Vol 3 Issue 8 Sept 2013 ISSN No : 2230-7850

Monthly Multidisciplinary
Research Journal

Indian Streams Research Journal

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RNI MAHMUL/2011/38595 **ISSN No.2230-7850**

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Indian Streams Research Journal
Volume-3, Issue-8, Sept-2013
ISSN 2230-7850

Available online at www.isrj.net

DOI : 10.9780/2230-7850/382013/3029

An Overview On Gis, Its History, Working And Its Application In Various Fields

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Abstract:Environmental deterioration has taken place along with excessive extraction of ground water as a result of industrialization and urbanization. Pollution load due to industrial effluents is also a matter of serious concern not only for the quality of nearby aquatic body but also for living being residing there. It seeps into the aquifers and pollute the ground water, which has adverse effects on users health. Hence industrialization offers a wide scope of ground water contamination and depletion of ground water level through excess extraction. GIS has been found very useful in establishing the spatial relationship between pollution level and its source. Now it is a readily available spatial analysis tool which gives unique and unparalleled insights into the natural and manmade environments due to its strength to link the "generic information" with its "location". It not only analyses the present environmental scenario but also helps in projecting the future, in other words, one can effectively use the GIS tool for past, present and future studies on environment and its protection for the generations to come in future GIS can be effectively used in environmental management and planning, ground water quality analysis and mapping, fresh water and saltwater interface, solid waste and waste water management, air & water pollution, natural hazards and their mitigation etc. This paper primarily focuses on the brief history, benefits and utilities of GIS in different field of environmental sciences.

Keywords: Geographical Information System, History, Components, Working, Practical Utility.

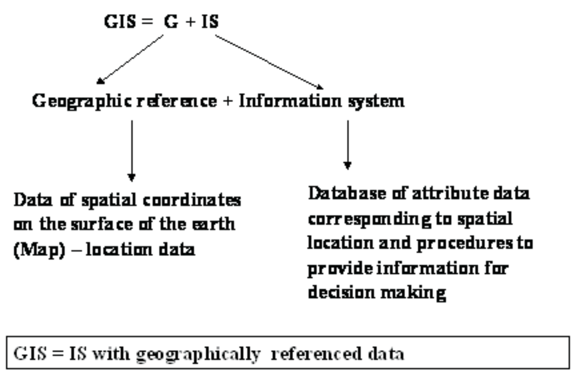
INTRODUCTION:

Due to the rapid growth of industrialization a negative impact has been created on the environment as many industries have discharged their effluent without any proper treatment. Industrial effluents contain toxic chemicals, colours, hazardous compounds, suspended solids and non-biodegradable materials. As soon as this untreated effluent seeps to ground water aquifer and water get contaminated. Groundwater is a valuable natural resource that is essential for health of human beings and their socio-economic development (Humphreys, 2009). It is evident that human activities are responsible for ground water contamination which has been observed worldwide. Now-a-days, there is need to develop a definite strategy for groundwater management especially for the protection of ground water from contamination and land based management of the groundwater resources. The major challenges in front of are to prevent ground water depletion, contamination and to mapped out the availability of ground water.

Geographical Information Systems (GIS) has emerged as a powerful tool for storing, analyzing, managing and capturing all geographical forms to display spatial data as reference information from many different sources and incorporating it into one database software for decision making operations in several areas (Goodchild, 1993 and Lo and Yeung, 2003) and have been used for a variety of groundwater studies. It can play a vital role for analysis and in formulating the quick mitigation plans for high risk environments. GIS is one of the key tools in the environmental data framework for data validation, digital data transfer standards, data retrieval/dissemination and analysis. It can serve as the ultimate communication of environmental information to the public and policy makers since it is the technical basis for the multimedia approach in environmental decision-making. The evolution of spatial data standards, the internet, and the next generation of GIS technology allow all types of users to access the environmental information in its proper spatial context. Two major techniques for groundwater protection strategies are groundwater vulnerability assessment and groundwater quality mapping. Mapmaking and geographic analysis are not new, but a GIS performs these tasks better and faster than do the old manual methods. And, before GIS technology, only a few people had the skills necessary to use geographic information to help with decision making and problem solving. Today, GIS is a multibillion-dollar industry employing hundreds of thousands of people worldwide. GIS is taught in schools, colleges, and universities throughout the world. Professionals in every field are increasingly aware of the advantages of thinking and working geographically.

What is GIS

GIS is a generic term implying the use of computers to create and display digital maps. The acronym GIS is also used for Geospatial Information Studies that refers to the academic study or discipline that works along with geographical information system. In the layman's terms, GIS means the incorporation of statistical analysis, cartography and the database technology. The attribute data which describe the various features presented in maps may relate to physical, chemical, biological, environmental, social, economic or other earth surface properties. GIS allows mapping, modelling, querying, analyzing and displaying large quantities of such diverse data, all held together within a single database. Its power and appeal stem from its ability to integrate quantities of information about the environment and the wide repertoire of tools it provides to explore the diverse data.



Source: Available at www.naarm.ernet.in/virtual/downloads/GIS%20concepts.doc?

Generally, GIS can be defined as a computerized system designed to dealing with the collection, storage, manipulation, analysis, visualization and displaying geographic information. It is basically a computerized information system like any other database, but with an important difference: all information in GIS must be linked to a geographic (spatial) reference (latitude/longitude, or other spatial coordinates). It is a tool to perform the spatial analysis which will put insight to the activities and phenomena carrying out every day. In other words, it is used to analyze any data or set of data that is spatial in its distribution and to make maps.

There are so many definitions of GIS given by various organizations and scientists to define the working and nature. One reason for the existence of so many vague definitions for GIS is that it is a young technology which is deeply rooted in a well established science.

Different definitions of GIS by Various Sources	
United States Geological Survey (USGS) http://erg.usgs.gov/isb/pubs/gis_poster/] accessed: 06/14/2005	*A GIS as a computer hardware and software system designed to collect, manage, analyze and display geographically (spatially) referenced data* . In the strictest sense, a GIS is a computer system capable of assembling, storing, manipulating, analysing and displaying geographically referenced information, i.e. data identified according to their locations. Practitioners also define a GIS as including the procedures, operating personnel, and spatial data that go into the system"
Duecker (1979)	GIS is a special case of information system where the database consists of observations on spatially distributed features, activities or events, which are definable in space as points, lines or area. A geographic information systems manipulates data about these points, lines and areas to retrieve data for ad hoc queries and analyses.
ESRI(Earth Science Research Institute)	? GIS as an organized collection of computer hardware, software, geographic data and personnel designed to efficiently capture, store, update, manipulate, analyze and display geographically referenced information that is tied to spatial data. ? GIS as a compu ter system capable of holding and using data describing places on the earth's surface.
INHS (Illinois Natural History Survey)	? A Geographic Information System (GIS) is an organized collection of computer hardware, software, geographic data, and personn el designed to capture, store, update, manipulate, analyze, and display all forms of geographically referenced information. This System allows users to perform very difficult, time consuming, or otherwise impractical spatial analyses.
Clarke (1986)	Computer assisted systems for the capture, storage, retrieval, analysis and display of spatial data.
Goodchild (1985)	A system which uses a spatial database to provide answers to queries of a geographical nature.
Calkins and Tomlinson (1977)	GIS is a process for the input, storage, retrieval, analysis, and output of geographic information.
Longley, et al, (2005)	A special class of information systems that keep track not only of events, activities, and things, but also of where these events, activities, and things happen or exist. ? A container of maps in digital form, ? A computerized tool for solving geographic problems, ? A tool for performing operations on geographic data that are too tedious or expensive or inaccurate if performed by hand
Worboys and Duckham (2004)	A computer-based information system that enables capture, modeling, storage, retrieval, sharing, manipulation, analysis, and presentation of geographically referenced data
Davis (2001)	A computer–based technology and methodology for collecting, managing, analyzing, modeling, and presenting geographic data for a wide range of applications.
Burrough and McDonnell (1998)	A powerful set of tools for storing and retrieving at will, transforming and displaying spatial data from the real world for a particular set of purposes.
Star and Estes (1990)	An information system that is designed to work with data referenced by spatial or geographic coordinates. In other words, a GIS is both a database system with specific capabilities for spatially–referenced data, as well as a set of operations for working with the data.

Brief History of GIS

The history of development of GIS parallels the history of developments in digital computers and database management systems on one hand and those in cartography and automation of map production on the other. The development of GIS has also relied upon innovations made in several other disciplines like geography, photogrammetry, remote sensing, civil engineering, statistics, etc.

There have been four distinct phases in the development of GIS.

Phase I (Early 1960s - mid 1970s) : new discipline being dominated by a few key individuals who were to shape the direction of future research and development.

Phase II (Mid 1970s - early 1980s) : adoption of technologies by national agencies that led to a focus on the development of best practice.

Phase III (1982 until the late 1980s) : development and exploitation of the commercial market place surrounding GIS.

Final phase (Since the late 1980s) : has seen a focus on ways of improving the usability of technology by making facilities more user centric.

The advancements in technology that has been recorded as the history of GIS development made the present GIS as it is today. In the 20th century, the printing of geographic locations were already made possible. During 1982, Environmental Systems Research Institute (ESRI) launched first commercially available GIS software. Now, ESRI became the dominant organization in this field. However, the images are not yet considered to be vital as there are no databases to link to them. A brief developmental history of GIS is given in the Table 1.

Table 1. Chronological history of Geographical Information System Development

1781-82	Maps of the Battle of Yorktown (American Revolution) drawn by the French Cartographer Louis-Alexandre Berthier contained hinged overlays to show troop movements
1832	The first documented application of what could be classed as a GIS was in France in 1832. French Geographer, Charles Picquet created a map based representation of cholera epidemiology in Paris by representing the 48 districts of Paris with different halftone colour gradients.
1838	Atlas to Accompany the Second report of the Irish Ra ilway Commissioners" showed population, traffic flow, geology and topography superimposed on the same base map
1854	A similar situation led to John Snow depicting cholera deaths in London using points on a map in 1854. The Snow map was important because it was not just a presentation of data. An attempt was made to present and argument worked from the data displayed on the map.
1881-82	A printing technique known as photozincography was used to separate out layer from a map.
1912	As early as 1912 thematic cartography had documented use.
1921-1981	Ian Mc Harg (Father of Geographical Information System)
1950s	Thematic map overlay (superimposition of maps drafted at the same scale)
1959	Use of transparent blacked-out overlays to find suitable locations (overhead)
mid 1960s	The nuclear arms program had given rise to hardware and mapping applications and the first GIS, Canada Geographic Information System was developed, combining spatially-referenced data, spatial models and map-based visualization, in mid-1960s to identify the nation's land resources and their existing, and potential uses. Its development provided many conceptual and technical contributions. It is still operating today.
1964	Harvard Laboratory for Computer Graphics (and Spatial Analysis) was established by Howard Fisher. This lab had major influence on the development of GIS until early 1980s. Many pioneers of newer GIS "grew up" at the Harvard lab.
1965	The development of the GBF-DIME files by the U.S. Census Bureau marked the large-scale adoption of digital mapping by the U.S. government. This system led to the production of the Census TIGER files, one of the most important socioeconomic spatial data sets in use today. (Topologically Integrated Geographic Encoding and Referencing system)
1966	Howard Fisher developed SYMAP (Synagraphic Mapping System) a general -purpose mapping package, producing isoline, choropleth and proximal maps on a line printer. It was characterized by poor resolution and limited functionality, but is was also simple to use. It represented a way for the non-cartographer to make maps and it was a first real demonstration of ability of computers to make maps.
late 1960s	CALFORM was developed. It is an improvement of SYMAP: • SYMAP on a plotter • user avoided double-coding of internal boundaries by inputting a table of point locations, plus a set of polygons defined by sequences of point IDs • more cosmetic than SYMAP - North arrows, better legends
late 1960s	SYMVU was developed: • 3D perspective views of SYMAP output • first new form of display of spatial data to come out of a computer GRID was developed: • raster cells could be displayed using the same output techniques as SYMAP • developed to allow multiple input layers of raster cells; beginnings of raster GIS • used to implement the ideas of overlay
late 1960s	US Bureau of the Census created the DIME program (Dual Independent Map Encoding) for all US streets to support automat ic referencing and aggregation of census data.
1969	Ian Mc Harg in his book "Design with Nature", popularized the use of georeferenced transparent map overlays for resource planning purposes
1969	Data formats begin to emerge and private vendors began o ffering GIS packages: Environmental Science Research Institute (ESRI) is founded by Jack and Laura Dangermond as a privately held consulting group. The business began with $1100 from their personal savings and operated out of an historic home located in Re dlands, California. Jim Meadlock establishes Intergraph Corporation (originally called M & S Computing Inc).
Early 1970s	POLYVRT ? various alternative ways of forming area objects ? motivated by need of computer mapping packages for flexible input, transfer of boundary files between systems, growing supply of data in digital form, e.g. from Bureau of the Census
Mid 1970s	Harvard University's Laboratory for Computer Graphics and Spatial Analysis developed a general-purpose GIS (ODYSSEY GIS) ? extended POLYVRT idea beyond format conversion to a comprehensive analysis package based on vector data ? first robust, efficient algorithm for polygon overlay included sliver removal.
1971	The Canada Geographic Information System (CGIS) becomes fully operational. General Information System for Planning (GISP) is developed by the US Department of the Environment. Maryland Automatic Geographic Information (MAGI), one of the first statewide GIS projects begins in US.
1974	The first AUTOCARTO (International Symposium on Computer Assisted Cartography) conference is held in Reston (Virginia).
1976	Minnesota Land Management Information System (MLMIS), another significant state-wide GIS, begins as a research project at the Centre for Urban and Regional Analysis, University of Minnesota.
1977	The USGS (U.S. Geological Survey) develops the Digital Line Graph (DLG) spatial data format.
1978	ESRI develops the first version of Arc/Info, the current leading GIS software package. ERDAS is founded.
1980s	Second GIS phase: the GIS was pushed to evolve towards analysis. • In this stage more functions for USER INTERACTION were develope d mainly in a graphical way by a user friendly interface (GUI, Graphical User Interface). • It gave to the user the ability to sort, select, extract, reclassify, re -project and display data on the basis of complex geographical, topological and statistical criteria. • The suppliers increased their knowledge on existing and growing data analyses techniques, specific subject matters (e.g.: ecology and hydrology), and data context issues. While data storage were still mainly centralized the user's access becam e more decentralized.
1982	ESRI's ARC/INFO® 1.0, the first commercially available GIS software package, which ran on mainframe computers (www.esri.com/company/about/history.html) was released. Army Corps of Engineers at the Construction Engineering Research Laboratory (CERL) started the development of the GIS GRASS –Geographic Resources Analysis Support System – as a raster based GIS programme for land management at military installations
1986	Laszlo Bardos, Andrew Dressel, John Haller, Mike Marvin and Sean O'Sullivan founded MapInfo. ESRI's PC ARC/INFO® 1.0, the first GIS software available for the personal computer, was released.
1987	The International Journal of Geographical Information Ana lysis gets published. Tydac releases SPANS GIS. Ron Eastman starts the IDRISI Project at Clark University
1988	First public release of the US bureau of Census 'TIGER' (Topographically Integrated Geographic Encoding and Referencing) digital data products. Founded as GIS World, the monthly magazine 'GEO World', the world's first magazine for geographic technology gets published. The National Centre for Geographic Information and Analysis (NCGIA, http://www.ncgia.ucsb.edu/) is established in the USA.
1989	Intergraph launches MGE (Modular GIS Environment). The desktop image processing software, 'ER Mapper' is launched.
1990s	Starting from the 1990s GIS entered in a new era. As computing power increased and hardware prices plummeted, the GIS became a viable technology for state and municipal planning. In this third phase of evolution GIS is asked to become a real Management Information System (MIS), and thus able to support decision making processes.
1992	In Lebanon, the Electricite du Libau (EDL) decides to rebuild the entire nations electricity network in GIS environment. ESRI released ArcView® 1.0, a desktop mapping system with a graphical user interface that marked a major improvement in usability over Arc/Info's command -line interface (http://www.esri.com/company/about/history.html). The ArcView standard was soon adopted by many government, business, defence and non- governmental organizations.
1993	Steve Putz developed PARC, the first Web -based interactive map The European Umbrella Organization for Geographic Information (EUROGI) is established in Europe. Viewer;
1994	The Open GIS Consortium aiming at developing publicly available geo -processing specifications was founded. http://www.opengeospatial.org/
1994	National Spatial Data Infrastructure (NSDI) is formed in US by an e xecutive order of President Bill Clinton. PCI Geomatics, a geomatics solution company is formed.
1995	National Geographic Data Framework (NGDF) established in UK. ESRI released Spatial Database Engine (SDE®), an innovative tool for storing and managing GIS data in a commercially available database management system (DBMS).

1997	The University of Minnesota (UMN) released MapServer 1.0, an open source development environment for building spatially -enabled Internet applications (http://mapserver.org/) ESRI released ArcView Internet Map Server (IMS), a commercial tool for publishing GIS data over the Internet.
1999	GRASS 5.0 is released under GNU GPL by the GRASS Development Team (http://grass.itc.it/). The first major change in years, this version incorporates floating point calculations and NULL support into GRASS raster engine.
2001	Refraction Research released PostGIS 0.1 (http://postgis.refractions.net/), an open source "spatially enabler" adding support for geographic objects to the PostgreSQL object relational database.
2002	ESRI began offering a wide selecti on of GIS software compatible with the Linux operating system. ArcIMS 4, ArcSDE 8.2, MapObjects -Java Standard Edition, and ArcExplorer 4 software are all supported on Linux.
2005	GRASS 6.0.0 is released with new interface, vector engine, and database supp ort.

Components of GIS System

Key components of GIS are hardware, software, data, users, methods and network.

Hardware: It is the device that is used for GIS operation, such as the computer, digitizer, plotter, etc.. Today, GIS software runs on a wide range of hardware types, from centralized computer servers to desktop computers used in stand-alone or networked configurations.

Software: GIS software provides the functions and tools needed to store, analyze, and display geographic information and to carry out multiple spatial analysis and management. Key software components are

Tools for the input and manipulation of geographic information

A database management system (DBMS)

Tools that support geographic query, analysis, and visualization

A graphical user interface (GUI) for easy access to tools

Data: Possibly the most important component of a GIS is the data. It contains either an explicit geographic reference, such as a latitude and longitude coordinate, or an implicit reference such as an address, postal code, census tract name, forest stand identifier, or road name. Geographic data and related tabular data can be collected in-house or purchased from a commercial data provider. A GIS will integrate spatial data with other data resources and can even use a DBMS, used by most organizations to organize and maintain their data, to manage spatial data. Data may be spatial or attribute type. Spatial data represent the geographical location of features for example points, lines, area etc. Spatial data typically include various kinds of maps, ground survey data and remotely sensed imagery and can be represented by points, lines or polygons. Attribute data refers to various types of administrative records, census, field survey records, and collection of historical records.

Users: They are the most active components may be technical specialists dealing with the design, programming, operation and management of GIS and also who use it to perform their everyday work.

Methods: These are referred to lines of reporting, control points, well-designed plan, rules and other mechanism for ensuring the high quality of GIS.

Network: It allows rapid communication and sharing digital information. The internet has proven very popular as a vehicle for delivering GIS applications.

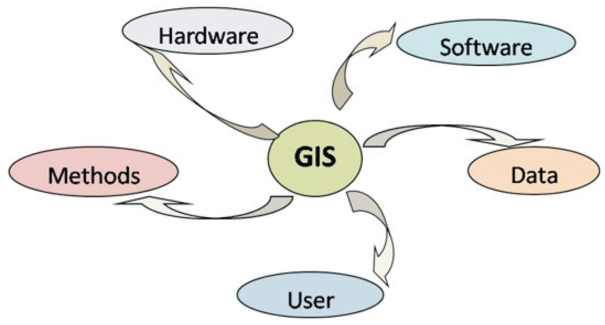


Figure 1. Components of GIS System

Working of GIS

A GIS stores information about the world as a collection of thematic layers that can be linked together by geography. The working of a GIS can be summarised as:

Dizitization of data / Data capture

The process of converting data from paper maps into computer files is called digitization. GIS technology is able to do it for large projects using electronic scanning devices, however, some smaller projects may require some manual digitizing. The process of getting data into a digital format recognised by the GIS is known as data capture.

Geographic References

Geographic information contains either an explicit geographic reference, such as a latitude and longitude or national grid co-ordinate, or an implicit reference such as an address, postal code, census tract name, forest stand identifier, or road name. An automated process called geocoding is used to create explicit geographic references (multiple locations) from implicit references (descriptions such as addresses). These geographic references allow you to locate features, such as a business or forest stand, and events, such as an earthquake, on the earth's surface for analysis.

Conversion of digital information

The ability of GIS to relate information from disparate sources helps in planning and management of natural resources. A GIS can be used for converting existing digital information, which may not be in map format, into forms, which it can recognise and use. For example, digital satellite images can be analysed to produce a thematic layer of digital information about vegetation. Additionally, existing tabular data such as census can be converted to map-like format. For the data to be usable, it needs to be geo referenced to the map in some way.

Manipulation of data

Data for a particular GIS project will need to be transformed or manipulated in some way to make them compatible with the system. This could be a temporary transformation for display purposes or a permanent one required for analysis. GIS technology offers many tools for manipulating spatial data and for weeding out unnecessary data.

Database Management System

For small GIS projects it may be sufficient to store geographic information as simple files. But for large projects, a database management system is used to store, organize, and manage data.

In GIS the relational design has been the most useful. In the relational design, data are stored conceptually as a collection of tables. Common fields in different tables are used to link them together. This surprisingly simple design has been so widely used primarily because of its flexibility and very wide deployment in applications both within and without GIS.

Query and Analysis

GIS provides both simple point-and-click query capabilities and sophisticated analysis tools to provide timely information to managers and analysts alike. GIS have many powerful analytical tools, but two are especially important.

1)Proximity Analysis
GIS technology uses a process called buffering to determine the proximity relationship between features.
2)Overlay Analysis
The integration of different data layers involves a process called overlay. At its simplest, this could be a visual operation, but analytical operations require one or more data layers to be joined physically. This overlay, or spatial join, can integrate data on soils, slope, and vegetation, or land ownership with tax assessment.

Projection

Before data is analysed, in most of the GIS projects, projection of the map is done. Projection, one of the fundamentals of mapmaking, is the mathematical method of transferring information from the earth's three-dimensional surface to two-dimensional medium. Map projections, however, will result in the distortion of one or more of these properties: shape, area, distance and direction. Some of the projections that are used are Universal Transverse Mercator (UTM), Lambert Conformal Conic, etc.

Data structures

Geographic information systems work with two fundamentally different types of geographic models, the "vector" model and the "raster" model.

(a) Vector Model

In this model, information about points, lines, and polygons is encoded and stored as a collection of x,y coordinates. The location of a point feature, such as a bore hole, can be described by a single x,y coordinate. Linear features, such as roads and rivers, can be stored as a collection of point coordinates. Polygonal features, such as sales territories and river catchments, can be stored as a closed loop of coordinates. Compared to a line designated in a raster format, a vector line is one-dimensional and has no width associated with it.

Advantages of vector type data

The vector type data uses less storage space.
It supports greater precision in the computation and processing of spatial features.
Extremely useful for describing discrete features, but less useful for describing continuously varying features such as soil type.

(b) Raster Model

The smallest feature in a raster data structure is represented by a single pixel. A raster image comprises a collection of grid cells rather like a scanned map or picture.

Advantages of raster data type

Provides better representation of continuous surfaces.
Map overlays are efficiently processed if thematic layers are coded in a simple raster structure.
Because the raster grid defines units or pixels that are constant in shape, spatial relationships among pixels are constant and easily traceable.

Both the vector and raster models for storing geographic data have unique advantages and disadvantages. Modern GIS are able to handle both models.

Visualization

For many types of geographic operation the end result is best visualized as a map or graph. Maps are very efficient at storing and communicating geographic information. Map displays can be integrated with reports, three-dimensional views, photographic images, and other output such as multimedia.

Applications of GIS

GIS is a multidisciplinary system which includes geography, cartography, geology, computer programming etc. It can be applied in various disciplines such as geography, geology, criminal justice, sociology, meteorology, political science, archeology and environmental sciences etc. and used to facilitate communication between different entities, to solve problems, to make decisions, to understand past and present situations and to anticipate future scenarios. Technically, a GIS is a system that includes mapping software and its application to remote sensing, land surveying, aerial photography, mathematics, photogrammetry, and geography.

GIS In Environmental Sciences

According to ESRI, GIS help to study the environment, report on environmental phenomena, and model how the environment is responding to natural and man-made factors. Using GIS software one can manage multiple types of geographic data, assess relationships such as runoff and groundwater purity, measure change such as wildlife habitat encroachment, model events such as drought impact on forest health and improve workflow processes, from data gathering and analysis to publication and distribution of findings. GIS software helps in mapping out the contaminants in soil and water using the spatial interpolation tools from GIS (Longley et al. 2005).

It is a powerful tool for environmental data analysis and planning. Environmental degradation caused due to the industrialization, urbanization and other factors, as a result of which, environmental agencies are placed in charge in remediating, monitoring, and mitigating the soil contamination sites. GIS is used to monitor the sites for metal contaminants in the soil, and based on the GIS analysis, highest risk sites are identified in which majority of the remediation and monitoring takes place.

It stores spatial data in a digital format. A digital basemap can be overlaid with data or other layers of information onto a map in order to view spatial information and relationships. GIS allows better viewing and understanding physical features and the relationships that influence in a given critical environmental condition. Factors, such as steepness of slopes, aspects, and vegetation, can be viewed and overlaid to determine various environmental parameters and impact analysis. It can also display and analyze aerial photos. Digital information can be overlaid on photographs to provide environmental data analysts with more familiar views of landscapes and associated data. GIS can provide a quick, comparative view of hazards (highly prone areas) and risks (areas of high risk which may occur) and areas to be safeguarded.

On completion of Data analysis GIS helps in Planning and Managing the environmental hazards and risks. In order to plan and monitor the environmental problems, the assessment of hazards and risks becomes the foundation for planning decisions and for mitigation activities. GIS supports activities in environmental assessment, monitoring, and mitigation and can also be used for generating Environmental models. Below are some of the applicable areas where GIS can be implemented for effective planning and management.

GIS has been used widely in the field of environmental sciences to study soil erosion, land use/land cover change, flood zones. It is also used to inventories landslide location, new construction, septic tank location, flora and fauna distribution, flooding history, regional geology, groundwater monitoring and mapping etc. Various application of GIS in environmental studies are (Figure 2):

Monitoring environmental risk
Modeling stormwater runoff
Management of watersheds, floodplains, wetlands, forests, aquifers
Environmental Impact Analysis
Groundwater modeling and contamination tracking
Emergency Services like Fire Prevention
Hazard Mitigation and Future planning
Air pollution & control
Disaster Management
Forest Fires Management
Managing Natural Resources
Waste Water Management
Oil Spills and its remedial actions
Sea Water - Fresh water interface Studies
Coal Mine Fires

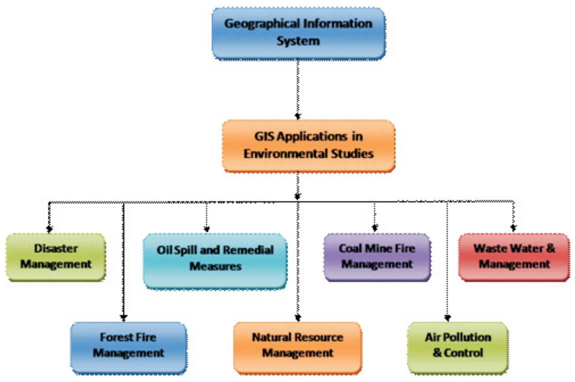


Figure 2. Diagram showing the application of GIS for various environmental solutions.

Field Applications of GIS

Apart from data analysis in laboratories GIS can also help the environmental data analysts in the field, the GIS tool is flexible enough to work in the field to give the exact location of devastation and amount of devastation. Some of the examples in field where GIS is applicable are

· GIS base mapping data allow a team in the field to visualize what they can't see i.e. helpful in locating underground utilities. It offer surveyors vast amounts of information, like who owns the property and how long they've owned it, the land use and zoning category on both sides of the boundary survey, etc.

· Using GIS in the field, an environmentalist can rapidly map waste storage sites; describe the volume, content, and state of waste containers.

· Retrieve previous inspection records to compare with the existing environmental conditions.

· View environmental data in relation to adjacent geographic features such as waterways, neighborhoods, or other sensitive areas such as high-risk zones for landslides, water pollution etc.

· Viewing topographic information over base mapping layers allows surveyors to become familiar with the lay of the land before going out the door. This is a real time-saving advantage if you want to get the project done better and faster than your competitor.

· If you have the site GIS information in a field computer, then clicking on the different features will help you identify specific features and information about each feature. This eliminates numerous trips back to the field.

· In most cases, the GIS data is fairly accurate, particularly where recent subdivision maps were used to create the parcel layer.

· The GIS data must be easily accessible not just by surveyors, but by everyone who can use the information to their advantage and benefit.

· The images depicted by GIS are very helpful, particularly for preliminary analysis, but cannot substitute for an accurate survey plat or a detailed legal description written from a survey plat.

· We have found certain information available from a GIS to be sufficient to use in lieu of field-surveyed data. An example is the online FEMA FIRM data, which is georeferenced and can be downloaded and inserted directly into a survey drawing to an accuracy that is sufficient for many uses. However, if an exact flood elevation needs to be determined, an actual field survey is required (Jackson and Rambeau, 2007).

· Integrated with a global positioning receiver, a field crew can use GIS to accurately ground truth satellite imagery in oil spill mapping and its effects on surrounding ecosystem.

Application of GIS in Ground water study

Groundwater can be optimally used and sustained only when the quantity and quality is properly assessed (Kharad et al., 1999). GIS can serve as a very useful tool for not only groundwater modeling but also for analyses of decadal variations in the groundwater quality, and development of conceptual groundwater model (Akankpo and Igboekwe, 2012). It is also used to obtain long-term groundwater level change maps. Map classi?cation of groundwater quality, can be done by correlating total dissolved solids (TDS) values with some aquifer characteristics (Butler et al., 2002) or land use and land cover (Asadi et al., 2007). Nas and Berktay (2010) have mapped urban groundwater quality in Koyna, Turkey, using GIS. GIS and remote sensing derived information can be well integrated with the conventional database for assessing the actual groundwater pollution scenario and pollution vulnerability (Remesan and Panda, 2008). The hydro-geochemical study with GIS reveals the zones where quality of water suitable for drinking, agricultural and industrial purposes (Khatib, 2010). Various workers have studied Groundwater quality mapping using geographic information system (GIS). Here, some studies are described. Balakrishnan et al. (2011) has studied spatial variations in ground water quality in the corporation area of Gulbarga City located in the northern part of Karnataka State, India, using GIS technique. They coded maps for potable zones, in the absence of better alternate source and non-potable zones in the study area. Akankpo and Igboekwe (2012) studied application of GIS in mapping of groundwater quality for Michael Okpara University of Agriculture Umudike and its Environs, Southeastern Nigeria. They studied the pollution sensitive zone map delineates the area into four zones: low hazard zone, moderate hazard zone, high hazard zone and very high hazard zone. The very high hazard zone seems to be the largest zone and extends mostly towards the southern part of the study area, indicating that the contaminants seem to concentrate at the southern part of the area, which also has low elevation. Other studies have used GIS as a database system in order to prepare maps of water quality according to concentration values of different chemical constituents (Skubon, 2005; Yammani, 2007). In such studies, GIS is utilized to locate groundwater quality zones suitable for different usages such as irrigation and domestic (Yammani, 2007). A similar approach was adopted by Rangzan et al. (2008) where GIS was used to prepare layers of maps to locate promising well sites based on water quality and availability. Subramani et al. (2005) assessed the quality of groundwater for determining its suitability for drinking and agricultural purposes using GIS in Chithar Basin, Tamil Nadu, India. Anbazhagan and Nair (2004) have used the geographical information system (GIS) to represent and understand the spatial variation of various geochemical elements in Panvel Basin, Maharashtra, India. Babiker et al. (2007) proposed a GIS-based groundwater quality index method which synthesizes different available water quality data (for example, Cl, Na, Ca) by indexing them numerically relative to the WHO standards. The use of GIS technology has greatly simpli?ed the assessment of natural resources and environmental concerns, including groundwater. In groundwater studies, GIS is also used for site suitability analyses, managing site inventory data, estimation of groundwater vulnerability to contamination, groundwater ?ow modeling, modeling solute transport and leaching, and integrating groundwater quality assessment models with spatial data to create spatial decision support systems (Engel and Navulur, 1999). Liaghat et al. (2012) determine optimum site for artificial recharge aided GIS and logical overlay function in Sarpaniran catchment, located in Pasargad in Fars province, considered as one of the important agricultural, industrial and residential centers. A GIS-based study was carried out by Barber et al. (1996) to determine the impact of urbanization on groundwater quality in relation to landuse changes. Ahn and Chon (1999) studied groundwater contamination and spatial relationships among groundwater quality, topography, geology, landuse, and pollution sources using GIS in Seoul. The advantages of using GIS over traditional methods in groundwater monitoring are: effective storage and analysis system for spatial and temporal database, spatial analysis of depicting the source- pollutant relationship, graphical presentation, visual impacts and spatial distribution of graphical outputs on water quality changes, pollution load and relationship with sources and management of river basin by generating buffer zones on the basis of water quality criteria.

Practical Utility of GIS

As a tool, researchers look at how multiple variables intersect with each other, it can be analyzed through a series of maps in GIS. One more advantage of GIS is that analysis can be instantly updated. However, GIS is not only a map making tool but also an analytical tool that provides new ways of looking at, linking and analyzing data by projecting tabular data into maps and integrating data from different, diverse sources. This it does by allowing creation of a set of maps, each with a different theme (soils, rainfall, temperature, relief, water sources, etc.). It improves efficiency, identifies opportunities and also improves decisions by providing needed tools and data. It is known to provide below mentioned benefits to the users:

Making Maps

Maps making is the key feature of GIS. It begins with database creation. Existing paper maps can be digitized and computer-compatible information can be translated into the GIS. The GIS-based cartographic database can be both continuous and scale free. It can create maps in different scales, projections and colours. Map products can then be created centered on any location, at any scale, and showing selected information symbolized effectively to highlight specific characteristics. The characteristics of atlases and map series can be encoded in computer programs and compared with the database at final production time. It permits identifying spatial relationships between specific different map features.

Perform Queries and Analysis

The ability of GIS to search databases and perform geographic queries has saved many companies literally millions of dollars. It has ability for complex analysis. It can perform analysis on spatial and non spatial components and fast recall of data especially recalling of non spatial data through object location.

Improve Organizational Integration

Many organizations that have implemented a GIS have found that one of its main benefits is improved management of their own organization and resources. Because GIS have the ability to link data sets together by geography, they facilitate interdepartmental information sharing and communication. By creating a shared database, one department can benefit from the work of another - data can be collected once and used many times.

Making Decisions process efficient

A GIS, however, is not an automated decision making system but a tool to query, analyze, and map data in support of the decision making process. GIS technology has been used to assist in tasks such as presenting information at planning inquiries, helping resolve territorial disputes, and siting pylons in such a way as to minimize visual intrusion. GIS can be used to help reach a decision about the location of a new housing development that has minimal environmental impact, is located in a low-risk area, and is close to a population center. The information can be presented succinctly and clearly in the form of a map and accompanying report, allowing decision makers to focus on the real issues rather than trying to understand the data. Because GIS products can be produced quickly, multiple scenarios can be evaluated efficiently and effectively.

GIS Assisted Database

GIS mapping will be helpful in identifying year wise the critical, moderate and acceptable limits of ground water and ground water level in the studied area. The GIS assisted database system would help to apply groundwater management practices such as; proper groundwater resource management in terms of groundwater quality & quantity, Integrated management of water and to prevent groundwater quality deterioration through proper monitoring & evaluation. GIS database provide help as information source to Institutions, researchers, groundwater practitioners and decision makers etc. It is also helpful to State government and Central government to prepare environmental management plan.

Other benefits of GIS

improves/enhances the effects of physical/environmental growth better management of resources
adding new value-added services
display of information in a different light/view
multiple scenario in planning can be performed easily

Constraints using GIS

There are some intricate problems in implementation of GIS in Environmental studies in India. The problems posed is the limited availability of useful data . Some aspects to this problem are.

1) Non availability of properly spatial data
2) information about natural resources, soils and vegetation, climate and geology are often not available.
3) Making maps as well as updating them is a costly and time- consuming activity, therefore detailed and current maps are scarce (Teefelen et al, 1992).
4) Dependence of developing country on developed country for data
5) Accessibility of existing data
6) Lack of proper infrastructure with the Government bodies
7) Meager skilled Manpower in the government planning and development departments
8) GIS softwares being more costly.
9) Unfortunately, in some rural areas the lack of detailed and accurate deed descriptions or survey plats can affect the accuracy of property lines in the GIS.
10) If the information in a GIS is not updated, then it is not a particularly valuable tool to the surveyor. This is especially true in areas that are being developed at a fast rate and where property values are increasing dramatically.

Some of the probable solutions to these problems are
1) Availability of map data in a centralized facility
2) Awareness and increasing the skills proficiency in GIS in government and private sector.
3) Increasing the infrastructure facilities to cope up with the latest technologies and
4) Supplementing the Environmental planning division with adequate funds

Summary

GIS is playing a vital role in environmental system management but, it seems very unusual for many departments in the country and due to some constraints it is still a problem. However, nowadays there are a big number of GIS projects taking place in developing countries. GIS becomes the primary repository of information that can be quickly accessed and viewed when required by the scientist, research scholars and others etc. With remote sensing, it makes a powerful tool that uses multiple kinds of spatial data, notably field data and existing maps. Geographic reference is the basic requirement in GIS applications. GIS is becoming more suitable for risk assessment, emergency operations and is integrating tools that allow real-time display of information. Rapid access to information, safety, efficiency, and better resource management decisions can be made with the use of GIS. GIS technology can provide critical information at the need of the hour to take the remedial measures.

ACKNOWLEDGEMENTS:
Authors are thankful to University Grant Commission for providing financial assistance under post doctoral fellowship for women to carry out present investigations.

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