. High spatial resolution satellite data with stereo vision capability can facilitate depth perception within the above said investigations and also for regional planning of huge commercial airports, harbors, industrial towns and recreational sites. The hydro geological and geomorphologic information alongside geological structures derived from satellite data are very useful in sitting the bottom – water bore holes.

Fig.10 Application of GIS in Regional Planning

F) Landslides -

Landslide is that the results of a good sort of processes which include geological, geomorphologic and

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meteorological factors. The important terrain factors are lithology, structure, drainage, slope, land use, geomorphology and road network. An entire landslide hazard assessment requires an analysis of these factors resulting in instability within the region. The feature extraction of a number of these factors are often done from the interpretation of satellite images. With the rise in efficient digital computing facilities, the digital remote sensing data and their analysis have gained enormous importance. Then the spatial and temporal thematic information derived from remote sensing and ground based information got to be integrated for data analysis. This will be alright achieved using GIS which has the capabilities to handle voluminous spatial data. With the assistance of GIS, it's possible to integrate the spatial data of various layers to work out the influence of the parameters on landslide occurrence.

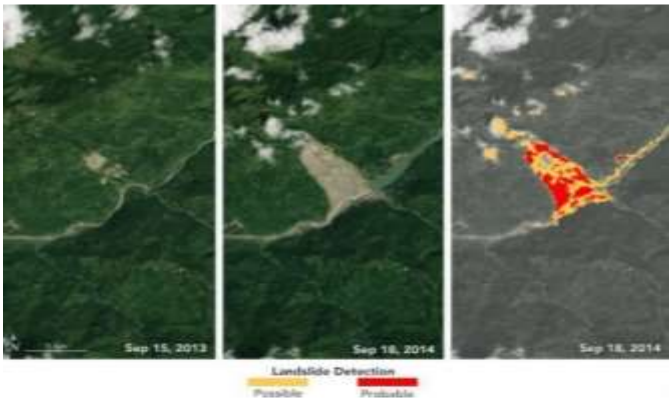

Fig.11 Application of GIS in Landslides

G) Terrain Mapping and Analysis -

Assessment of the performance of the terrain for specific developmental activities are often made through terrain evaluation. For this, terrain information are often acquired from RS data and by generating the Digital Terrain Model (DTM). A DTM is an ordered array of numbers representing the spatial distribution of terrain characteristics stored during a computer so on enable the determination of any quantitative data concerning terrain. DTMS is beneficial in investigation of variety of other horizontal and vertical alignments of canals, roads, pipelines or corridors for any such applications. In engineering construction like dam, the knowledge of fabric comprising the terrain is important for correct planning, location, construction and maintenance of engineering facilities. For computation of hydro-graph parameters like peak runoff rate, time of concentration and time to peak, the peak and slope information derived from Digital Elevation Model (DEM) are useful. The knowledge on regional engineering soils is important for general planning and site evaluation purposes. High spatial resolution satellite data are often analyzed to delineate various landforms, mapping of soil classes of significance to engineering construction, delineation of landforms – engineering, soil relationships and grouping of landforms with various physiographic setting or terrain associations.

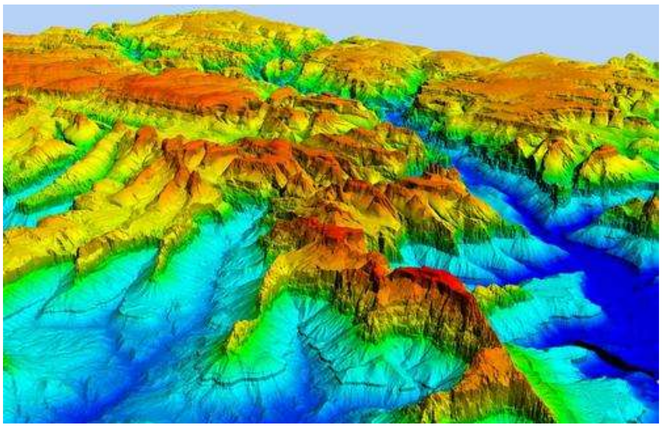

Fig.12 Application of GIS in Terrain Mapping

H) Disaster Management -

Effective and realistic emergency management programs depend upon data from various sources which should be collected, analyzed, displayed, disseminated and utilized in an organized manner. It’s therefore desirable to possess the proper data within the right place at the proper time. The info should be organized during a usable format for stakeholders to reply and take action just in case of an emergency. Most of the emergency data requirements are of spatial nature hence a requirement for a Geographic data system (GIS).

Disaster management starts with locating and identifying potential emergency problems and the way they relate to the prevailing environment. What facilities exist in impact zones, location of mitigation facilities like fire stations, potential refugee and IDP camps, spread of spills, location of medical facilities, extent of injury and infestation, water sources and any humanitarian intervention. GIS provides a mechanism to integrate data from a spread of sources, analyze it and present it to planners and decision makers during a time and reliable manner.

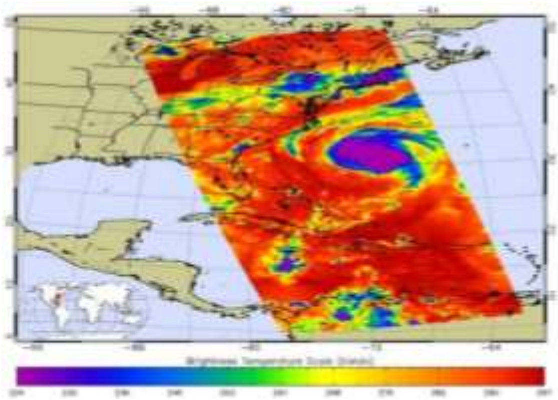

Fig.13 Application of GIS in Disaster Management

VII. CONCLUSION

GIS has a crucial application for instance in engineering projects like involve the management, analysis and

 DOI : 10.35291/2454-9150.2020.0539

ISSN : 2454-9150 Special Issue - .inSIGHT'20

integration of huge amounts of geographic information to make sure success. this will include a good range of data like detailed design drawings originating from software solutions, detailed mapping, air photography, geological investigations, solid waste management, disaster management, population information, traffic flows and environmental models

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