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CHAPTER - IV

OVERVIEW OF GEOGRAPHIC INFORMATION SYSTEM (GIS)

4.1 INTRODUCTION:

Information about our world has been depicted on maps of various forms for many centuries. During the golden age of exploration, maps showed critical paths of navigation to the known world, as well as strategic political boundaries and information about establishments and natural resources. Most recently, computer-related advances have led to a revolution in handling of Geographic Information.

Geographic Information (GI) is the "information, which can be related to a location (defined in terms of a point, area or volume) on the Earth, particularly information on natural phenomena, cultural and human resources." The positional data can be a specific set of spatial coordinates, or can cover less precise locations or areas, such as addresses, postal codes or administrative boundaries, regions or even whole countries. Most GI also includes a time dimension, since the world is not a static place. GI can be divided into two major classes: Base data (sometimes called core data or framework data), which are necessary for most applications, and application-specific data, sometimes referred to simply as Thematic data.

Base data may include:

1. The basic geodetic frameworks for determining geographic location,
2. Elevation data,
3. Thematic data on the location of natural objects, such as rivers, coasts and lakes, and anthropogenic features such as roads, railways, towns and cities, and administrative boundaries at national, regional and local levels, and
4. Linkage data, permitting non-spatial data to be more easily analyzed spatially (e.g. relating addresses to coordinate systems).

Application specific data covers all other kinds of GI that may be used in one application but not in all applications. Examples include socio-economic data from planning studies and censuses and natural resource data such as soil information or groundwater quality, or special purpose versions of the base data (e.g. the use of road center lines for auto navigation). Application specific data are largely thematic and may range from measures of reflected radiation captured by remote sensing sensors to data on utility networks to information about land ownership, land use and natural resources, or demography and health. By means of computerized Geographical Information Systems (GIS) base data can be exchanged, used, modified and combined with other spatial and non-spatial data in an unlimited number of ways.

4.2. WHY GI IS IMPORTANT?

The ability to relate information on activities and resources to a spatial location and to monitor or predict changes over time is fundamental to modern society. In this respect, the importance of socio-economic data, such as that produced by national censuses, cannot be overstressed. International, national, regional and local governments use GI for a host of applications from defense and policing activities through regional planning, strategic studies for renewable energy resources, environmental management and risk avoidance through urban and rural policy decisions to day-to-day operational activities such as land registration, property taxation or routing of traffic.

Industry and commerce use GI in many ways. Utility companies (power, gas, water, and telephone) are major investors in digital GI technology for managing and monitoring their supply networks, often on an international basis. Businesses use GI together with other economic information to determine optimal delivery routes, the location of potential markets or the site of outlets or factories. Constructors of major infrastructure (roads, railways, and bridges) use GI to estimate the amounts and costs of material needed.

In sectors such as agriculture, forestry, water resources or mining, GI is used to assess yields and management strategies. In service industries, GI is used by consultants to advice on how to improve business efficiency, or to provide services for tourism and transport. In social investigations, GI is used to help analyze spatially varying attributes of the population such as income, crime, health or the quality of housing. GI is used in a wide range of practical environmental issues from global warming and sea level rise to erosion, flooding and soil, air and water pollution. Geographic information increases knowledge and reduces uncertainty; this helps to improve and expedite decision–making, prevent mistakes and in the process saves money [1].

Development of GIS Geographic information systems have their roots in efforts begun in the 1960s to bring computation to the processing of mapped information. The earliest GIS, the Canada Geographic Information System was built to automate the processing of the information collected in map form by the Canada Land Inventory, and was justified on the simple proposition that computers could perform numeric determinations of area from digital representations of maps much more accurately and cheaply than humans working from the maps themselves. In somewhat similar vein, the U.S. Bureau of the Census constructed a rudimentary geographic information system in the run-up to the 1970 census on the grounds that computerization could reduce the rate of errors in tabulating and spatially aggregating census results.

Throughout the 1970s and 1980s the progress of GIS was measured at least in part through its ability to perform complex spatial analyses. GIS's were built and marketed as slave-like processors, computer applications that could perform operations on geographic data much more cost-effectively than could humans. By the late 1970's commercial GIS's began to appear that were capable of supporting both the basic types of geographic data model (raster and vector), all the necessary housekeeping functions, and many of the most useful analytic operations. GIS technology has now been extended for use in transportation modeling, planning, reporting, and decision –making.

Table – 4.1

Evolution of GIS

Stage of Development	The Formative Years	Maturing Technology	GI Infrastructure
Time Frame	1960-1980	1980-Mid-1990	Mid-1990s-present
Technical environment	Mainframes and minicomputers. Proprietary software. Proprietary data structure. Mainly raster based.	Mainframes and minicomputers. Geo-relational data structures. Graphical users interface. New data acquisition technologies like GPS, Remote sensing	Workstations and PCs. Network/Internet. Open system design. Multimedia. Data Integration. Enterprise computing. Object-relational data model.
Major Users	Government, Universities, Military	Government, Universities, Military, Utilities, Business	Government, Universities and schools, Military, Utilities, Business, General Public
Major Application Areas	Land and Resource Management, Census, Surveying and Mapping	Land and Resource Management, Census, Surveying and Mapping, Facilities Management, Market Analysis	Land and Resource Management, Census, Surveying and Mapping, Facilities Management, Market Analysis, Utilities, Geographic Data Browsing

Source: C.P. Lo Albert, K.W. Yeung, Concepts and Techniques of Geographic Information Systems; Prentice Hall of India

GIS is not only one of the fastest growing areas in applied computing, but is an integrated technology bringing together information, systems, applications and people from diverse fields. GIS are important to a wide range of disciplines and applications including transportation, mining and exploration, environmental and natural resources management, urban and regional planning, land administration, asset management and utilization, health monitoring and management, demographic marketing etc. The unique ability of GIS to handle complex spatial relationships makes it a natural tool to use in the planning and analysis of transportation systems specifically public transportation system.

4.3 WHAT IS GEOGRAPHIC INFORMATION SYSTEM (GIS)?

There are different definitions for Geographic Information System, each developed from a different perspective or disciplinary origin. Some focus on the map connection, some stress the database or the software tool kit and others emphasis applications such as decision support. Defining a GIS can be done by either explaining what it can do (Functions) or by looking at the components. Both are important to really understand a GIS and use it optimally. An analysis of the three letters of the acronym GIS gives a clear picture of what GIS is all about:

G Geographic: Implies an interest in the spatial identity or locality of certain entities on, under or above the surface of the earth.

I Information: Implies the need to be informed in order to make decisions. Data or raw facts are interpreted to create information that is useful for decision-making.

S System: Implies the need for staff, computer hardware and procedures, which can produce the information required for decision-making that is data collection, processing, and presentation.

4.3.1 A GIS is a computer-assisted system for the collection, storage, management, analysis and representation of geo-referenced data to support decision-making. This definition includes what some regard as the fringe elements of GIS, remote sensing, global positioning systems, computer cartography, multimedia, etc.

4.3.2 GIS is defined as a computerised system for capture, storage, retrieval, analysis and display of spatial data describing the land attributes and environmental features for a given geographic region, by using modern information technology (Thurgood, 1995). According to this definition, a GIS includes not only computing capability and data, but also managers and users, the organisation in which they function and institutional relationships that govern their management and use of information.

4.3.3 A GIS can be defined as a computing application capable of creating, storing, manipulating, visualizing, and analyzing geographic information. It finds its strongest applications in resources management, utilities management, telecommunications, urban and regional planning, vehicle routing and parcel delivery, and in all of the sciences that deal with the surface of the Earth.

4.3.4 Geographic Information System is a system of hardware, software, data, people, organisations and institutional arrangements for collecting, storing, analyzing and disseminating information about areas of the earth.

4.3.5 A Geographical Information System is an information system that is designed to work with data, references by spatial or geographic coordinates. In other words, a GIS is both a database system with specific capabilities for spatially, reference data, as well as a set of operations for working with data. In a sense, a GIS can be thought of as a high-order map (Star, Estes, "Geographic Information Systems", 1990, Page 2-3).

4.3.6 GIS are commonly defined by the processes that are carried out: "Computer System[s] for capturing, storing, checking, integrating, manipulating, analyzing and displaying data related to positions on the Earth's surface"

4.3.7 GIS is a system of hardware, software, and procedures designed to support the capture, management, manipulation, analysis, modeling, and display of spatially referenced data for solving complex planning and management problems (Rhind 1989).

4.3.8 GIS is defined as a decision support system involving the integration of spatially referenced data in a problem-solving environment. GIS offers the unique capacity for spatial analysis and overlay enabling decision-maker to integrate information through several layers of data and perform multi-criteria analysis and evaluation (Cowen 1988).

4.3.9 GIS is an electronic information system that analysis, integrates, and displays information based on geography. GIS systems have powerful visual display capabilities that present the results of analysis on maps on a wide variety of scales, ranging from very large (accurate to within inches) to very small (accurate only in broad overview).

4.3.10 GIS is a special case of information systems where the database consists of observations on spatially distributed features, activities, or events, which are definable in space as points, lines or areas. A GIS manipulates data about these points, lines, and areas to retrieve data for adhoc queries and analyses (Dueker [1979; P. 106]).

4.3.11 GIS is an automated set of functions that provides professionals with advanced capabilities for the storage, retrieval, manipulation, and display of geographically located data (Ozemoy, Smith, and Sicherman [1981; P. 92])

4.3.12 GIS is defined as a powerful set of tools for collecting, storing, retrieving, at will, transforming and displaying spatial data from the real world (Burrough [1986; P. 6]).

4.3.13 GIS is defined as a form of MIS [Management Information System] that allows map display of the general information (Devine and Field [1986; P. 18]).

4.3.14 GIS is a system for capturing, storing, checking, manipulating, analyzing, and displaying data which are spatially referenced to the Earth (Department of the Environment [1987, P. 132]).

4.3.15 GIS is a database system in which most of the data are spatially indexed, and upon which a set of procedures operated in order to answer queries about spatial entities in the database (Smith, Menon, Starr, and Estes [1987; P. 13]).

4.3.16 GIS is any manual or computer based set of procedures used to store and manipulate geographically referenced data. (Aronoff [1989, P. 39])

4.3.17 GIS is an institutional entity, reflecting an organizational structure that integrates technology with a database, expertise, and continuing financial support over time (Carter [1989; P. 3]).

4.3.18 GIS is a system with advanced geo-modeling capabilities (Koshkariov, Tikunov, and Trofimov [1989; P. 259])

4.3.19 GIS is an information technology, which stores, analyses, and displays both spatial and non-spatial data (Parker; [1989; P. 1547]).

4.3.20 A geographical information system may be defined as a computer-based information system, which attempts to capture, store, manipulate, analyze and display spatially referenced and associated tabular attribute data, for solving complex research, planning and management problems. The system may be viewed to embody:

1. A database of spatially referenced data consisting of locational and associated tabular attribute data.

2. Appropriate software components encompassing procedures for the interrelated transaction from input via storage and retrieval, and the adhering manipulation and spatial analysis facilities to output (including specialized algorithms for spatial analysis and specialized computer language for making spatial queries), and
3. Appropriate software components including high-resolution graphic displays, large-capacity electronic storage device which are organized and interfaced in an efficient and effective manner to allow rapid data storage, retrieval and management capabilities and facilitate the analysis.

4.3.21GIS can be defined as a computer –based tool that is used for referencing information based at location-such information about terrain. Using GIS, any particular point on a map can serve as a reference to a particular area. As the potential of this technology is huge, one can find this technology being deployed in large number of government sectors.

4.3.22 An information system that has been designed specifically to work with data referenced by spatial and geographic co-ordinates can be appropriately termed as a Geographic Information System. With this information system one can capture, store, retrieve, manipulate and display the results of a spatial analysis of geographically referenced data. GIS thus has the ability to store, process and effectively present the geographically referenced data, primarily because of its power to combine the relational databases with geographic features on the map.

4.3.23 The term geographical information system is now used generically for any computer-based capability for the manipulation of geographical data. A GIS includes not only hardware and software, but also the special device used to input maps and to create map products, together with the communication systems needed to link various elements. The hardware and software functions of a GIS include:

1. Acquisition and verification
2. Compilation
3. Storage
4. Updating and changing
5. Management and exchange
6. Manipulation
7. Retrieval and presentation
8. Analysis and combination.

All of these actions and operations are applied by a GIS to the geographical data that forms its database. (Geographic Information Systems An Introduction by Tor Bernhardsen)

4.3.24 GIS is a system of hardware, software, and procedure designed to support the capture, management, manipulation, analysis, modeling and display of spatially –referenced data for solving complex planning and management problems. - NCGIA Lecture by David Cowen, 1998.

4.3.25 GIS is a system for capturing, storing, checking, integrating, manipulating, analyzing and displaying data, which are spatially referenced to the earth. – Chorley 1987.

4.3.26 GIS is a automated system for the capture, storage, retrieval, analysis and display of spatial data – Clarke1990.

4.3.27 GIS is an integrated package for the input, storage, analysis and output of spatial information, analysis being the most significant. GIS are simultaneously the telescope, the microscope, the computer and the Xerox machine of regional analysis and synthesis of spatial data.

4.3.28 At the simplest level, GIS can be thought of as a high-tech equivalent of a map. GIS facilitates map creation and data storage in an easily accessible digital format, which, in turn, enables complex analysis and modeling [2].

4.3.29 In the strictest sense, a GIS is a computer system capable of assembling, storing, manipulating, and displaying geographically referenced information, i.e. data identified according to their locations. Practitioners also regard the total GIS as including operating personnel and the data that go into the system – United States Geological Survey (USGS).

4.3.30 A geographic information system (GIS) is a computer-based tool for mapping and analyzing things that exist and events that happen on earth. GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps – Environmental Systems Research Institute (ESRI).

4.3.31 GIS is an integrated system of computer hardware, software, and trained personnel linking topographic, demographic, utility, facility, image and other resource data that is geographically referenced. - NASA

4.3.32 A GIS is a computer system for managing spatial data. The word geographic implies that location of the data items are known in terms of geographic co-ordinates (Latitude and Longitude). The word information implies that the data in a GIS are organized to yield useful knowledge, often as coloured maps and images, but also as statistical graphics, tables and various onscreen responses to interactive queries. The word system implies that a GIS is made up from several interrelated and linked components with different functions.

Thus GIS has functional capabilities for data capture, input, manipulation, transformation, visualization, combination, query, analysis, modeling and output. A GIS consists of a package of computer programmes with a user interface that provides access to particular function.

4.4 COMPONENTS OF A GIS:

A working GIS integrates five components: Hardware, Software, Data, People, and Methods.

4.4.1 Hardware:

Hardware is the computer on which a GIS operates; GIS software runs on a wide range of hardware types, from centralized computer server to desktop computers and in stand-alone or networked configurations.

4.4.2 Software:

GIS software provides the functions and tools needed to store, analyze and display geographic information. Key software components are

1. Tools for the input and manipulation of geographic information.
2. A database management system (DBMS)
3. Tools that support geographic query, analysis and visualization.
4. A geographical user interface (GUI) for easy access to tools.

4.4.3 Data:

Possibly the most important component of a GIS is the data. 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 mange spatial data.

4.4.4 People:

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

4.4.5 Methods:

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

Geographic Information System- The organized activity by which people,

1. Measure aspects of geographic phenomena and processes.
2. Represent these measurements, usually in the form of a computer database, to emphasize spatial themes, entities and relationships.
3. Operate upon these representations to produce more measurements and to discover new relationships by integrating disparate sources.
4. Transform these representations to conform to other frameworks of entities and relationships.

These activities reflect the large context (Institution and Cultures) in which these people carryout their work. GIS is primarily a computer software package for organizing data with location dimension. However, its capacity to assimilate the concepts and algorithms from many discipline such as cartography, geography, surveying, statistics, operation research techniques and computational mathematics make it a versatile tool for handling geo-referenced data.

It establishes one-to-one correspondence between the spatial and non-spatial data and thereby performs an integrated analysis. The spatial data could be in the form of charts, aerial photos, satellite imageries, plane table surveyed maps and Global Positioning System (GPS) generated observations i.e. essentially mapped databases. The non-spatial or the attribute data could be in the form of words, numbers and symbols obtained from say census, secondary surveys and other sources.

GIS has the capacity to keep spatial and non-spatial information in different layers. The information can be processed according to any combination of layers. This greatly facilitates various spatial operations like overlay, union, intersection and clippings of maps with corresponding operation performed on the linked databases. The results of the analysis could be depicted in the form of maps, statistical table, reports and slide [3].

4.5 DATA ORGANISATION METHODS:

4.5.1 Layer Based Approach:

The traditional method of classifying information in a GIS derived from the ability to graphically distinguish various layers or levels of data, also affected by the practical limitations of available computing capacity. Compared to previous means of producing hard copy maps, though, these restrictions did not prevent reasonable modeling of data. Rather, it allowed the storage, maintenance, and manipulation of many more levels of information than previously possible through manual drafting or overlay means.

GIS stores information about the world as a collection of thematic layers that can be linked together. Many GIS related issues require information from four or five or even more layers for analysis [4]. Thus the primary function of a GIS is to link multiple sets of geo-spatial data and graphically display that information as maps with potentially many different layers of information. Assuming that all the information is at the same scale and has been formatted according to the same standards, users can potentially overlay spatial information about any number of specific topics to examine how the layers interrelate. Each layer of a GIS map represents a particular "theme" or feature, and one layer could be derived from a data source completely different from the other layers. For example, one theme could represent all the streets in a specified area. Another theme could correspond to all the buildings in the same area, and others could show vegetation or water resources. As long as standard processes and formats have been arranged to facilitate integration, each of these themes could be based on data originally collected and maintained by a separate organization.

This simple but extremely powerful and versatile concept has proven invaluable for solving many real-world problems, analyzing this layered information as an integrated whole can significantly aid decision makers in considering complex choices, such as where to locate a new department of motor vehicles building to best serve the greatest number of citizens, tracking delivery vehicles, to record details of planning applications, to modeling global atmospheric circulation.

Figures below portray the concept of data themes in GIS. The expansion of Internet connectivity in recent years has substantially enhanced the potential value of GIS because now it is possible to locate and harness data from many disparate GIS databases to develop very rich analytical information on almost any topic that is associated with physical locations. Data that were once collected and used only for a single purpose could now have much broader applications. Further, the community of GIS users has been broadened to include potentially anyone with an Internet connection. For example, citizens can now use home computers to obtain answers to specific questions about land use in their state or local jurisdiction. Commercial entrepreneurs can combine GIS data about zoning and tax-incentive areas to determine what parts of a city are best suited for establishing a new business.

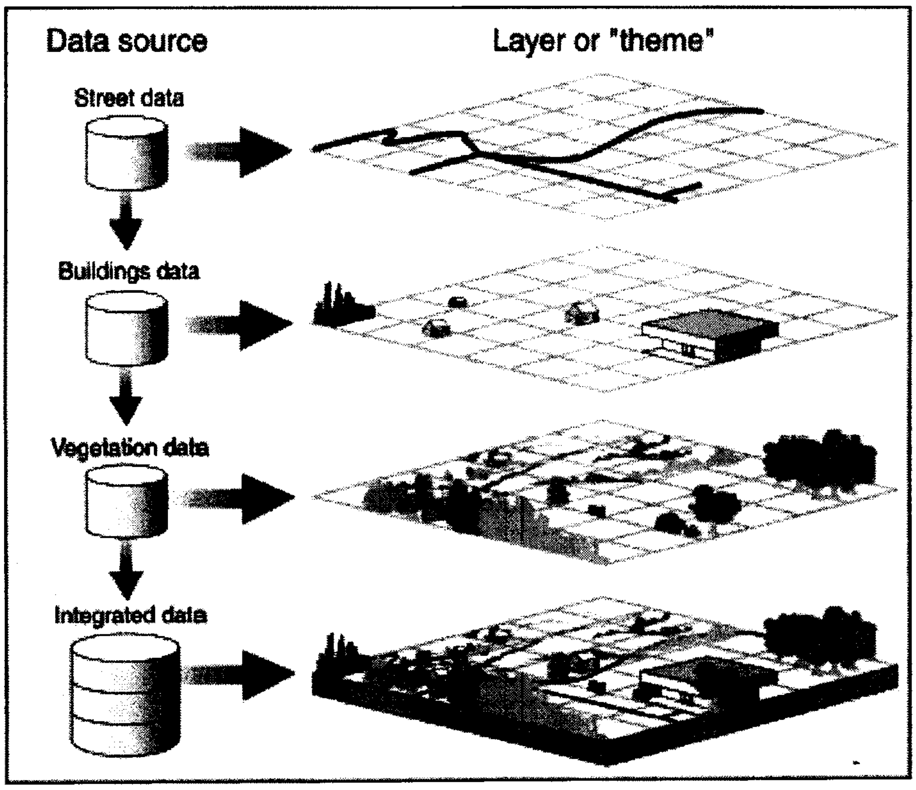

Figure 4.1: GIS Layers or "Themes"

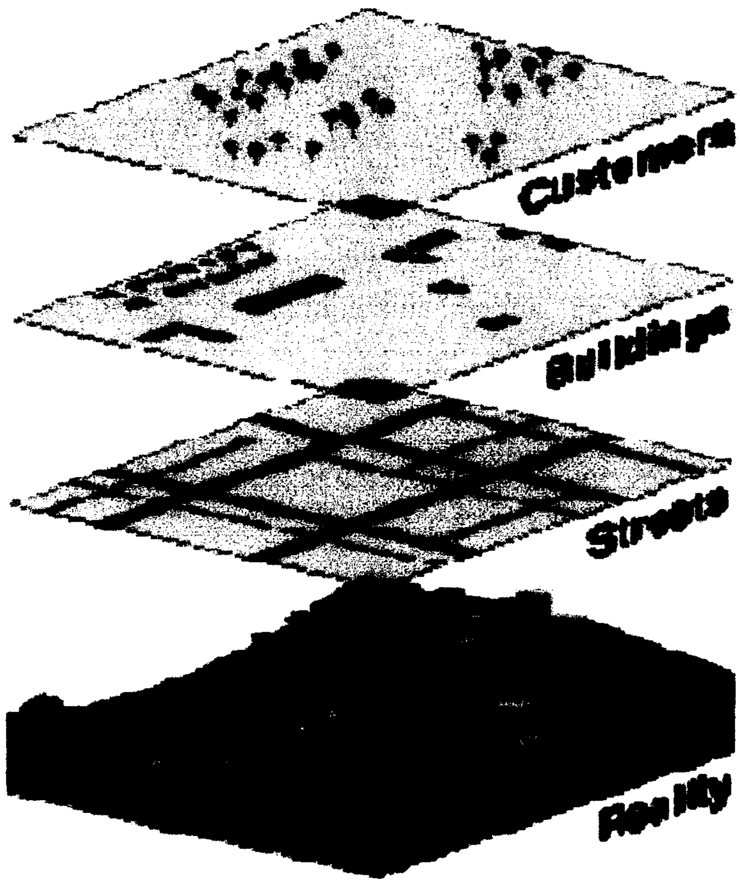

Figure 4.2: Layer Based Approach [1]

In addition to all cartographic information GIS allows for the powerful addition of tabular information to be attached to the GIS layers. The figure below shows how each element of a map layer is given a unique id number. These unique id number ties into a database management system. This allows for the addition of attributes describing the cartographic data.

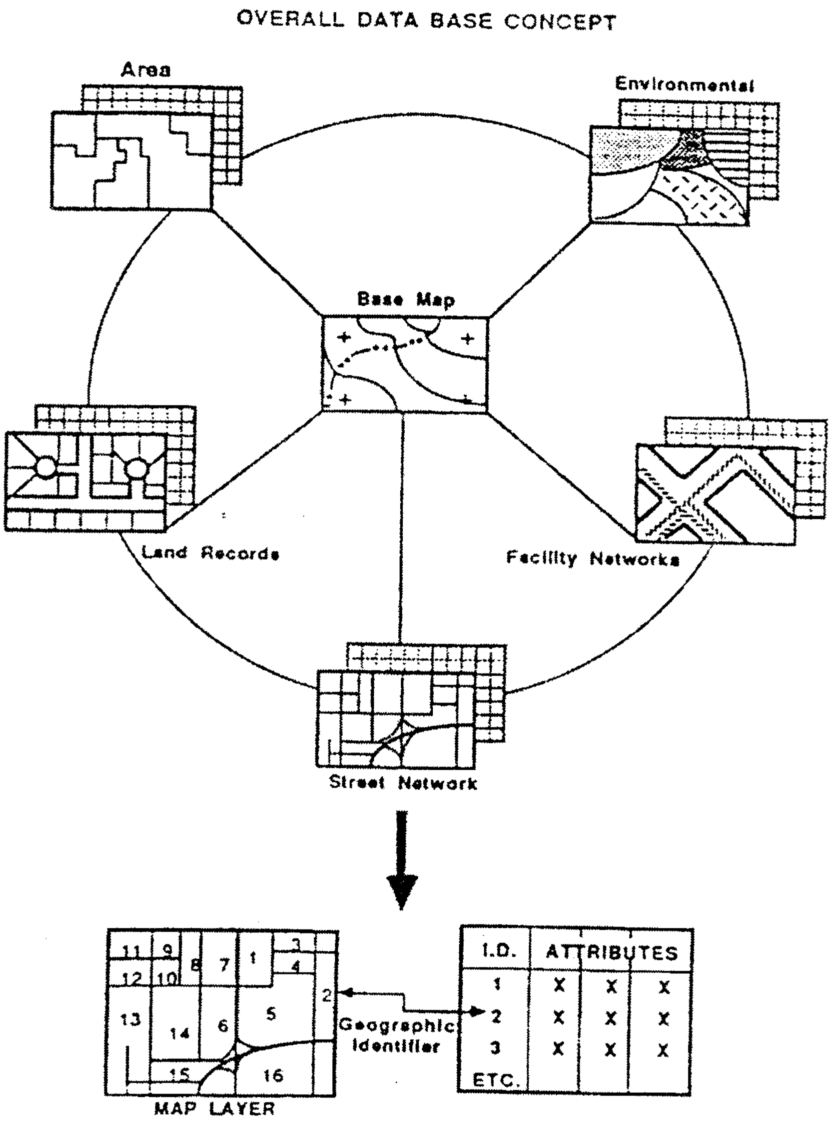

Figure 4.3: Map Layer and Tabular Attributes Linked by Geographic Identifier

4.5.2. Object-Oriented Approach:

An alternative method for organizing spatial data is objected-oriented. In an objected –oriented GIS, the geographic features and all the information related to a feature are stored as an object. "An object is a structure that represents a single entity, describing both its information content and its behavior. Every object belongs to a class, which defines a structure and a set of operations that are common to a group of objects. Individual objects of a given class are often referred to as instances of the class". When using an object-oriented model in a GIS "each object instance contains all of its graphical characteristics, its geographic location, and all of the associated data."

By storing information in thematic data layer or objects registered to a common geographic coordinate system, any combination of these layers or objects may be overlaid to form a new dataset to be used to answer a question or analyze a problem. This ability to manipulate the separate data layers and objects provide a GIS with vast analytical power [5].

4.5.3 Relational Approaches:

As a first step in the evolution from a purely graphical system, it was recognised that links to additional geographic attributes in a GIS would radically increase the utility and power of such information system. Although early GISs provided an ability to graphically model and depict cartographic information, such systems became extremely cumbersome and limiting when trying to really apply the power of computers to selective retrieval and analysis of spatial information. The simplest relational model used in GIS consists of a graphic-based component that carries with each geographic primitive (Points, Line or Polygon), a unique identifier or tag, which is the means to associate the geometry with additional non-graphic information defining the characteristic of the spatial feature.

4.6 DATA CAPTURE AND STORAGE:

A GIS can be used to emphasize the spatial relationships among the objects being mapped. While a computer-aided mapping system may represent a road simply as a line, a GIS may also recognize that road as the border between wetland and a urban development, or as the link between main street and the super express lane.

If the data to be used are not already in digital form that is in a form a computer can understand and recognize, various techniques are available to capture the information. Maps can be digitized, or hand traced with a computer mouse, to collect the coordinates of the features. Electronic scanning devices will also convert map lines and points to digits.

Putting the information into the system is the time consuming component of GIS work. Identities of the object on the map must be specified, as well as their spatial relationships. Editing of information that is automatically captured can also be difficult. Electronic scanners record blemishes on a map just as a faithfully as they record the map features. For example, a fleck of dirt might connect two lines that should not be connected. Extraneous data must be edited, or removed from the digital data file.

GIS has the ability to extract information from one layer of topology based on its relationship to another layer, and to integrate information from different topological layers based on their relationship to each other. An important concept, which makes GIS different from other computerized graphical system, is topology. Topology is defined as the spatial relationships between connecting or adjacent spatial objects (Example: Points, Lines, Polygons).

Topological relationships are built from simple elements into complex elements such as points (simplest element), line (sets of connected points) and polygons (closed set of connected lines) [6].

4.7 GRAPHICAL REPRESENTATION OF OBJECTS:

Graphical information on objects may be entered in terms of

1. Points (No dimension)
2. Lines (One dimension)
3. Areas / Polygon (Two dimensions)

4.7.1 Points:

A point is the simplest graphical representation of an object. Points have no dimensions but may be indicated on maps or displayed on screen using symbols. The corner of a property boundary is a typical point, as is the representative coordinate of a building. The scale of viewing determines whether an object is defined as a point or an area. In a large-scale representation a building may be shown as an area, whereas it may only be a point (symbol) if the scale is reduced.

4.7.2 Lines:

Lines connect at least two points and are used to represent objects that may be defined in one dimension. Property boundaries are typical lines, as are electric power lines, telecommunication lines. Roads and rivers on the other hand, may be either lines or areas depending on the scale.

4.7.3 Areas/polygons:

Areas are used to represent objects defined in two dimensions. An area may typically represent a lake, an area of woodland, or a township. Again, physical size in relation to the scale determines whether an object is represented by an area or by a point. An area is delineated by at least three connecting lines, each of which comprises points. In databases, areas are represented by polygons (i.e., plane figures enclosed by at least three straight lines intersecting at a like number of points). Therefore, the term polygon is often used instead of area.

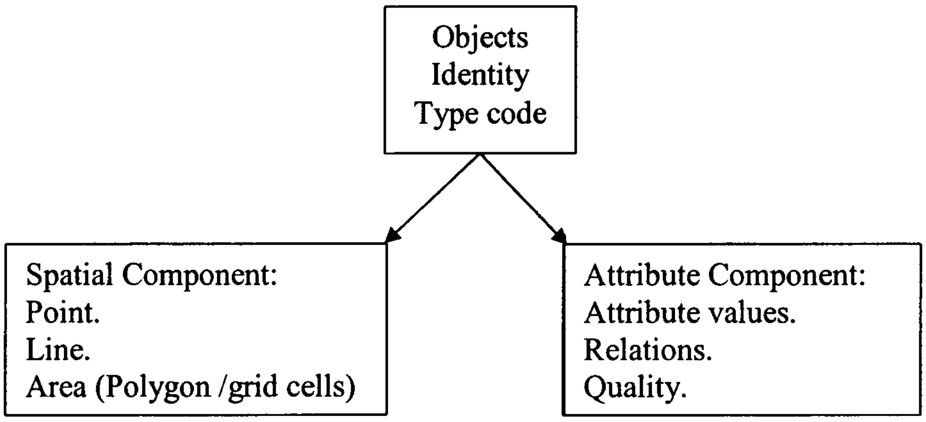

Figure 4.4: Objects Identity Code Type

4.7.4 Textual Database:

Besides the spatial information in a map, the GIS can usually store non-spatial information, which is related to the spatial entities. For instance an urban GIS database may have a map theme of property boundaries. Attached to each parcel will be the textual database, which might store the name of the owner, the address, the assessed value of the property, or the type of services and utilities available on the/ near the site [7].

4.8 DATA TYPES IN GEOGRAPHIC INFORMATION SYSTEMS (MAP DATA REPRESENTATION) [8]:

A Geographic information system stores two types of data that are found on a map- the geographic definitions of earth surface features and the attributes or qualities that those features possess. Not all systems use the same logic for achieving this. Nearly all, however, use one or a combination of both of the fundamental map representation techniques:

1. Raster Based
2. Vector Based

Even though both techniques do the basic task of storing, retrieving, updating, manipulating, and displaying data, their basic structures are different, and their displays are strikingly different.

4.8.1 Vector Systems:

With vector representation, the boundaries or the course of the features are defined by a series of points that when joined with straight lines, form the graphic representation of that feature. The points themselves are encoded with a pair of numbers giving the x and the y coordinates. That is the information about points, lines and polygons is encoded and stored as a collection of x and y coordinates. The location of a point feature, such as a bore well/bore hole can be described by a single x, y coordinate. For example, the location of a point, which is 300 meters east, and 200 meters north of an origin (0, 0) would be stored as the x, y co-ordinate pair (300,200). 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.

The vector model is extremely useful for describing discrete features, but less useful for describing continuously varying features such as soil type or accessibility costs for hospitals. Vector GIS's produce data products more like the analog maps produced by draftsmen of CAD system. Most of the data layers are developed digitizing (Determining the latitude and the longitude) lines from existing maps, changing the digitized lines into polygons, and storing these polygons along with their attributes. The familiar map graphics and ability of vector systems to include very small or minor areas are the most important advantage of vector GIS.

Vector system has the following drawbacks:

1. Slower computer operational speeds during the query process.
2. Generation of silvers during the overlay process.
3. Problems creating vector data from raster data.
4. Inability of vector system software to process more than two data layers in the same query statement.
5. Vector data usually requires less storage space in the computer, but it may be difficult in a vector system to perform certain data overlay functions, vector processing requires more sophisticated programming and processing time.
6. In a vector system, coordinates may be stored at any desired scale [8].

Table - 4.2

Some Common Vector Data Formats

Name	Description
GBF/DIME (Geographic Base File/Dual Independent Map Encoding)	The data format developed by the US Bureau of the Census for digitally storing street maps to assist in the gathering and tabulation of data for the 1970 census, which was used again for the 1980 census
TIGER (Topologically Integrated Geographic Encoding and Referencing system)	Created by the US Bureau of the census as an improvement to the BBF/DIME and was used in the 1990 census. This format is known as TIGER/SDTS for the 2000 census.
DLG (Digital Line Graphs)	The format used for the USGS topographic maps
AutoCAD DXF (Data Exchange Format)	One of the file formats of AutoCAD and AutoCAD Map that has become de facto industry standard and is widely used as an export format in many GIS
IGDS (Intergraph Design System) DGN File	A proprietary file format for Intergraph CAD systems, which is also widely used in the mapping industry.
ArcInfo Coverage	The proprietary data format of ArcInfo; stores vector graphical data using a topological structure explicitly defining spatial relationships.
ArcInfoE00	The export format of ArcInfo.
Shapefiles	The data format for ArcView GIS that defines the geometry and attribute of geographically referenced objects by three specific files (i.e., a main file, an index file, and a database table.)
CGM (Computer Graphics Metafile)	An ISO standard for vector data format that is widely used in PC-based computer graphic applications.

Source: C. P. Lo. Albert. W. Yeung, Concepts and Techniques of Geographic Information Systems; PHI (2002), P. 87.

4.8.2 Raster Systems:

With raster systems, the graphic representation of features and the attributes they possess are merged into unified data file. In fact, we typically do not define features at all. Rather, the study area is divided into a fine mesh of grid cells in which we record the condition or attribute of the earth's surface at that point. That is Raster data are stored as a matrix of pixels (Contraction of the term picture element) with each pixel location assigned a row and column designation.

Each cell is given a numeric value, which may than represent either a feature identifier, a qualitative attribute code, or a quantitative attribute value. For example, a cell could have a value "6" to indicate that it belong to District 6 (A feature identifier), or that it is covered by soil type 6 (A qualitative attribute) or that it is 6 meters above sea level (A quantitative attribute value).

Points are represented as a single pixel, lines as a series of contiguous pixels, and area as group of pixels.

Raster systems have several drawbacks:

1. The graphic output does not look like maps people are used to seeing.
2. Minor characteristics of an area may be lost.
3. Linear data, such as roads, are difficult to depict.
4. Boundaries between units are often represented by stair steps.

5. With raster storage it is necessary to store the entire matrix of rows and columns. Storing the entire matrix may include unwanted data.

Raster system has the following advantage:

1. The raster structure, by virtue of its matrix, has a built in ability to perform neighborhood-type analysis easily, that is, it is easy for the computer to identify which features are adjacent to other features because of the row and column structure.

Thus Vector data represents geographic entities by means of an x-y coordinate system. Raster data uses a matrix of cells, which form a grid, the data grid themselves can be thought of as images- images of some aspect of the environment-or as layers-each one of which stores one type of information over the mapped region- that can be made visible through the use of a raster display.

Table - 4.3

Some Commonly Used Raster File Formats

Format Name	Description
BMP	The format used by bit map graphics in Microsoft windows application.
PCX	A proprietary bit map format of Zsoft that is supported by many image scanners.
TIFF (Tagged Image File Format)	A nonproprietary system-independent format designed as a non proprietary format for the storage of scanned images and the exchange of data between graphics packages. TIFF/JPEG, commonly referred to as TIFF 6.0, is an extension of the TIFF format.
GeoTIFF	An extension of the TIFF format that contains georeferencing information in its file header. GeoTIFF is developed and maintained as the result of the concerned effort of GIS software developers, commercial data suppliers, and data users to provide a publicly available and platform – interoperable standard for the support of raster geographic data in TIFF.
GIF (Graphic Interchange Format)	A cross platform format, proprietary to CompuServe that is widely used for the transmission of images on the world wide web.
JPEG (Joint Photographic Experts Group)	Another cross-platform format developed primarily for storage of photographic images and is also widely used for graphics on the world wide web
PNG (Portable Network Graphics)	A patent free raster format that is intended to replace the proprietary GIF format
GRID	The proprietary raster format used by ESRI (Environmental Systems Research Institute Inc.) in its software products such as ArcInfo and ArcView GIS

Source: C.P.Lo. Albert. W. Yeung, Concepts and Techniques of Geographic Information Systems; PHI (2002), P. 87.

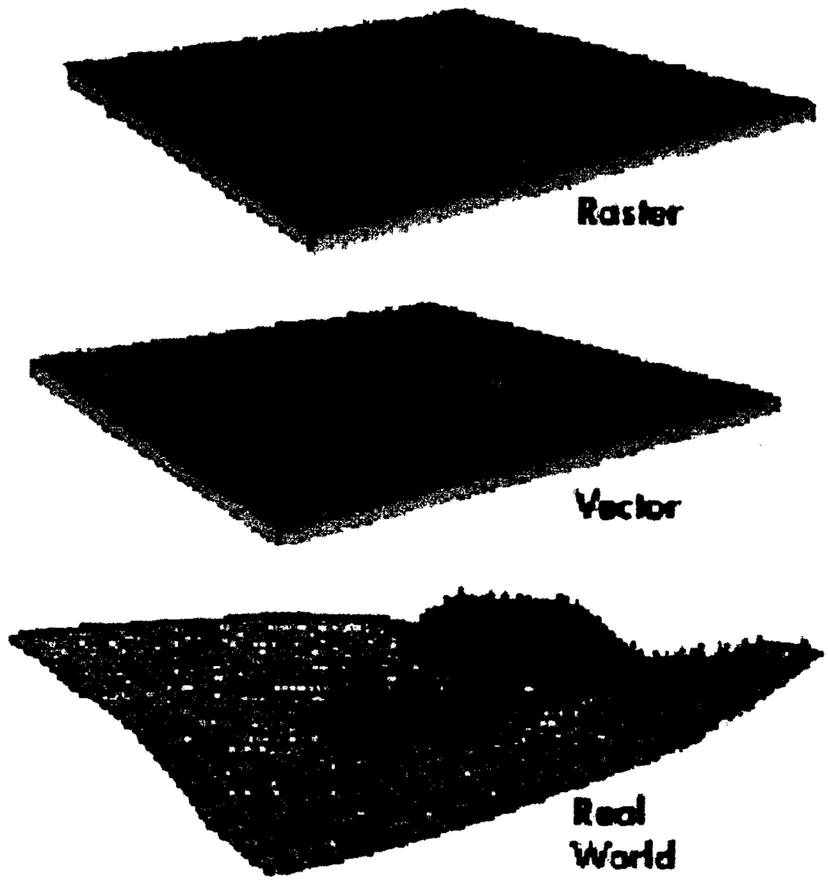

Figure 4.5: Raster and Vector Representations of Real World Data [10]

4.8.3 Raster Versus Vector:

Raster systems are typically data intensive (Although good data compaction techniques exist) since they must record data at every cell location regardless of whether that cell holds information that is of interest or not. However, the advantage is that geographical space is uniformly divided in a simple and predictable fashion. As a result, raster systems have substantially more analytical power than their vector counterparts in the analysis of continuous space and are thus ideally suited to the study of data that are continuously changing over space such as terrain, vegetation biomass, rainfall and the like.

The second advantage of raster is that its structure closely matches the architecture of digital computer. As a result, raster systems tend to be very rapid in the evaluation of problems that involve various mathematical combinations of data in multiple layers. Hence they are excellent for evaluating environmental models such as soil erosion potential and forest management suitability. Further satellite imagery employs a raster structure, most raster systems can easily incorporate these data, and some provide full image processing capabilities. Raster systems are predominantly analysis oriented.

Vector systems are more database management oriented. Vector systems are quite efficient in their storage of map data because they only store the boundaries of features and not what's inside those boundaries. Because the graphic representation of features is directly linked to the attribute database, vector systems usually allow one to roam around the graphic display with a mouse and inquire about the attributes associated with a displayed feature, such as the distance between points or along lines, the areas of region defined on the computer screen.

Vector systems do not have as extensive a range of capabilities for analysis over continuous space. They do however excel at problems concerning movements over a network and can undertake the most fundamental of GIS operations that will be sketched out below. For many, it is the simple database management functions and excellent mapping capabilities that make vector systems attractive. Because of the close affinity between the logic of vector representation and traditional map production, a pen plotter can be driven to produce a map that is indistinguishable from that produced by traditional means. As a result, vector systems are very popular in municipal applications where issues of engineering map production and database management predominates.

4.8.4 Querying the GIS:

GIS stores both spatial and non-spatial data in a database system, which links the two types of data to provide flexible and powerful ways of querying or asking about the data. In some cases we query by location For example "what land use is at this location?" In other cases we query by attribute –"What areas have high levels of carbon-di-oxide?" Some time we undertake simple queries such as the above and at other time we ask about complex compounds of conditions like- "Show all wetlands that are larger than 1 hectare and that are adjacent to industrial lands" [11].

4.9 APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS:

At a broad range of scales, map have become increasingly important as legal document that convey land ownership and jurisdictional boundaries, as tools to support decision making (For example, in urban planning).

GIS provides the ability to completely model utility networks, such as those supplying water, power and telecommunications to a large number of consumers. Such a system may operate at a variety of scales, modeling service connections to consumers, service districts as well as detailed facilities inventories and layouts, such as transformers, valves conduits, and schematic diagrams.

What's in a GIS map? Today we look for it to guide our decision-making through fuller control of our natural resources, a giant step in itself and more than ambitious enough in many respects. GIS has become a key element at many levels:

1. In customer support (to respond to service failure),
2. In maintenance and daily operations (To identify work requirements and assess inventories) and
3. In planning (to respond to projected needs).

GIS provides link between many information systems, including engineering, planning and customer billing, which can increase overall performance and operational efficiency. Examples of the types of activities that are being addressed through this technology are listed below:

1. *Municipal Infrastructure:* Centre-line drawings for streets, water and sewer utilities linked to databases for integrated planning, construction, and maintenance management.
2. *Regional Planning:* Maps, land records, highways, redevelopment plans analyzed for regional impact.
3. *Tax Management:* Property maps, tax records, assessment for tax collection and planning.

4. *Emergency Services:* Responding to fire, explosions, hazardous material spills, and other unpredictable events.

5. *Environmental Studies:* Evaluation of wetlands, erosion patterns and watersheds using aerial digital orthophotography.

6. *Oil Spill Impacts:* Remote sensing and surface based evaluation for tanker spills, war disasters, and real time management of emergency operations.

7. *Wastewater Management:* integrated planning system including sewers, catch basins, ditches, and waterways for planning storm impacts.

8. *Water Quality Management:* Modeling soil, land use, and watershed characteristics to evaluate alternative scenarios.

9. *Air Emissions:* Modeling and display of dispersal and risk from air toxics on regions surrounding industrial facilities.

10. *Process Hazard Analysis:* Linking drawings and databases to conduct hazardous operations analysis for chemical operations.

11. *Forestry Management:* Imaging and digital elevation modeling to evaluate damage to forests from the effects of fire, logging, pesticides, and acid rain and to describe trends in forest resources.

12. *Population Planning:* Spatial distribution and mapping overpopulation and slums in underdeveloped countries using satellite imagery.

13. *Habit Characterization:* Analysis of population and migration patterns to support preservation of endangered species.

14. *Urban Development Planning:* Modeling diffusion of development processes to predict real estate growth patterns.

15. Use of GIS as Automation Tool: GIS may be seen as a means to automate spatial operations or as a tool for obtaining better information about business operations. Map automation is most relevant where traditional paper maps were used; this arises only in specialist role in most business organisations. One example is the field of Facilities Management (FM), which makes use of computer aided design approach to record factory layouts, location of pipe networks etc. Typically these layouts were superimposed on maps, therefore GIS can be used better integrate this data and to produce appropriate integrated maps in a less expensive and timelier way.

    Utility companies such as electricity, gas or water companies can also exploit GIS to support routine maintenance of pipe, cable and power networks. For these organisations, the ability to locate quickly a pipe or cable is critical to their ability to continue to provide service to their customer. GIS based technology can be used to automate the search procedure for pipe location, thereby making operations more efficient.

16. *GIS as a Database:* A GIS interface can be used to query a database; although this requires a more sophisticated interface with the ability to formulate a query using interactive commands. Modern desktop GIS software packages like MapInfo, ArcGis, ArcInfo, ArcView have sophisticated database functionality. Database capability allows queries to be generated in the GIS to show only areas selected by attribute value, for example sales value. This type of software also allows simple spatial database queries such as selection of a particular region and operations such as buffering or overlay.

17. *GIS as an Information Tool:* The simplest forms of information-based application are those where a map is produced with some graphical information on attribute values superimposed. Presentation

mapping has been identified as the dominant requirement of the business use of GIS based technology. Presentation mapping creates a one-way report; the user cannot query the map presented, instead the user assimilates the information provided and indirectly manipulates the data.

Modern desktop GIS software, such as ArcGIS or MapInfo, can be regarded as much more than presentation mapping software. This software can be better regarded as illustrating the database or spatial analysis view of GIS. However, in addition this type of software also provides comprehensive presentation facilities. These facilities include the ability to generate thematic maps using a variety of shading techniques, bar and pie charts, graduated symbols, and dot density maps. Modern presentation mapping software allows three-dimensional representation to be used, with the capability to extrude areas on the map to represent particular attribute.

4.9.1 Business Application of GIS:

Business organizations operate in an ever changing and challenging environment, in which competitive forces require that information technology be exploited to the full. On widely cited model of business, the Value Chain Model by Porter identifies five primary business activities:

1. Inbound Logistics (Inputs)
2. Operations
3. Outbound Logistics (Outputs)
4. Marketing and sales and
5. Services.

Information Technology can contribute to the efficient organization of all the primary business activities. As business environment becomes increasingly competitive, the use of IT becomes an important component of business strategy. Importantly, spatial techniques can have major role in this contribution. There is increasing concern about the natural environment and companies are anxious to be seen to respond to these concerns. Issues such as pollution control often have a spatial dimension and planning for the location of new facilities requires the use of spatial techniques to address public concern over issues such as traffic impacts.

4.9.2 Logistics Support:

Business logistics has an inherent spatial dimension, as goods must be moved from one point to another. Modern businesses have sophisticated supply chain, with goods being moved around the world on a just-in-time basis. However, these supply chains are vulnerable to disruption due to political events, bad weather and natural disasters and unforeseen events: such as quarantine due to diseases. In these circumstances, it is important to be aware of the spatial location of parties involved and to be able to plan rapidly alternative routes to resolve any difficulties.

It is therefore not surprising that routing and location analysis are some of the most important areas of application of spatial techniques, a good example being the comprehensive restructuring of a Procter and Gamble's logistics. Logistics applications are therefore of considerable importance to business and a field where the contribution of quantitative approaches has long been recognized, in the fields such as routing and location analysis.

4.9.3 Operational Support:

Organizations with substantial use of spatial data for logistics form one group of potential users of GIS techniques. Other organizations will focus on the use of spatial techniques for different operational applications. IT continues to be of critical importance to the routine operations of many businesses, which rely on systems, such as airlines booking systems, point of sales system and bank networks to facilitate their routine operations.

Many operational applications of GIS lie in the government sector, these often involve private contractors. For example, road networks may be publicly owned, but may be constructed and maintained by the private sector. The use of GIS should lead to greater efficiencies in this type of application and ultimately to new procedures and processes for the allocation of this type of work.

Organisations using spatial data for operational reasons have the opportunity to exploit their spatial data resources for strategic management purposes. This will mean a move towards spatial decision support applications and the incorporation of spatial data in the Executive information systems (EIS).

The synthesis of EIS and spatial techniques is most promising where there is already a large volume of operational spatial data in the organization, as well as a requirement for access to spatial data outside the organization.

4.9.4 Marketing:

In disciplines such as marketing, additional possibilities for analysis are provided by the availability of increasing amount of reasonably priced spatial data. Demographic data is of particular importance to business and basic census information is now available for use in GIS throughout the western world. The relevance of GIS to this type of work is becoming widely recognized. The availability of user friendly SDSS to manipulate this type off data will lead to additional decision possibilities being examined, which are difficult to evaluate without the use of such techniques. This is reflected in increasing interest in spatial applications for sectors such as retailing, which may not have used this form of technical analysis in the past. GIS has been seen as being a critical component of a marketing information system.

4.9.5 Service:

Within Porter's value chain model, service refers to customer related activities other than direct sales and product delivery. This would include after sales service and support. With the routine high standards in modern manufacture and the outsourcing of logistics, service is often one area where companies can try to achieve a competitive advantage.

GIS based techniques have an important role to play in customer service. Call centers will often use a customer's telephone number to identify where they are calling from, thereby providing a service appropriate to that customer. Spatial database can be used to identify the nearest shop or repair centre or an ATM of a particular bank for a customer. Utilities can identify whether a customer is sufficiently close to a cable network or telephone exchange to avail of an improved service.

4.9.6 New Areas for SDSS Use in Business:

One area of growing importance of SDSS application is businesses where the importance of both spatial data and modeling is some what neglected at present, in sectors where decision-makers are less accustomed to using maps. Groups such as insurance sector have been accustomed to using statistical and actuarial models, but have not attempted to use information on the location of their customers. As insurance risks are often strongly spatially correlated, this sector needs to make more use of spatial techniques in the future.

Mobile computing and telecommunications is an emerging area of IT application that is of increasing interest to business. GIS is widely used by operational activities by mobile service providers for modeling service levels and locating signal masts. Mobile services can be largely distinguished from fixed Internet services by the presence of a locational element. Future developments will enhance the capabilities of mobile devices and we are likely to see the integration of mobile data devices and spatial technologies such as Global Positioning Systems (GPS). This will allow the location of the mobile user to be easily identified and will therefore provide the basis for a service customized to that location. This allows for the growth in situation-dependent services directed at a particular customer in a particular location [12].

4.10 BENEFITS OF GEOGRAPHICAL INFORMATION SYSTEMS:

GIS can lead to new ways of thinking about and dealing with old problems, because the data is tied to a common referencing system, it is easy to use the same data to various applications as well as to associate diverse data sets previously unavailable for joint analysis. Topology permits new questions to be asked and encourages a new style of analysis that is in many cases fundamentally better than those used traditionally.

GIS provides the following benefits:

1. It adds a degree of intelligence and sophistication to a transport database that has previously been unknown.
2. It is possible to perform, geographic queries in a straightforward, intuitive fashion.
3. The analyst can ask a series of geo-based questions and obtain the answers quickly in an easy to understand colour-coded display on the screen, hard copy or disk file.
4. Integrates different databases into one environment. Each layer in a GIS database may represent a complete database (One layer may contain census geographic with associated demographic information. Additional layers might include the national wetlands, Inventory data from the fisheries and wildlife departments, land ownership of the local government so on and so forth). Different individual layer databases are used for their own purposes and analysis, but value increases drastically when included as a layer in a GIS: these layers (databases) may be over laid with one another for spatial analysis.

5. Displays and manages spatial data in a spatial context. Often, spatial data are managed in tabular database that do not allow viewing or management of the data with spatial tools.
6. Production of specialized maps and graphic products.
7. Redundancy and other problems of multiple map sets are eliminated.
8. Map data is easier to search, analyze and present [13].

4.11 FUNCTIONS OF GEOGRAPHIC INFORMATION SYSTEMS:

The processes of integration and interrogation can be broken down into a number of general categories. Laurini and Thompson have identified ten major tasks for spatial information systems:

1. Automated Mapping: Replicating paper maps on computers.
2. Thematic Mapping: For instances using customer information and demographic data.
3. Map Overlay or Composite Mapping: Producing a map from several layers of data.
4. Spatial Querying: Obtaining information from a database in response to identification of particular conditions.
5. Spatial Browsing: Exploring the contents of a database in response to identification of particular conditions.
6. Spatial Problem Solving: For example deducing inclusions of points in polygons, or for spatial decision-making incorporating both spatial and logical deductive reasoning.
7. Analysis of Spatial Data: Tasks which deal with the attributes of entities, like the average size of sales territories or the degree to which product sales are related to weather conditions.

8. Creating Spatial Statistics: Tasks that require measurements of spatial properties of phenomena, like the total distance traveled by a vehicle on a road network.
9. Analysis of Spatial Statistics: Tasks which treat spatial properties as attributes, for example the correlation between the highway network connectivity and levels of economic development.
10. Spatial Analysis: Encompassing tasks, including simulation, which use a variety of tools of spatial statistics and location-based problem solving.

These tasks define ways in which users make use of spatial data. Tasks are carried out on spatial and attribute data sets held in a database.

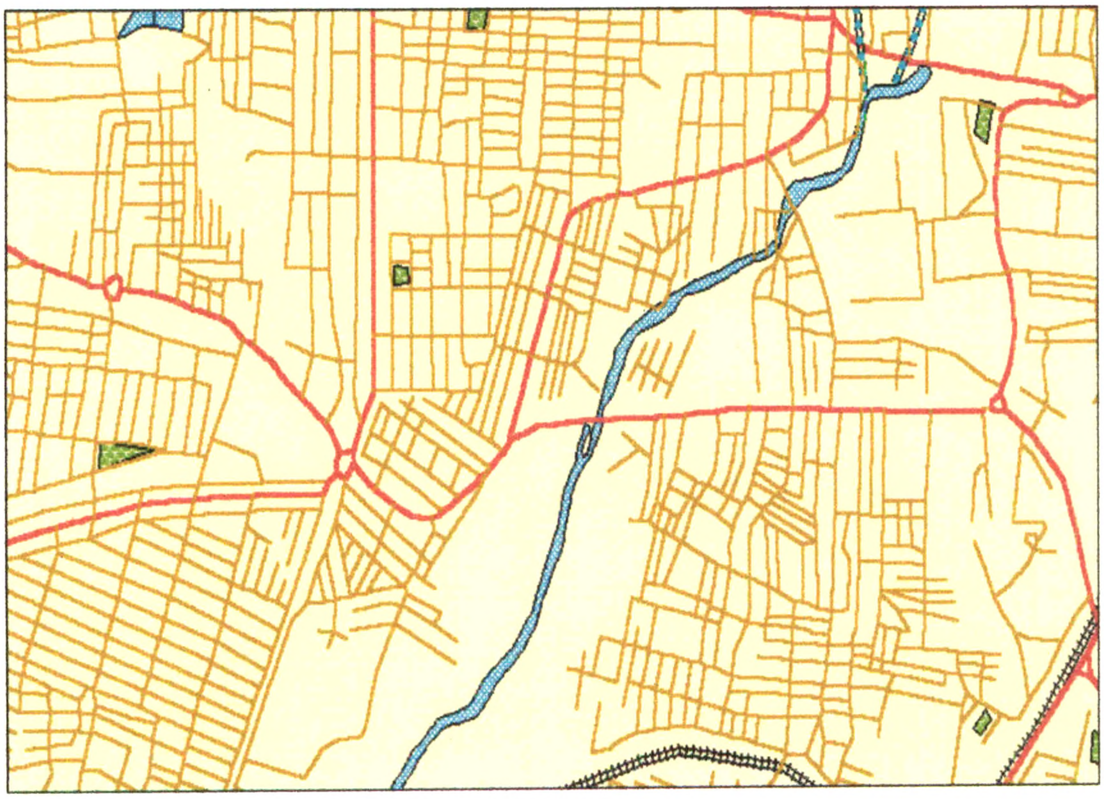

Figure 4.6: Example of Geographical Map Data

VIL_NO	NAME	TALUK	DISTRICT	AREA	PERIMETER	RES_HOUSE	HOUSEHOLDS	T_POPLN	T_M_POPLN
400,100,132	BAWALGAON	Aurad	Bidar	15,263,110	18,920.24	356	356	2,139	1,051
400,100,131	NANDI BIJALGAON	Aurad	Bidar	10,237,210	14,220.72	249	249	1,730	884
400,100,127	CHIKLI UDGIR	Aurad	Bidar	15,904,840	16,859.64	427	427	2,622	1,343
400,100,133	HOKRANA	Aurad	Bidar	15,116,460	16,596.63	472	472	2,897	1,473
400,100,130	MUTHKHED	Aurad	Bidar	4,227,513	8,434.98	101	101	517	264
400,100,125	DABKA(CHAWAR)	Aurad	Bidar	15,042,400	16,422.93	536	536	3,028	1,578
400,100,134	HANGERGA	Aurad	Bidar	10,477,420	13,716.23	320	320	1,769	916
400,100,128	AKANAPUR	Aurad	Bidar	2,264,024	6,320.29	27	27	190	94
400,100,135	SAWARGAON	Aurad	Bidar	9,802,902	12,846.97	234	234	1,445	740
400,100,136	BONTHI	Aurad	Bidar	20,039,430	23,234.16	367	367	2,479	1,265
400,100,138	KHERDA(B)	Aurad	Bidar	11,886,750	14,894.86	323	326	1,919	1,031
400,100,126	GANGANBEED	Aurad	Bidar	12,407,850	13,851.62	173	173	1,210	620
400,100,149	GANESHPUR (UDGIR)	Aurad	Bidar	4,808,090	8,778.43	163	163	993	492
400,100,137	LINGI	Aurad	Bidar	8,293,926	14,247.49	176	178	993	488
400,100,139	BHANDAR KUMTA	Aurad	Bidar	13,433,300	16,015.12	366	366	2,401	1,211
400,100,147	MURKI	Aurad	Bidar	20,344,170	20,860.18	542	542	3,555	1,825
400,100,145	CHIMEGAON	Aurad	Bidar	15,757,360	17,147.8	331	331	1,904	984
400,100,148	WAGANGERA	Aurad	Bidar	5,613,051	10,783.95	104	104	704	364
400,100,146	HANDIKHERA	Aurad	Bidar	7,699,371	11,487.73	287	287	1,844	924
400,100,143	MALEGAON	Aurad	Bidar	4,865,167	9,768.42	184	184	1,338	671
400,100,004	HULYAL	Aurad	Bidar	6,703,383	11,341.05	171	175	1,257	633
400,100,140	DANGORGAON	Aurad	Bidar	9,987,154	13,506.13	173	173	1,011	514
400,100,003	EKAMBA	Aurad	Bidar	19,320,940	18,386.7	496	497	3,100	1,534

Figure 4.7: Example of Computerized Database

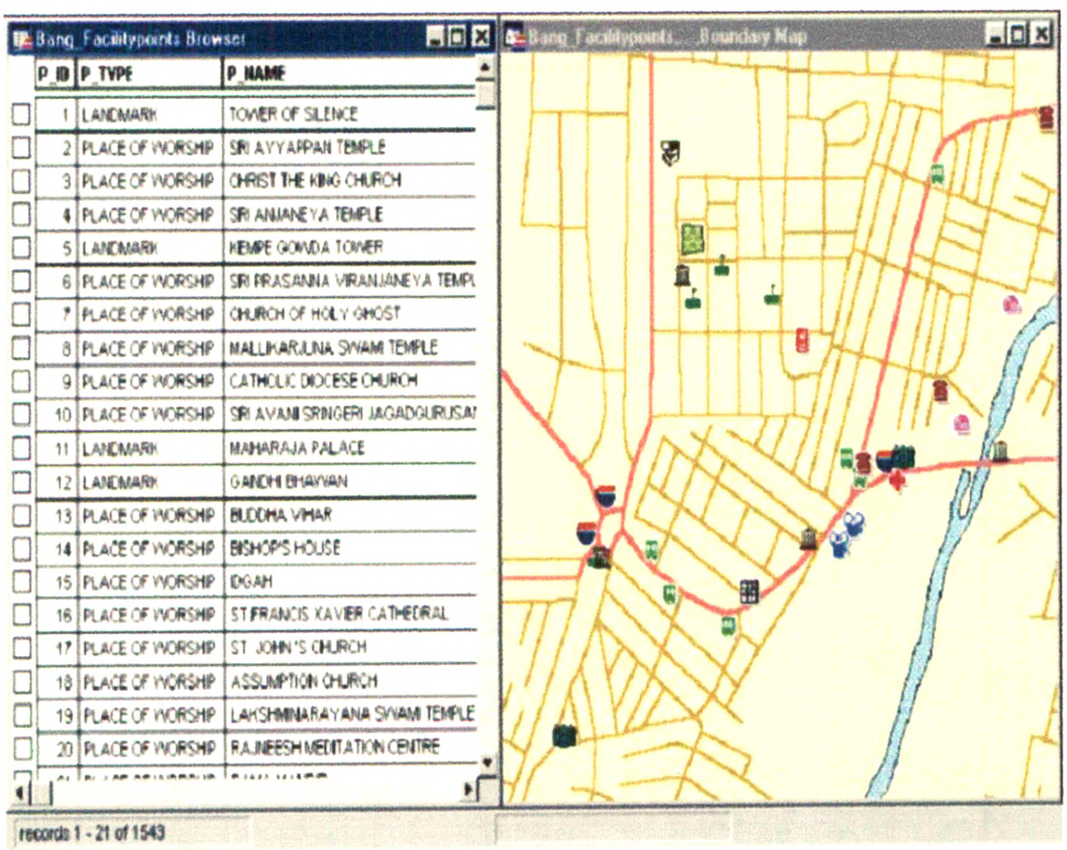

Figure 4.8: Integration of Tabular Data with the Digital Ma:

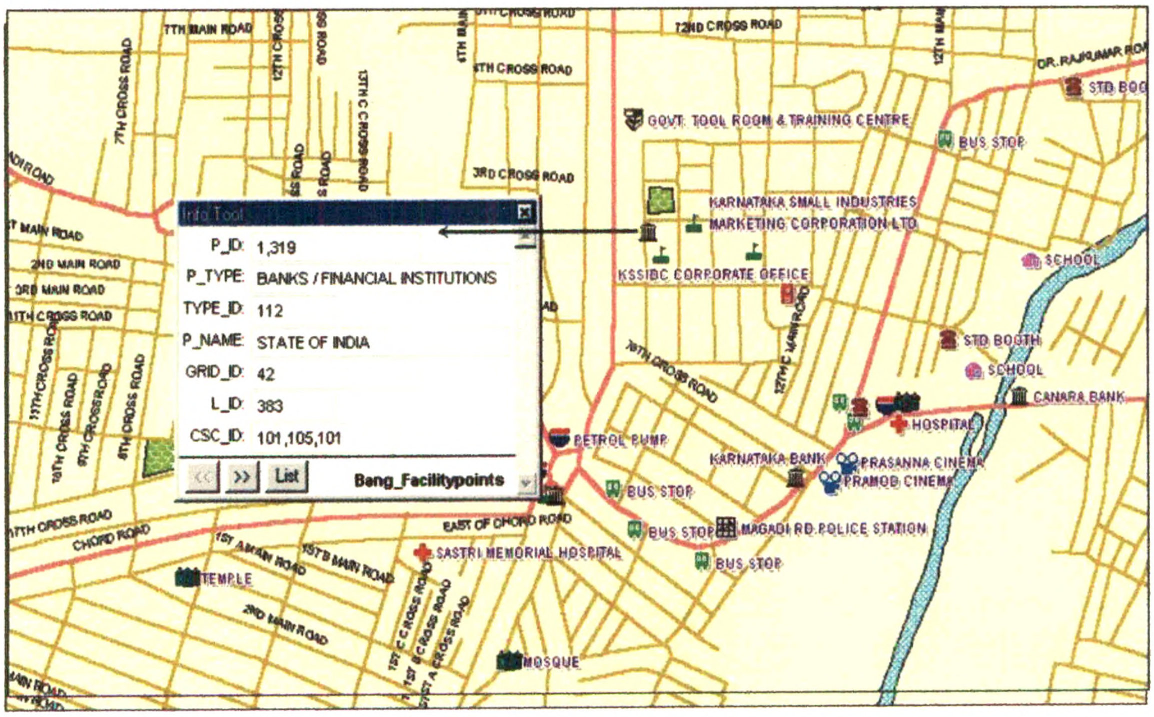

Figure 4.9: Intelligent Map Developed (GIS Data)

YOUR CHOICE:

ID	NAME	AREA	Total_Population
1	Chikmagalur	7,070,867,000	754,494
2	Chitradurga	8,555,236,000	1,347,738
3	Davanagere	5,791,004,000	1,325,182
4	Haveri	4,845,495,000	1,094,942
5	Shimoga	8,250,978,000	1,381,313

TABULAR DATA?

OR MAP?

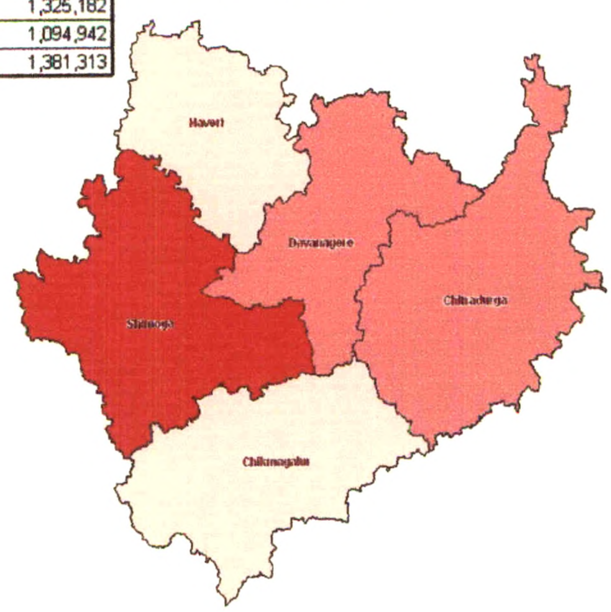

Figure 4.10: Data Visualization [14]

4.12 TRENDS IN BUSINESS GEOGRAPHIC INFORMATION SYSTEMS:

Business use of GIS covers a wide spectrum of GIS applications. The use of GIS application is still somewhat fragmented and there is a need for future integration with other forms of information technology. The trend in IT applications has been for initial operational use in specialized situations, followed by a more general information providing use, followed in turn by sophisticated specialist decision-making and executive management applications. Recent research shows a common trend in public organizations towards GIS becoming an integral part of the overall corporate information system.

GIS applications are relevant to a wide range of sectors, from engineering related applications where technical solutions are readily accepted, to marketing departments where there is less tradition of using IT. GIS faces particular problems as most people in business have little training in spatial techniques and may consequently be slower to make full use of the technology. Where top managers have little appreciation of the technology, they are unlikely to be sufficiently enthusiastic in supporting it.

At the government level, current trends have created an environment for efficient management of the large volumes of complex, multi application information required in the land records management needs of planning, public works, tax assessment, mapping, emergency services, utility facilities management and other applications. Through the enhanced power and flexibility provided by these trends, users will have greater capabilities than ever for the input, management, analysis of attribute and graphic information from diverse sources and for providing rapid response to comprehensive inquires about this information.

4.13 GIS TOOLS:

There are an extraordinary range of software packages that are presented as tools for developing IS applications. There are about 63 GIS software systems currently available. Most of these are sold as application software only or as turnkey systems that include hardware, software and user training. A few are offered as consulting services. Some of the products such as base networks or data files, for which the user must develop data input and retrieval routing, are limited in the form but broad in scope. There are a number of GIS software packages available today. Some of them are listed below:

1. AGIS	12.GIMMS	23. PMAP
2. ARC/INFO	13.GISIN	24. SICAD
3. ARCVIEW GIS	14. GRAMS	25. SPANS
4. ATLAS GRAPHICS	15. GRASS	26. STRINGS
5. CARIS-GIS	16. IDRISI	27. TIGRIS
6. EPPL 7	17. IGDS/DMRS	28.TOPOLOGIC
7. ERPAS	18.IMAGE	29. TRANSCAD
8. FMS/AS	19.MAPINFO	30. UFOSNET
9. GEO-GRAPHICS	20.MIPS	31. USEMAP
10. GEOMEDIA	21.MGE (INTERGRAPH)	32. VANGO
11. GFIS	22. PC ARC/INFO	

4.14 GIS IN INDIA:

Farmers in Uttar Pradesh's, Badaun district no longer use farming techniques that haven't changed in centuries. Now, before deciding on which crop to grow on his land, a farmer no longer says a prayer, asking for divine help, but simply drops in at the nearest Tata Kisan Kendra (TKK) set up by Tata Chemicals. All he has to do is mention his name and the computer at the centre generates an image of his field and tells him the type of crop to grow on his field or how much fertilizer to use. The TKK tracks key parameters relevant to farmers, such as soil, ground water and weather on a real-time basis with the help of GIS or Geographic Information Systems.

Welcome to the new age of precision farming where agriculture has become a refined art thanks to GIS. Today, with the help of GIS, TKK can not only suggest the type of crop that would best suit a particular plot of land, but also keep track of other parameters that have a bearing on this decision. What's more, a GIS can even help predict pest attacks since it combines remotely sensed data, ground verification data, meteorological information, and crop growth and soil moisture models to provide a visual representation of current conditions. Cases like the TKK project though rare in the country; simply affirm the potential of a technology such as GIS in a country like India.

4.14.1 Scenario:

India has a well-established framework for collecting geographical data. Two government agencies—The Survey of India (SOI) and the National Remote

Sensing Agency (NRSA) through its remote sensing satellites, are the most important generators of geographical data. The SOI, which was established way back in 1767, is responsible for all topographical and development surveys in India. Similarly, Indian remote sensing satellites have been providing data for monitoring and management of India's natural resources. Further, there are a lot of other agencies for different sectors such as meteorological data, oceanographic data and groundwater data. Though work done by various agencies is excellent, the same is not completely available to the general public. This rigidity in approach has been a major obstacle in the growth of the Indian GIS industry. But despite the obstacles, almost all Indian players are bullish on the growth potential of the industry, which is growing at an average of 35-40 percent year-on-year.

4.14.2. Indian Market:

In GIS there are different components like data collection, data capture, data conversion, consulting and system integration. Most Indian firms in GIS are involved in the data collection, data capture and data conversion scenario. But some players have moved up the value chain to offer consulting and system integration. Some of the success stories in the Indian GIS space include companies such as Rolta, Infotech Enterprises, Genesys, Nucleus Netsoft and GIS India, ESRI India and Spatial Data.

The Indian market potential in GIS is high. With GIS already having made inroads into sectors such as defense, natural resources management and environmental management, we see increased application of GIS in areas such as land and property information management, utilities and facilities management, agriculture, e-governance, and more significantly as an important planning and decision-making tool. According to market reports, in the year 2000 alone, the Indian government invited major tenders worth more than Rs. 200 Crore in this sector. It is also estimated that private players in infrastructure, telecom and other utilities are spending around Rs 50 Crore annually on GIS products and services. In short, the growth indicators are extremely positive feels Ajay Lavakare, CEO of RMSI. Though there have been no official figures on the GIS market in India, market sources estimate the entire GIS industry to be close to Rs 80 Crore.

As noted earlier, the Government is the biggest consumer of GIS applications and uses it actively. India, with its diverse landscape is a perfect fit for a technology like GIS. The use of geographic data has always been considered to be a vital asset in decision-making for any nation. For instance, knowledge of geographic data is absolutely critical while planning a town or building a highway-any infrastructure, for that matter. Keeping this in mind, a large number of government departments, both at the centre and the state level, have established GIS centers.

Dr D K Munshi, of GIS solutions at Rolta India says, the maximum potential has been in the government departments, which are actively involved in spatial data generation and planning and implementation of various programmes. For example, various departments responsible for execution and implementation of development schemes have been using GIS. The departments, which are involved in implementation of GIS activities are the Department of Space through NRIS, the department of Science and Technology through NRDMS, Forest Survey of India, Survey of India and National Hydrographic Survey." Simply put, this is a massive market for GIS players to address. There is also an increased use of GIS by central, state and local governments in the areas of converting their existing maps to digital formats and in areas such as land record management.

4.14.3 Issues:

While there have been interesting and innovative cases of the use of GIS, there are also critical issues that need to be resolved immediately to boost the growth of the industry. For instance, there are still many government restrictions on the Survey of India map data for large portions of India.

Lack of reliable and accurate digital data, in addition to policies, are some of the major obstacles. For example, a private sector player who creates a digital map has to get it cleared by the Ministry of Defense. There are also no clear guidelines. Everything is treated on a case-to-case basis and this sometimes takes more than a year. The end result is that, by this time, there are changes in the attributes of the location itself, such as the coming up of new shops, and data has to be sent all over again to the ministry, Says Rajagopalan of Spatial Data.

Explains Lavakare, India has a well-documented history of maps but the rigid framework of restriction of map data policy has tied down GIS players within India. In addition, there is no 'quality standard' or certification standard for GIS data produced, and end users are unable to evaluate the quality of data supplied by GIS players. The other real obstacles are low awareness of the benefits of GIS, no clearly outlined government policy in this area, and the lack of finance to support GIS solutions, especially at the state and local government level. Consequently, although government bodies in India have been one of the biggest consumers of GIS, compared to international trends the usage of GIS-related technology has been comparatively low in India so far. As a result, most of the larger and more professional GIS service firms in India are focused on the international market. Hence, success stories of the benefits of GIS technology and their applications are few and not so well known.

Adds Bharti Sinha, vice president of Marketing and Sales for Asia Pacific at Infotech Enterprises, "Indian users need to be educated on the power of GIS-based applications. There is also a need for ridding the industry of short-term, fly-by-night operators who take customers for a ride and ultimately the quality of projects gets affected, which in turn affects the whole industry. Additionally, users need to understand the need for comparing apples with apples and not apples and oranges, when deciding on a major project. For instance, many projects still are decided only on the basis of cost, which leads to the lowest priced vendor being selected, but who may not have the capability to deliver."

Sinha feels that the government needs to lay down strict guidelines for acceptance on quality and credentials in order to remove the chaff from the grain.

Manoj Thakur, president and CEO of Nucleus Netsoft, also puts forward a very valid point on the need for a change in mindset on the part of the government. Says he, the policy maker's mindset has to change on availability of data for public consumption. The Survey of India needs to be left to do what they have been doing for centuries, in their military role. Public availability of data can only increase with a civilian copy of SOI. If ISRO and NRSA could work closely with private service providers in making satellite originated GIS products publicly available, it could lead to a great win-win situation for not only Indian users but users worldwide.

In addition to these issues, there is also a need for dissemination of spatial data through the Internet. A clear-cut policy on map publication and distribution on the Internet needs to be framed, taking into consideration the security concerns of the country. The policy should also address the issues of data availability for the common man, its accessibility, dissemination and standardization. Lavkare of RMSI feels that the government should institute an annual award to recognize the best Internet GIS usage by any government agency, similar to the e-governance award already in place for government websites providing e-governance services.

To conclude, there are about 263 companies in India dealing in GIS. While the Indian market is still at a nascent stage, major growth can be achieved if the government decides to follow progressive policies similar to other countries. And when that happens, Indian GIS-based technology providers can surely look to the sky as their upper limit for growth [15].

14.15 WHY IS GIS DIFFICULT?

The use of computer-based Geographic Information Systems (GIS) technology in the government, business, and non-profit sectors has expanded tremendously in the last decade. GIS has become a pivotal component for decision making and planning in government agencies, in business, and already had significant impact in applications ranging from facilities management through marketing analysis to the monitoring of global change and environmental degradation. The audience of GIS Technology continues to diversify, and it is expected that GIS will be adopted by millions of new users in the years ahead. While many of these new users will be seeking simplified tools custom tailored to their applications, a significant fraction will need the rich repertoire of data development, data management, and spatial analysis functions provided by a full-scale GIS software environment [16].

Despite this growth, obstacles to the widespread use of GIS technology remain. One of the most serious obstacle is the apparent complexity of GIS analysis techniques and systems. As GIS commonly uses graphical presentation methods, almost anyone can understand and appreciate its results. However, highly trained personnel are usually required to produce these results. GIS systems are actually becoming more complex due to the more integration of remote sensing and other functions [17].

GIS is difficult because:

1. *Openness of the GIS Domain:* GIS is difficult because institutional and environmental constraints restrict the analyst's activities or interface with his/her objectives. In the real world, GIS is not distinguished from other activities that strictly might be considered to be unrelated to GIS. In particular, the general hardware and software environment that supports the GIS becomes part of the domain. Many of the problems that people cited as "GIS problems" actually stemm from difficulties with hardware configurations, operating systems and so on. Similarly, activities related to assembling or compiling information (e.g. reading reports, contacting town planning boards, tracing out boundaries on paper maps, doing ground checks) also appear to be viewed as part of the GIS domain. Problems of source data accessibility or quality, as well as organizational barriers related to data ownership, are all identified as "GIS problems".

2. *Management of Details:* GIS is difficult it requires recording, recall and use of many details, which are outside of the GIS database proper. Practically every user uses some kind of external aids for maintaining information about his or her GIS work. Many users keep notebooks or logs of their project work, recording a wide variety of items such as coordinates, tolerances, lists of data layers or maps, special cases or problems to be considered etc. They also use sketches and other graphics to record problems, procedures, or plans.

   In addition to these notes on project work, several users keep notebooks on topics related to the GIS software itself. These notebooks are used to record problem, workarounds, detailed procedures, shortcuts, and so. In general, users view this information as (essential) supplements to the GIS product documentation. Users feel that many of the errors they made were due to the failure to record, or inability to recall, this type of detailed information. They had learned, through experience, the importance of maintaining and managing the specifics items of information that they, personally, tended to forget.

3. *Data versus Operations as the Focus of Work:* GIS is difficult because users focus on data, while GIS software focuses on operations.

   GIS is typically described as a set of operations applied to data: overlying polygons, buffers, calculating view shed. There have even been attempts to specify a formal "algebra" of spatial operations. Most commonly used GIS software is also organized around operations. Originally, each operation was associated with a command verb. Although many GIS software packages now use a graphical, menu-based interface, the action-oriented organization has not changed significantly. First, the user selects an action from the menu; secondly, he or she supplies information on the data sets to be processed, as operation parameters [18].

To conclude GIS is difficult even for experienced users because:

1. It subsumes a wide range of institute and environment issues, outside the formal definition of the domain;
2. It requires management of large amount detailed information, distinct from the GIS data;
3. The task structure enforced by current GIS software does not match the way experts approach GIS problems.

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