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DIPLOMA IN DISASTER MANAGEMENT

DDM-02

Geographical Information System and ICT in Disaster Management

Block

1

GEOGRAPHICAL INFORMATION SYSTEM AND ICT IN DISASTER MANAGEMENT

Unit – 1

Geographical Information System (GIS)

Unit – 2

Remote Sensing

Unit – 3

Advanced Technologies for Early Warning System

EXPERT COMMITTEE

DIPLOMA IN DISASTER MANAGEMENT

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Unit – 1

Geographical Information System

Objectives

After completion of this unit, you should be able to:

- *Have basic understanding on GIS concepts, techniques and real world applications.*
- *Understand the basic concepts of geography necessary to efficiently and accurately use GIS technology.*
- *Understand basic of spatial data and types*
- *To know about the component of GIS in larger context of business needs and IT strategies.*
- *Have an ability to perform basic GIS analysis of concepts*

Structure

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1.1. Introduction

Today many of us use GIS technology in day to day life but we are not aware of it. Some of us use navigation system in our cars to get the shortest route and driving directions to reach our destination. We go online, type the name of the restaurant and get an idea about location and direction of the place. The ambulance and emergency managers also use this technology to route the vehicles in easing the traffic providing emergency services to disaster victims. The career which will allow you to discover new places, to work with computers and to give knowledge about cities and rural areas is possible due to Geospatial Technology. All these actives are GIS technology, a technology that can handle geographically referenced data or geographic information. Geographic information (i.e.., land information, spatial information) is information that can be associated with a place name, a street address, section/township, a zip code, or coordinates of latitude and longitude. Geographically referenced data not only provide knowledge about the location but also characteristics of the element. There are widespread applications of GIS in crime analysis, market analysis, emergency management, traffic easing and land record managements. Further, integration of GIS technology with global positioning systems (GPS), Satellite imageries and other mobile devices are providing services like interactive mapping, location based services and navigation systems. Hence, GIS technology is the one of the three emerging industries along with nanotechnology and biotechnology. There are also high chances of misusing the data and result for this enabling technology. Therefore, for better use of this technology, we must be familiar with basic concepts and technology that drive technological convergence and more sophisticated application.

1.2. Definition of GIS

G stands for Geographic, GIS has something to do with geography.

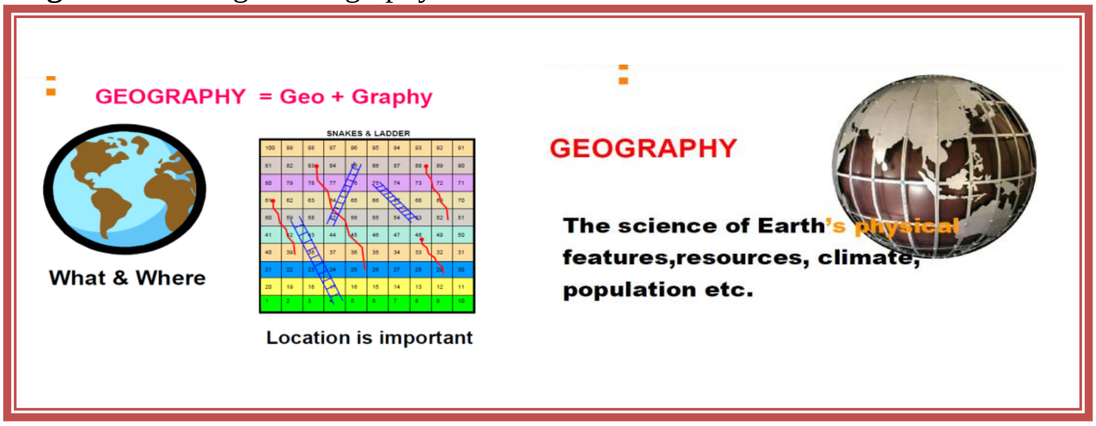
I stands for Information, GIS has something to do with information, namely geographic information.

S stands for System, GIS is an integrated system of geography and information tied together.

A "Geographic Information System" (GIS) is a computer based tool that allows you to create, manipulate, analyze, store and display information based on its location.

Explaining Geography - Geo means Earth + graphy means description. The location of features or spatial key is central to data handling, analysis and reporting which maker GIS different from other information system (Fig. 1.1.).

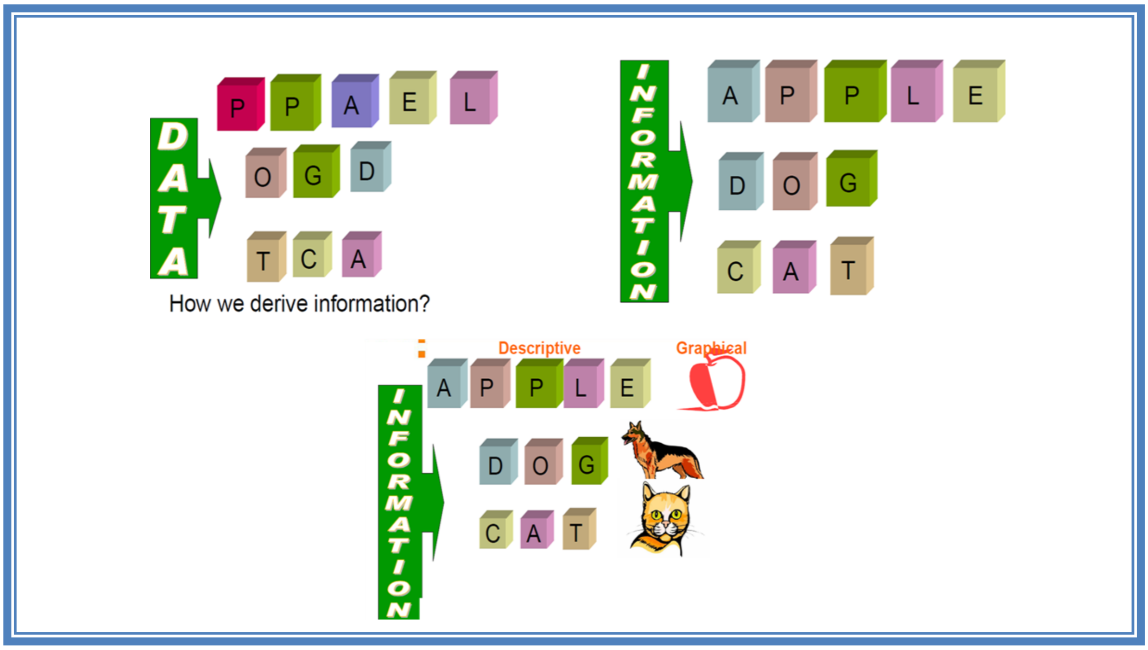
Fig. 1.1. Meaning of Geography



Explaining Information

The Latin root of the word is 'informare', which literally means to give form or shape and this is usually extended into to give form to the mind as in education, instruction, or training. Before defining GIS, we should know the crucial difference between data and information highlighted in picture below. Normally our eyes register text, symbols and numbers but our mind interpret in form of information. Information is also what we see on the map image. Our eyes register pixels (data) but our mind registers the best route (information) (Fig.1.2).

Fig. 1.2. Deriving Information from Data



Geographic Information

- Information about places on Earth's surface

Geographic* versus *spatial

Geographic refers to Earth's surface and near surface

Spatial refers to any space (more general)

- Knowledge about *where* something is
- Knowledge about *what* is at a given location
- Can be very detailed or very course
- Can be relatively static or change rapidly
- Can be very sparse or voluminous

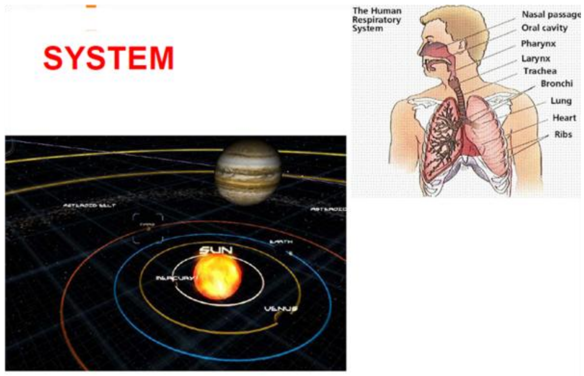
Difference between Data and Information

Data is what is stored and transported, such as strings of characters or pixels, or defined structures thereof.

Information is a result of the interpretation when visualizing or analyzing data.

Explaining System

It’s a system of hardware, software and human ware to manage geographical data and use geographical information in critical understanding for effective use.



GIS Definition

It is a comprehensive collection of tools for capturing, storing, retrieval, transformation, and visualization of spatial data of the real world for special applications **(P.A. Burrough, 1979)**.

It is an information system with a database of observables of spatially distributed objects, activities, or events, which can be described by points, lines, or surfaces **(K.J. Dueker, 1979).**

It is a system for decision support which integrates spatial data in a problem-solving environment **(D.J. Cowen, 1988)**.

It is a computer-based information system that enables capture, modeling, manipulation, retrieval, analysis and presentation of geographically referenced data **(Worboys, 1997).**

Other Definition of GIS

General Public – A container of map in digital form.

Scientist or Researchers - A tool for revealing invisible in geographic information.

Resource Manager - A mechanized inventory of geographically referenced features.

Decision Makers and Planners - A computerized tool for solving geographic problems.

GIS Experts - A set of hardware and software components needed for the handling of geospatial data.

Developers or Modelers - A collection of algorithmic and functional tools

1.3. Concept of space and Time

Space and Time are two closely related concepts that have been the subject of philosophical and scientific consideration since the dawn of mankind. The space that humans live in is the three-dimensional (Euclidean) space as a frame of reference for our senses of touch and sight. Of all possible spaces, this is the only space that is illustrative and that we perceive as being real. Time is a measure for change in our immediate experience. Usually we assume time to be of a continuous linear nature extending from the past, through the present into the future. Space and time (at least as we perceive them) are so well known and appear to be given beyond any doubt that we hardly ever contemplate their structure and characteristics in our everyday lives. Mathematically spacetime can be described by co-ordinate system of three spatial dimensions (length, width, height), and one temporal dimension (time). Dimensions are independent components of a coordinate grid needed to locate a point in a certain defined "space". For example, on the globe the latitude and longitude are two independent coordinates which together uniquely determine a location. In spacetime, a coordinate grid that spans the 3+1 dimensions locates events (rather than just points in space), i.e., time is added as another dimension to the coordinate grid. This way the coordinates specify where and when events occur.

Type of Space

1. **Time less space -** Space is static
2. **Meaningless Space -** Space is divorced from human meaning and life.

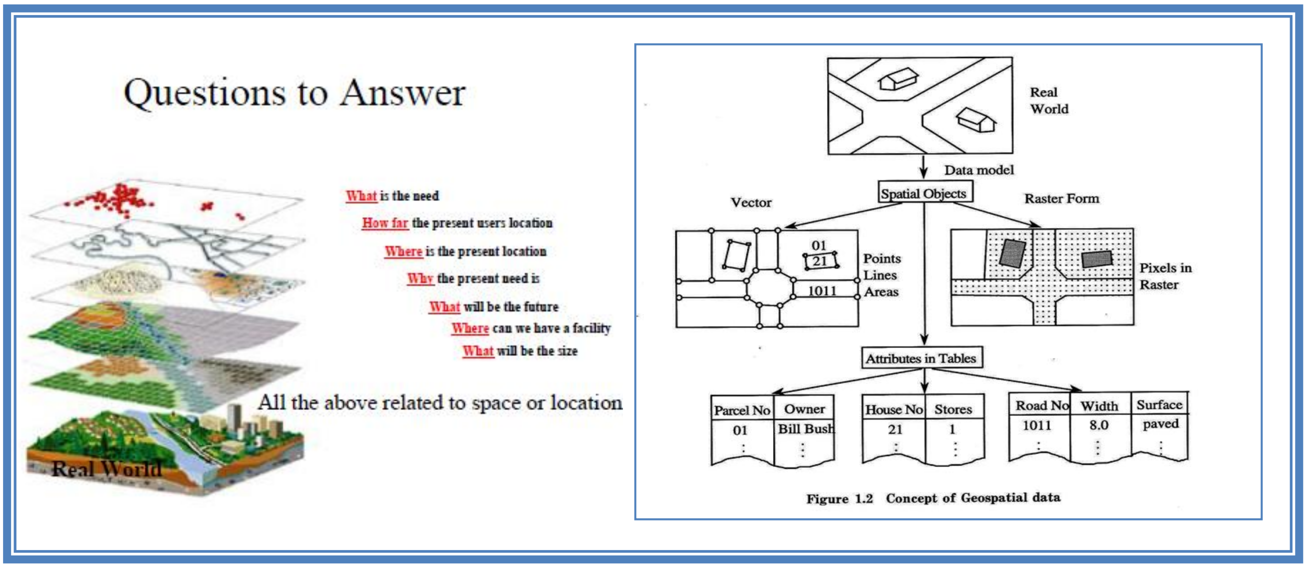
3. **Empty Space -** Space that can contained
4. **Absolute space** - Space as a set of places. It is an absolute real entity, the container of all things.
5. **Relative space** - Space is a system of relations. It is the set of all material things, and relations are abstracted from them.

1.4. Spatial Data

Spatial data describe the location of spatial features, which may be discrete or continuous. To describe a new bus terminal, we refer to its location (i.e. where it is) and its characteristics (e.g. name, area, land use and elevation). The location also called geometry or shape represents spatial data whereas the characteristics are called attribute data. Discrete features include point (e.g. landmarks), line (e.g.

rivers) and polygon (e.g. land parcels). Continuous features are features that exist spatially between features (Fig. 1.3).

Fig. 1.3. Concept of Spatial Data



Source: http://www.isprs.org/caravan/documents/Lao_Basic_GIS

A GIS represents these spatial features on Earth surface as map feature in on plane surface. This transformation is done by using spatial reference system and data model. The locations of spatial features on surface of the earth based on geographical coordinate system with longitude and latitude values whereas the location map features are based on plane coordinate systems with x-, y-coordinates. Projection is the process that can transforms the Earth spherical surface to plane and bridge the gap between two reference systems.

The data model represents a set of guidelines to convert the real world (called entity) to the digitally and logically represented spatial objects consisting of the attributes and geometry.

There are two major types of geometric data model (Fig.1.4.).

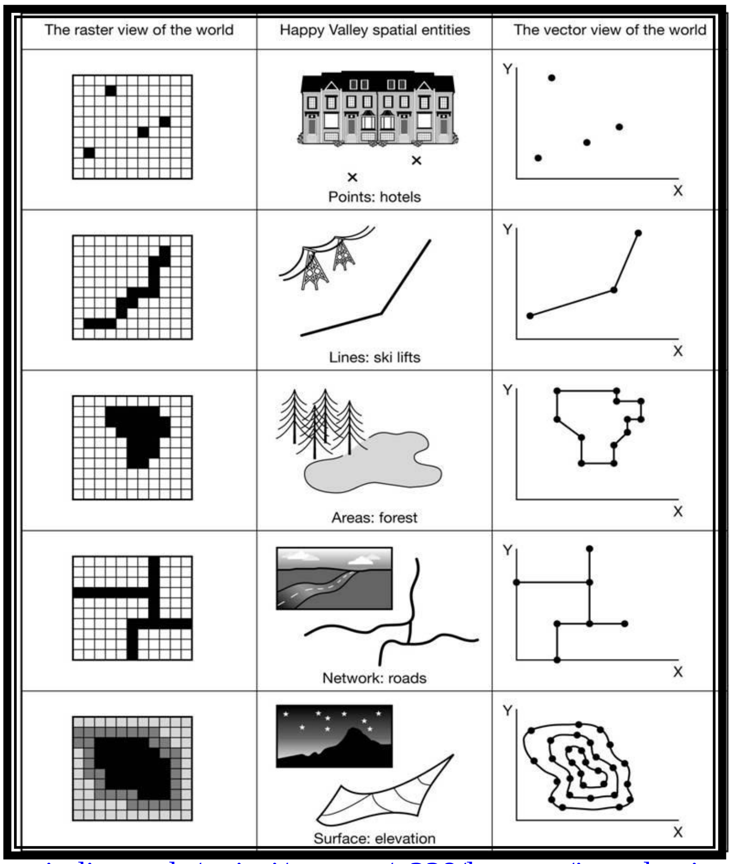
a. Vector Model

Vector model uses discrete points, lines and/or areas corresponding to discrete objects with name or code number of attributes. Vector data represent geographic space that is intuitive and reminiscent of analog maps.

b. Raster Model

Raster model uses regularly spaced grid cells in specific sequence. An element of the grid cell is called a pixel which contains a single value of attributes.

Fig.1.4. Differences between Rater and Vector Data Model



Source: http://www.indiana.edu/~gisci/courses/g338/lectures/introduction_vector.html

Raster Model	Vector Model
Advantage 1. It is a simple data structure. 2. Overlay operations are easily and efficiently implemented. 3. High spatial variability is efficiently represented in raster format. 4. The raster format is more or less required for efficient manipulation and enhancement of digital images.	**Advantage** 1. It provides a more compact data structure than the raster model. 2. It provides efficiently encoding of topology and as result more efficiently implementation of operations that require topological information, such as network analysis. 3. The vector model is better suited to supporting graphics that closely approximate Hand-drawn maps.
Disadvantage 1. It is less compact therefore data compression techniques can often overcome this problem. 2. Topological relationships are more difficult to represent. 3. The output of graphics is less aesthetically pleasing because boundaries tend to have a blocky appearance rather than the smooth lines of hand-drawn maps.	**Disadvantage** 1. It is a more complex data structure. 2. Overlay operations are more difficult to implement. 3. The representation of high spatial variability is inefficient. 4. Manipulation and enhancement of digital images cannot be effectively done in vector domain.

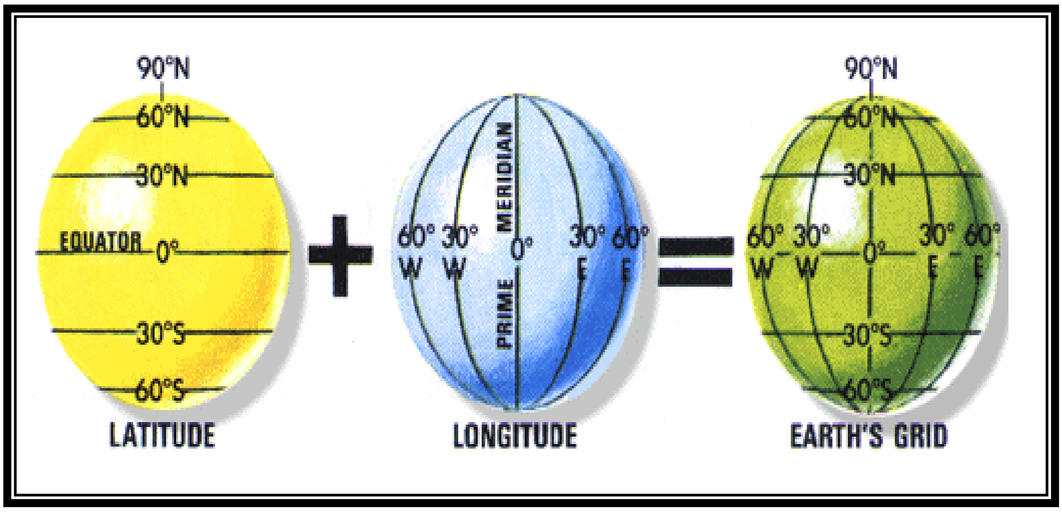
1.5. Map Projection and Datum

Map projections are the different techniques used by cartographers for presenting a round globe on a flat surface. The locations of map features are based in a plane coordinate systems expressed in x- and y-coordinates whereas the spatial features on earth surface are based in geographic coordinates expressed in latitudinal and longitudinal value (Fig.1.5). Whether you treat the earth as a sphere or a spheroid, you must transform its three-dimensional surface to create a flat map sheet. This mathematical transformation from 3 dimensional surfaces to 2 dimensional plane surfaces is called map projection.

Elements of Map Projection

1. **Parallels of Latitude:** These are the circles running round the globe parallel to the equator and maintaining uniform distance from the poles. In the spherical system, horizontal lines, or east–west lines, are lines of equal latitude, or parallels. They are demarcated as 0º to 90º North and South latitudes.
2. **Meridians of Longitude:** These are semi-circles drawn in north south direction from one pole to the other, and the two opposite meridians make a complete circle, i.e. circumference of the globe. Vertical lines, or north–south lines, are lines of equal longitude, or meridians. There is no obvious central meridian but for convenience, an arbitrary choice is made, namely the meridian of Greenwich, which is demarcated as 0° longitudes. It is used as reference longitudes to draw all other longitudes.
3. **Graticule:** The encompassed latitude and longitude in gridded network covering surface of the earth is called a graticule. The origin of the graticule (0,0) is defined by where the equator and prime meridian intersect. The globe is then divided into four geographical quadrants that are based on compass bearings from the origin. North and south are above and below the equator, and west and east are to the left and right of the prime meridian.

Fig.1.5. Latitude, Longitude and Graticules



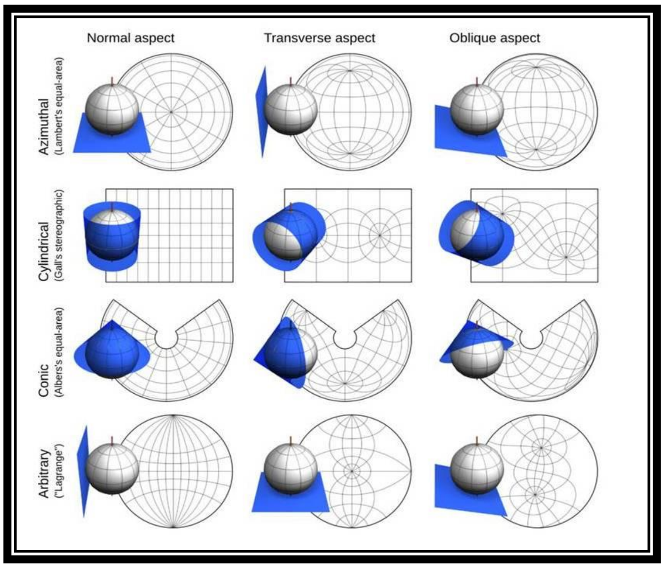
4. **Reduced Earth:** This is mathematical model of earth with reduced scale having the length of polar diameter lesser than equatorial and on this model the network of graticule can be transferred.
5. **Distortions:** Scale**,** angles, areas, directions, shapes, and distances can become distorted when transformed from a curved surface to a plane. Different projections have been designed where the distortion in one property is minimized, while other properties become more distorted. Due to this reason, map projection is also defined as the study of different methods which have been tried for transferring the lines of graticule from the globe to a flat sheet of paper. So map projections are chosen based on the purposes of the map.

Types of Map Projection

There are four families of map projections—Azimuthal (planar), Cylindrical, Conic, and Mathematical—and there are several individual projections belonging to each family (Fig.1.6.).

1) **Azimuthal family** - The grid of a generating globe (a model based on spherical, ellipsoidal, or geoidal representations of the Earth) is projected onto a plane.
2) **Cylindrical projections –** These projections are created by first wrapping a plane into a cylinder and then projecting the grid is projected onto that cylinder. The cylinder is then unrolled into a flat map.
3) **Conic projections -** They are created by first wrapping a plane into a cone onto which the projecting the grid is projected. The cone is then unrolled into a flat map.
4) **Mathematical projections –** These are oftentimes resemble geometric projections but cannot be developed by projective geometry. Mathematical projections sometimes are sub-classified as pseudocylindrical, pseudoconic, and pseudoazimuthal.

Fig.1.6. Type of Map Projection



Source: http://docs.qgis.org/2.0/en/docs/gentle_gis_introduction/coordinate_reference_systems.html

Table 1.1. Commonly used Map Projection

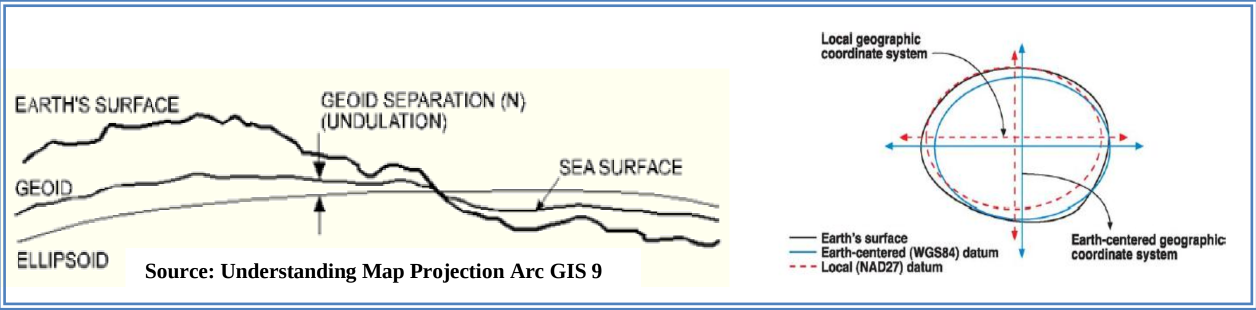
Projection	Type	Key virtues	Comments
Stereographic	Azimuthal	Conformal	**Created** in before 1500 **Best Used** in areas over the Poles or for small scale continental mapping
Lambert Conformal Conic	Conic	Conformal	**Created in** 1772 **Best Used in** mid-latitudes - eg USA, Europe and Australia
Mercator	Cylindrical	Conformal and true direction	**Created in** 1569 **Best Used in** areas around the Equator and for marine navigation
Robinson	Pseudo-cylindrical	All attributes are distorted to create a 'more pleasant' appearance	**Created in** the 1963 **Best Used** in areas around the Equator
Transverse Mercator	Cylindrical	Conformal	**Created in** 1772 **Best Used** for areas with a north-south orientation

Geodetic Datum

A datum is a mathematical model of Earth, which serve as the reference or base for calculating the geographic coordinate of location.

A datum is the mathematical model that fits the earth to an ellipsoid. It is a reference from real-world to this ellipse (Fig.1.7).

Fig.1.7. Concept of Datum



Source: Understanding Map Projection Arc GIS 9

The earth's surface is not perfectly round. Instead, it is ellipsoid, with mountains and valleys. Datum is used to correct for these undulations. A datum provides a frame of reference for measuring locations on the surface of the earth. It defines the origin and orientation of latitude and longitude lines.

Common Global Datum

1. **WGS84** (World Geodetic Survey, 1984)
2. **GRS80** (Global Reference System, 1980)
3. **Clarke 1866** ellipsoid (used with California's State-wide Teale Albers projection)
4. **NAD83 or 27** datum (North American Datum, 1983 or 1927)

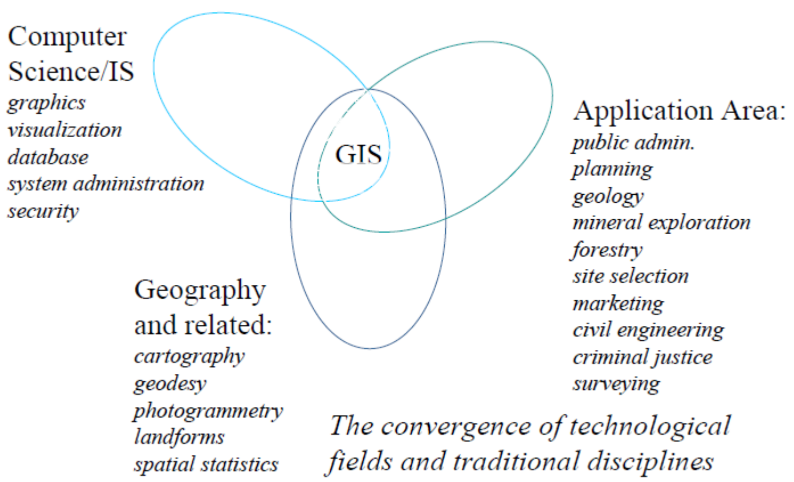
1.6. Domains of spatial information system

Spatial information is always related to geographic space, i.e., large-scale space. This is the space beyond the human body, space that represents the surrounding geographic world. Within such space, we constantly move around, we navigate in it, and we conceptualize it in different ways. Geographic space is the space of topographic, land use/land cover, climatic, cadastral, and other features of the geographic world. Geographic information system technology is used to manipulate objects in geographic space, and to acquire knowledge from spatial facts. Hence, the Spatial Information Technology relates to the use of the technological inputs in collecting, storing, retrieving, displaying, manipulating, managing and analysing the spatial information. It is an amalgamation of Remote Sensing, GPS, GIS, Digital Cartography, and Database Management Systems. The examples of spatial information system are shown in Tables

Examples of Spatial Information System

1. Cadastral Information System
2. Image based Information System
3. Land Data System
4. Geographically Referenced Information System
5. Natural Resource Management Information System
6. Market Analysis Information System
7. Planning Information System
8. Soil Information System
9. Spatial Decision Support System
10. Urban Information System

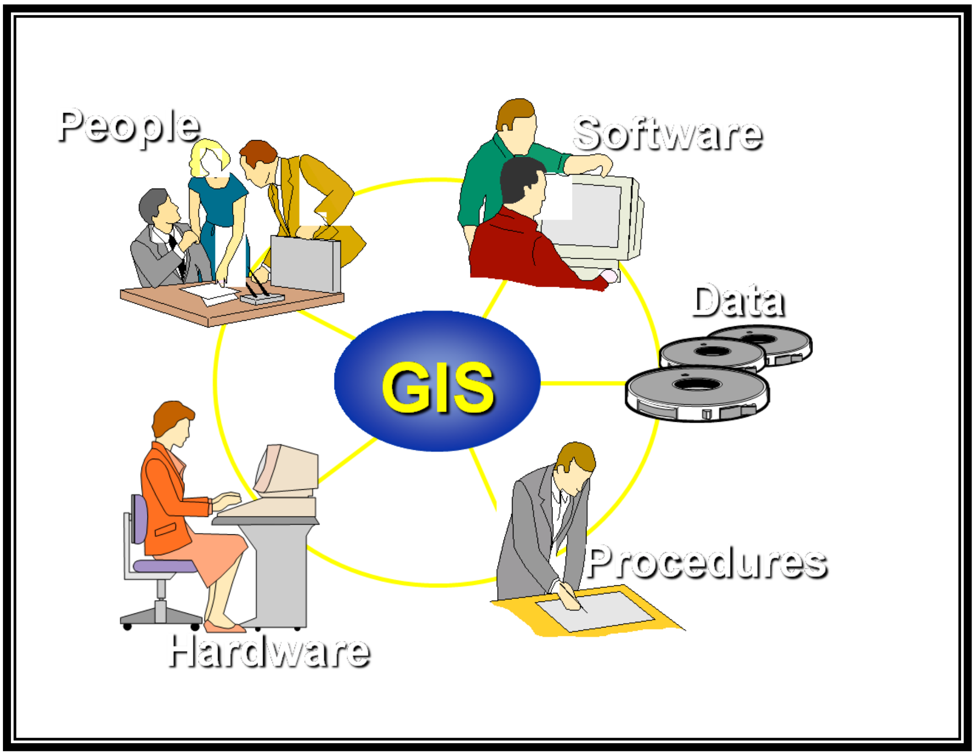
Knowledge Base GIS or Spatial Information System



1.7. Components of GIS

An operational GIS require the following six components to make the system work. A working GIS integrate these six components: Hardware, soft ware, people, data, network and procedures.

Fig.1.8. Component of GIS



1) **Hardware -** Hardware is the computer system includes computer and operating system on which a GIS operates. 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. Further, choices of personal computers using window operating systems or workstations use UNIX or Linux operating systems. Additional hardwares are monitor for display, digitizer and scanner for data input and printer and plotter for hard copy display.

Input devices	Computer CPU	Output devices
Digitizer Scanner Digital camera Data on EDP media Remote sensing	Mainframe Unix workstation PC	Monitor Inkjet printer Laser printer Offset printing (Plotter)

2) **GIS Software –** GIS Software are program and interfaces to store, analyze, and display geographic information. The most common interfaces are graphical icons, menu, script and command lines (Table 1.2.).

Table1.2. GIS Softwares

License Version	Open sources
ARC GIS	GRASS
ERDAS IMAGINE	FLOWMAP
ER MAPPER	QUANTUM
JT MAPS	MAPWINDOW
GEOMEDIA	SPRING

3) **Data:** Geographical data are taken as various inputs by GIS to produce meaningful information. The spatial data (point, line and polygon) and tabular data are collected in-house, compiled to custom specifications and requirements, or occasionally purchased from a commercial data provider. Further, spatial and tabular data can be integrated at GIS platform.

4) **People:** People refers to GIS experts and users who define the purpose and objective in solving real time spatial problem and also provide the reason and justification in using GIS in everyday life. The identification of GIS specialist in organization for proper implementation of GIS technology in solving real world problems.
5) **Procedure:** An operating procedures and well-designed implementation plan are the business rule for success for all organization. It requires necessary investments in hardware and software, but also in the retraining and/or hiring of personnel to utilize the new technology in the proper organizational context.

6) **Networks:** With rapid development of IT, today the most fundamental of these is probably the network, without which no rapid communication or sharing of digital information could occur. GIS today relies heavily on the Internet, acquiring and sharing large geographic data sets.

1.8. GIS Functionalities for end user/system

GIS functionalities categories are no longer follow a set of sequence because the functions interact with each other in a manner that corresponds to a network rather than to a sequential list. The simplest way to order GIS activities are the life cycle of spatial data from creation via structuring and storage and eventually to analysis and presentation. The listed groupings also depend on the type of end user and also their respective application. The end users need to understand both data and software in order to create unique spatial questions and maintain the spatial information produced. GIS activities can be grouped in following categories.

Data Acquisition	Refers to acquiring geographically referenced data
Data Input	Refers to the creation of digital spatial data
Data Management	Refers to unique issues in the maintenance of spatial data such as error or level of accuracy; storing data; retrieving data; and metadata. Data management is one of the key issues determining the usability of spatial data.
Data Analysis	Refers to answer questions of user that may not be explicitly stated in the data.
Data Modeling	Refers to use of GIS functionalities in developing model using geospatial data**.**
Data Output	Refers to the method used to visually display analysis performed using GIS. Output can be in the form of jpg to large plotted images.

1.8.1 Data Acquisition

Acquiring geographic data is an important factor in any geographic information system (GIS) effort. It has been estimated that data acquisition typically consumes 60 to 80 percent of the time and money spent on any given project. Therefore, care must be taken to ensure that GIS projects remain mindful of their stated goals so the collection of spatial data proceeds in an efficient and effective manner as possible. In GIS, the data sources for data acquisition should be carefully selected considering the application and scale. The present day data supplies make the digital data readily available, which range from small-scale maps to the large-scale plans. For many local governments and private organizations, such data form an essential source and keep such groups of users free from overheads of digitizing or collecting their own data. Although, using such existing data sets is attractive and time saving, serious attention must be paid to data compatibility when data from different sources/ supplies are combined in one project. The differences in terms of projection, scale, base level and description in attributes may cause problems.

Data Sources of GIS

Analog maps
Elevation, soil, landuse, climate, etc.

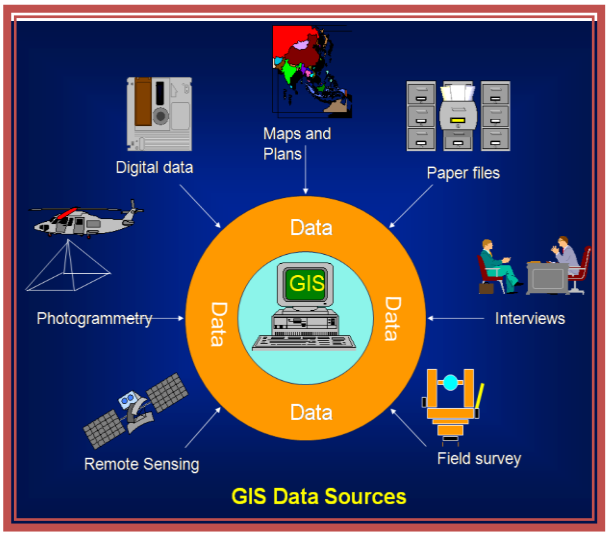
Aerial photographs
DEM, landuse (Urban)

Satellite image
Landuse (regional), vegetation, temperature, DEM

Ground survey with GPS
Detailed information

Reports and publications
Attributes, statistics

Fig.1.9. GIS Data Source



where data are used from a number of sources, and particularly where the area of study crosses administrative boundaries, the difficulties in data integration are caused by different geographical referencing systems, data classification and sampling. Hence, the user needs to be aware of these problems, which are particularly prone when compiling inter province, and inter-district data sets. Once, the compatibility between the data acquired from different suppliers is established, the next stage involves the transfer of data from a medium of transfer to the GIS. The use of DAT tapes, CD ROMS and floppy disks is becoming increasingly common for the purpose. At this stage, the conversion from encoding and structuring system of the source to that of GIS to be used is important.

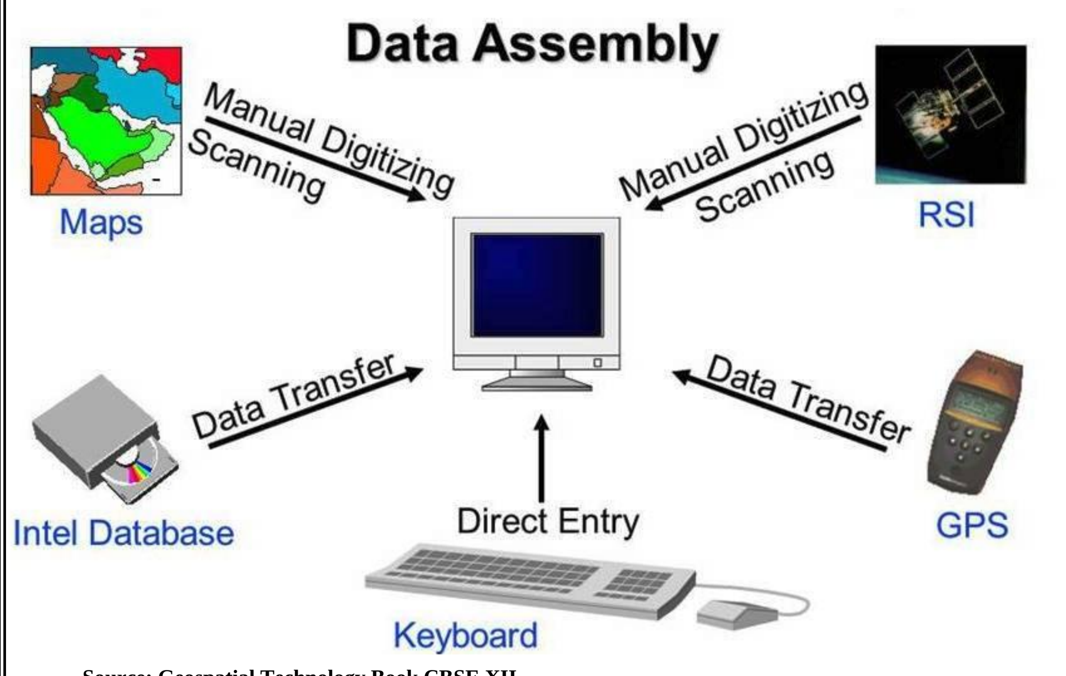
1.8.2. Data Input

The most expensive part of GIS project is about construction of data base i.e. converting paper map to digital map. A data input system help the user to capture, collect, and transform spatial and thematic data into digital form. Although, in recent years digital clearing houses are common place in internet but sill the topic of data are important from two reasons. First, data available in public domain are intended for all end users rather than user of particular software. Second, government agencies and private companies are continuously producing new data for putting in internet or to be sold to customers. Sometime GIS users may not find digital data for their project and they have to create their own data. The creation of an accurate and well-documented database is critical to the operation of the GIS.

New GIS data are usually derived from a combination of satellite images, aerial photographs, field data, text files with x- and y-coordinates, street addresses, paper maps, reports and survey documents. The data can entered to GIS systems using following five key methods (Fig.1.10 & Fig.1.11.)

1) **Keyboard entry**
2) **Coordinate geometry**
3) **Manual digitizing**
4) **Scanning**
5) **Input of existing digital files**

Fig.1.10. GIS Data Input System



Source: Geospatial Technology Book CBSE XII

Keyboard entry: involves manually entering the data at a computer terminal. Attribute data are commonly input by keyboard whereas spatial data are rarely input this way. Keyboard entry may also be used during manual digitizing to enter the attribute information. However this is usually more efficiently handled as a separate operation. Roads file versus the census file -- roads file will use codes for the various road types while the census file uses exact numbers for things like total population, age range, etc.

Coordinate Geometry (COGO): involves entering survey data using a keyboard. From these data the coordinate of spatial features are calculated. This produces a very high level of precision and accuracy which is needed in a cadastral system. For a city with 100,000 parcels, it would cost approximately $1 - $1.50 per parcel or $100,000 to $150,000 to digitize the parcels manually. COGO procedures are commonly 6 times and can be up to 20 times more expensive than manual digitizing. Surveyors and engineers want the higher accuracy of COGO for their applications. Planners and most others are happy with the lower accuracy provided by manual digitizing.

Manual Digitizing: The most widely used method for entering spatial data from maps. The map is mounted on a digitizing tablet and a hand held device termed a puck or cursor is used to trace each map feature. The position of the puck is accurately measured by the device to generate the coordinate data. Digitizing surfaces range from 12 inches x 12 inches (digitizing tablet) to 36 x 48 (digitizing table) and on up. The digitizing table electronically encodes the position of the pointing device with a precision of a fraction of a millimeter. The most common digitizer uses a fine wire mesh grid embedded in the table. The cursor normally has 16 or more buttons that are used to operate the data entry and to enter attribute data. The digitizing operation itself requires little computing power and so can be done without using the full GIS. A smaller, less expensive computer can be used to control the digitizing process and store the data. The data can later be transferred to the GIS for processing. The problem with this is having enough software for all the computers.
The efficiency of digitizing depends on the quality of the digitizing software and the skill of the operator. The process of tracing lines is time-consuming and error prone. The software can provide aids that substantially reduce the effort of detecting and correcting errors. Attribute information may be entered during the digitizing process, but usually only as an identification number. The attribute information referenced to the same ID number is entered separately. Manual digitizing is a tedious job. Operator fatigue (eye strain, back soreness, etc.) can seriously degrade the data quality. Managers must limit the number of hours an operator works at one time. A commonly used quality check is to produce a verification plot of the digitized data that is visually compared with the map from which the data were originally digitized.

Scanning: Scanning provides a faster means of data entry compared to manual digitizing. In scanning, a digital image of the map is produced by moving an electronic detector across the surface of the map. There are two types of scanner designs: Flat-bed scanner: On a flat-bed scanner the map is placed on a flat scanning stage and the detectors move across the map in both the X and the Y directions (similar to copy machine). Drum scanner: On a drum scanner, the map is mounted on a cylindrical drum which rotates while the detector moves horizontally across the map. The sensor motion provides movement in the X direction while the drum rotation provides movement in the Y direction. The output from the scanner is a digital image. Usually the image is black and white but scanners can record color by scanning the same document three times using red, green and blue filters.

Inputting existing digital files: There are many companies and organizations on the market that provide or sell digital data files often in a format that can be read directly into a GIS. These digital data sets are priced at a fraction of the cost of digitizing existing maps. Over the next decade, the increased availability of data should reduce the current high cost and lengthy production times needed to develop digital geographic data bases.

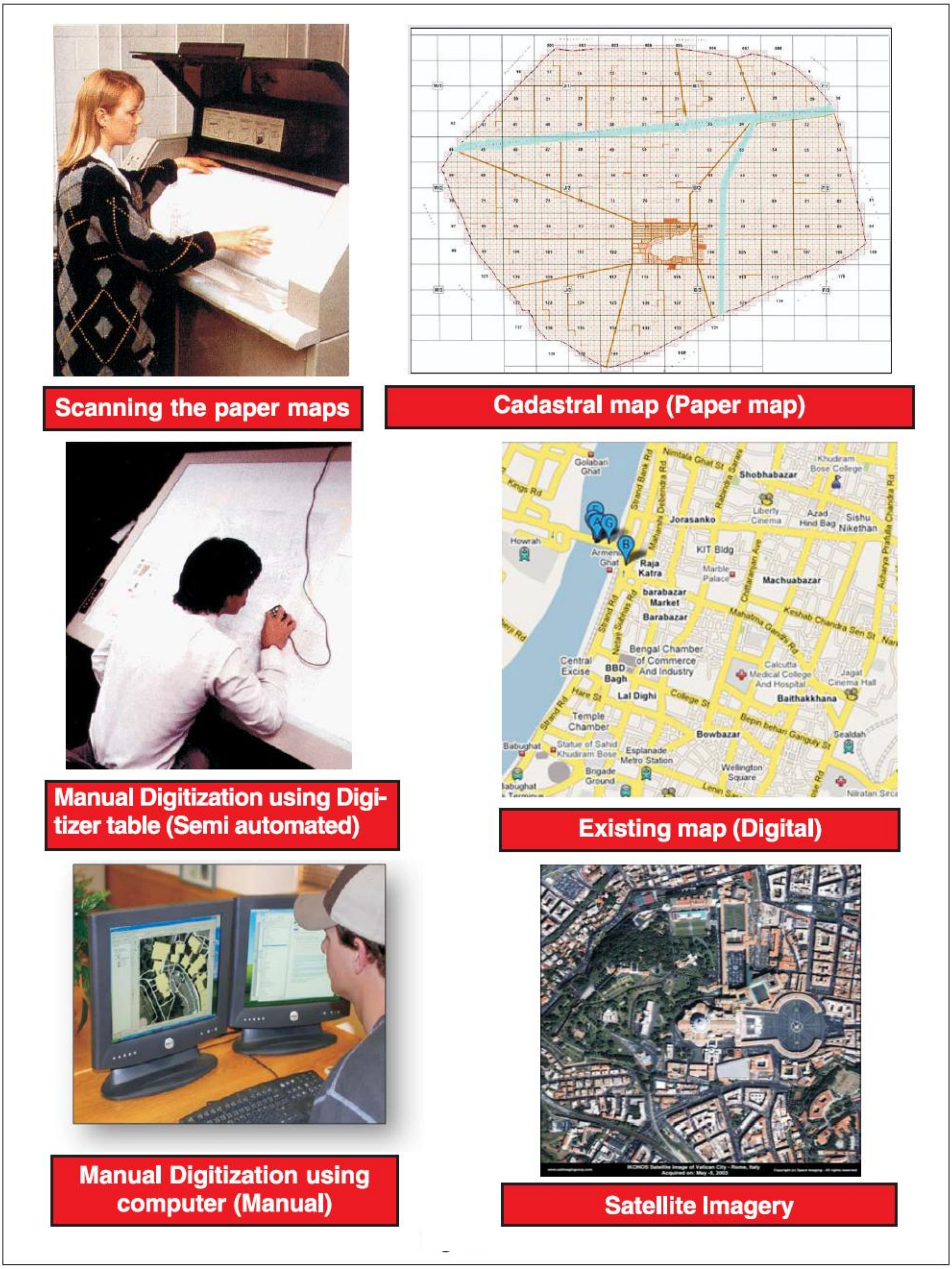
The choice of data acquisition method for data input are shown in table 1.3

Table 1.3. Choice of Data Acquisition Method

Choice of data acquisition method

Data Sources	Method	Equipments	Accuracy	Cost
Analog Map	Manual Digitizing	Digitizer	±0.1 mm (on a map)	cheap
	Semi-automatic Scanning	Scanner	±0.1 mm (on a map)	high
Aerial Photos	Analytical Photogrammetry	Analog Stereo Plotter	±10 cm	high
	Digital Photogrammetry	Digital Phot. Workstation	±10 cm	very high
Satellite Images	Visual Interpretation	Image zoom scope	±30~50m	cheap
	Digital Image Processing	Image Processing System	±10~30m	high
Ground Survey	Field Measurement	Total station, GPS	±1 cm	very high
Reports	Keyboard Entry	Keyboard, PC		cheap

Fig.1.11. GIS Input Data Technique



Source: Geospatial Technology Book, CBSE XII

1.8.3. Data Management

Data management is a process involving a broad range of activities from administrative to technical aspects of handling data. The term ―data management‖ embraces the full spectrum of activities involved in handling data. The GIS data base management component provides the environment within which the GIS functions and the means by which data are controlled. The system management environment is furnished by the operating system of the host computer. Operating systems have generic capabilities to organize, coordinate, facilitate, and execute the commands of one or many system users in sequence, or in parallel, depending on hardware, software, and demand constraints. Data base management elements of the GIS are executed within the operating system control. GIS data base management functions parallel those of a non spatial DBMS, but with extensions beyond the addition, deletion, revision, and Boolean retrieval capabilities of a standard DBMS. The GIS data base management system will have hardware and software facilities for the storage, retrieval, and update of spatial information. It will incorporate storage structures to minimize data redundancy and to aid spatial searches. In addition, the GIS DBMS (like its non spatial counterparts) must include features for maintaining data independence, security, and integrity and have the file management capabilities to handle a potentially large archive of data files. The difference between spatial server and hybrid model are highlighted in table 1.4.

Data Management

Refers to unique issues in handling of spatial data. Data management is one of the key issues determining the usability of spatial data.

Data Errors/ Level of Accuracy	• Errors in digitizing • Errors in original data • Errors in data entry • Method of data entry • Scale of data
Storing Data	• Upkeep of historical data sets • Warehousing state and city data
Retrieving Data	• How can users access stored data?
Metadata	• Using national standards to record and maintain key information about data creation, scale, projection, and attributes.

Table 1.4. Difference between spatial server and hybrid model

	Spatial Server (RDBMS)	Hybrid Model or Flat File
User Access	Roles, users built-in-security	No inherent security
Security	Stored in Proprietary files not accessible from any other application than the RDBMS	Disk files easily recognizable, editable with external applications
Data integrity	Enforces referential integrity, data stamping, user access and rights, triggers, procedures, transactions (rollback commits)	No internal enforced referencing (IDEDIT, RENODE)
Buffered Throughput	Designed for fast transfer of packets through network. Only access what you need.	Access everything within the spatial extent, accessing both spatial and attribute features each with their own data structure.
Multi user	Multiple users can access data allows for row or table level locking. Optimistic and pessimistic updating. User roles determine editing rights.	Only one user can edit records. No built in locking or updating mechanisms. No built in security.
Open data structure	Relational database mechanism is well known ORACLE spatial data option is normalized tables. SDE uses blobs-but reveals a lot about the data structure.	Shape Files: one feature table. One index file and one dBase file- very difficult ARC INFO totally proprietary.
Robustness	Roll-back segments. Redo logs files. Back and recovery tools. Well established kemel	Lose or corrupt the file and hope that you have some back-up
Data Restructuring	Views can be created from table and can be stored as objects within the database.	One flat file is a file can create definitions within Arc View or reselect statements in ARC INFO. Not predefined objects.

Source: http://www.isprs.org/caravan/documents/Lao_Basic_GIS

Meta Data

Metadata summarizes basic information about data, which can make finding and working with particular instances of data easier. For example, author, date created and date modified and file size are examples of very basic document metadata. Having the abilty to filter through that metadata makes it much easier for someone to locate a specific document.

Metadata is a summary document providing content, quality, type, creation, and spatial information about a data set. It can be stored in any format such as a text file, Extensible Markup Language (XML), or database record. This is an exciting time to work with metadata because an Internet infrastructure for global data access is fully functional.

1.8.4. Data Analysis

The strength of the GIS lies in its analytical capabilities. What distinguish the GIS from other information systems are its spatial analysis functions. The analysis functions use the spatial and non-spatial attributes in the database to answer questions about the real world. Geographic analysis facilitates the study of real world processes by developing and applying models. Such models provide the underlying trends in geographic data and thus, make new possibilities available. The objective of geographic analysis is to transform data into useful information to satisfy the requirements of the decision-makers. For example, GIS may effectively be used to predict future trends over space and time related to variety of phenomena. However, before undertaking any GIS based analysis, one needs to identify the problem and define purpose of the analysis. It requires step – by – step procedures to arrive at the conclusions. The basic analytical tools in GIS platforms are classified in box below.

Data Analysis

1. **Vector data Analysis**
   Buffering – It creates buffer zones by measuring straight line distances from selected features**.**
   Overlay – It is a tool to combine geometrics and attributes from different layers to create outputs**.**
   Distance Measurement – It calculate straight line distance between spatial features.
   Spatial Statistics – It detect spatial dependence and pattern of concentration among features.
   Map Manipulation – It is tool available in GIS package for managing maps and altering layers in data base.
2. **Raster Data Analysis**
   Local - It operate on individual cells.
   Neighborhood – It operate by specified neighborhood such as a 3-by-3 windows.
   Zonal – It operate with group of value with same value or like features
   Global – It operate on entire raster data set.
3. **Terrain Mapping and Analysis**
   Mapping techniques such as contouring, hill shading, profiling, hypsometric tinting and 3-D views are useful for visualization and analysis of landforms.
4. **Viewshed and Watershed**
   A viewshed analysis determines the area of land surface that are visible from one or more observation point.

Watershed analysis can derive topographical features such as flow direction, stream network and water shed boundaries for hydrologic functions.

5. Spatial Interpolation

It is a process of using points of known value to estimate the value at other points.

6. Geocoding and Dynamic Segmentations

Gecoding converts street address or street intersection into points features. Dynamic segmentation plot linear reference data on a coordinate systems.

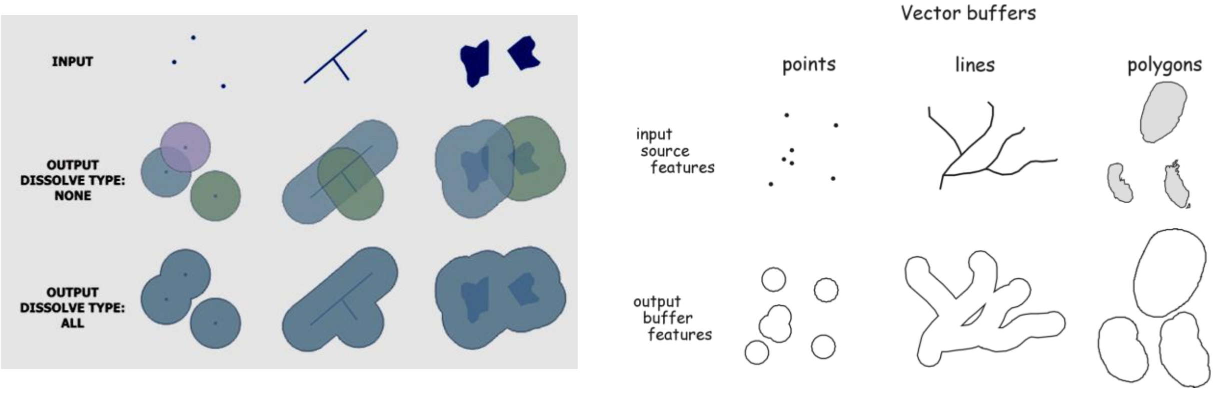
7. Path Analysis and Network Application

It includes determination of optimum path using specified decision rules. The decision rule likely to be based on minimum time, minimum distance, maximum correlation occurrence or capacity, shortest path and son

Buffering Technique

Buffering is technique to find an area with certain distance from given point or line. For example noise polluted area can be extracted by buffering an area within 30 meters distance from trunk road (Fig.1.12).

Fig. 1.12. Buffering methods



Source: http://www.geo.hunter.cuny.edu/~rdatta/gis2/lectures/lecture5/lecture5.html

Overlay Technique

Overlay is at the core of GIS analysis operations. It combines several spatial features to generate new spatial elements. Overlay can be defined as a spatial operation that combines various geographic layers to generate new information. Overlay is done using arithmetic, Boolean, and relational operators, and is performed in both vector and raster domains.

Mathematical Operators in Overlay Function

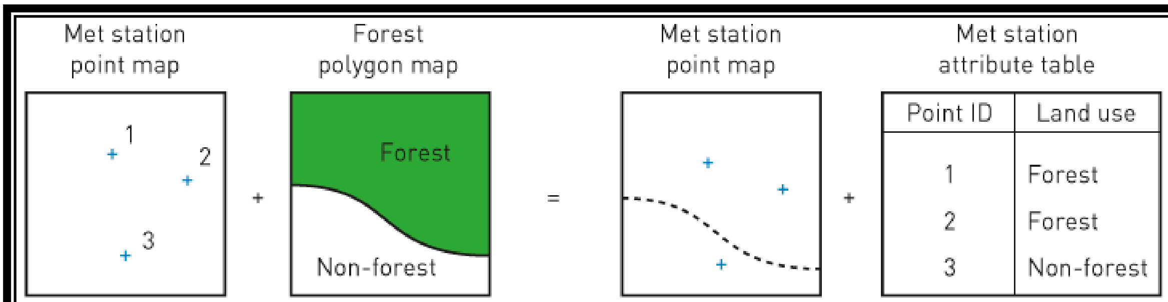
1. **Arithmetic operators (+, −, ×, ÷)** allow for the addition, subtraction, multiplication, and division of two raster maps or numbers or a combination of the two.
2. **Boolean operators** (and, not, or, xor) use Boolean logic (true or false) on the input values. Output values of true are written as 1 and false as 0.
3. **Relational operators** (<=, =, >, >=) evaluate specific relational conditions. If the condition is true, the output is assigned 1; if the condition is false, the output is assigned 0.

Types of Overlay Function

Overlay function can be classified into point in polygon, line in polygon and polygon in polygon.

Point in polygon overlay operation, the same point features in input layers are included in output but each is assigned with a attributes of polygon within it falls (Fig.1.13.). Which metro stations are located in the forested areas?

Fig. 1.13. Point in Polygon

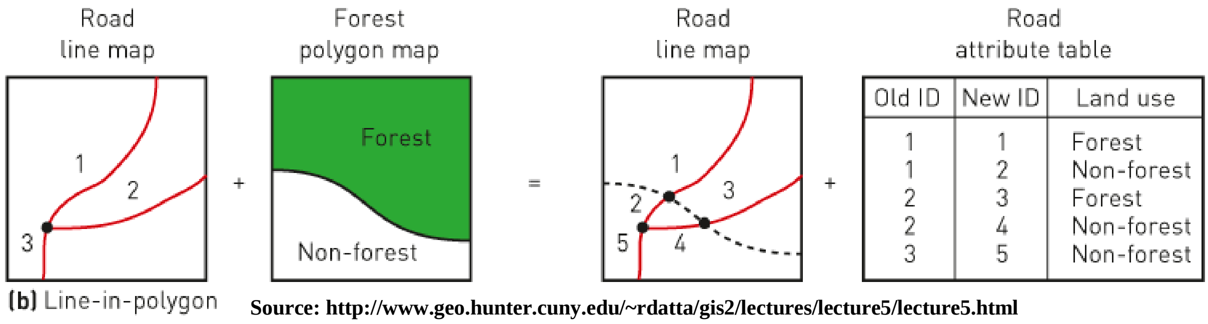


(a) Point-in-polygon

Source: http://www.geo.hunter.cuny.edu/~rdatta/gis2/lectures/lecture5/lecture5.html

Line in polygon overlay operation, the out contains the same features as in the input layer but each line a feature is dissected by polygon boundary on overlay layer (Fig1.14.). Which sections of road pass through the forest?

Fig. 1.14. Line in Polygon



Source: http://www.geo.hunter.cuny.edu/~rdatta/gis2/lectures/lecture5/lecture5.html

Polygon on polygon combines two polygon boundaries from input and overlay to create new a new set of polygon. Each new polygon carries attributes from both the layers and theses attributes differ from those adjacent polygons (Fig.1.15.). Which areas are covered by forest OR are within the resort boundary?

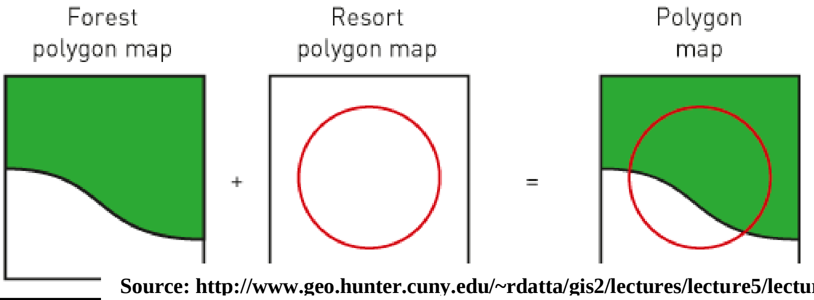


Fig.1.15. Polygon in Polygon

Source: http://www.geo.hunter.cuny.edu/~rdatta/gis2/lectures/lecture5/lecture5.html

Basic GIS Operation

Clipping Features

Use the clip operation when you want to cut out a piece of one theme using another theme as a "cookie cutter". For example, you might want to select a village boundary theme to extract the roads from a roads theme to create a new theme containing roads for a particular district.

Merging Features

Use the Merge process when you want to create a new theme containing two or more adjacent themes of the same shape file type. For example, you may want to merge or append highway data delivered as a series of tiles. Merge allows you to append the data while maintaining the attributes contained in whichever shape file you select.

Buffering Graphics and Features

Buffering allows you to put boundary around a specified feature (point, line, or polygon) at a distance you specify. For example, buffering a point feature using a buffer distance of300 meters would create a circle polygon with a radius of 300 meters, centered on the point.

Querying Attributes

Any attribute or combination of attributes contained in the attribute table can be used to select features. For example, a polygon team contains an attribute giving the area of the polygon. You could use that attribute to find all polygons greater than 1200 square meters, or less than 52 square meters, etc.

1.8.5. GIS Data Modeling

GIS modeling refers to the use of GIS functionalities in building a model with geospatial data. A model is a simplified representation of phenomena or system. A data model in geographic information systems is a mathematical construct for representing geographic objects or surfaces as data. For example, the vector data model represents geography as collections of points, lines, and polygons; the raster data model represent geography as cell matrices that store numeric values; and the TIN data model represents geography as sets of contiguous, non overlapping triangles. The development of model follows a series of steps. The first step is to define the goals of the model. The second step is to break down the model into elements and to define the properties of each element and interaction between the elements. The third step is the implementation and calibration of the model. Final step of model is to validate under different set of data used in calibration phase.

GIS can assist the modeling processes in several ways. First, GIS is a tool that can processes, display and integrate different data sources including maps, digital elevation models, GPS data, images and tables. Second, models built with a vector-based or raster based. Third, conversion algorithm between raster and vector are avliable in GIS packages. Fourth, many GIS packages like Arc GIS, GRASS, IDRISI, ILWIS, MF Work have extensive function for modeling.

Classification of GIS Models

1. **Descriptive or prescriptive:** A descriptive model describe the existing condition of spatial data but prescriptive model offers a prediction of what condition could or should be.
2. **Deterministic or Stochastic:** A Deterministic model provide no assessment of errors with predicted value but Stochastic model offers assessment of prediction errors with estimated variance.
3. **Dynamic or Static:** A dynamic model emphasizes the changes of spatial data and interaction between variables whereas static model deal with state of spatial data at a given time.
4. **Deductive or Inductive:** A deductive model represents the conclusion derived from set of premises but inductive model represents the conclusions derived from empirical data and observations.

Types of GIS Modeling

1. **Binary Models** – It is a model to use logical expression to select spatial features from composite feature or multiple rasters. The output of binary model is in binary format: 1(true) for spatial features that meet selection criteria and 0 (false) for features that do not.

2. **Index Model** – An index model calculates the index value from overlay output and rank areas based on index value. An index is similar to binary model in that both involve multi-criteria evaluation and both depend upon the overlay operation for data processing. But index model produce for each unit area an index value rather than a simple yes or no.

3. **Regression Model** – A regression model relates a dependent variable to a number of independent (explanatory) variables in a equation which can used for prediction or estimation.

4. **Process Model** – A process model integrate existing knowledge about environmental processes in the real world into set of relationship and equation for quantifying the processes.

1.8.6. Data Output

Data Output is the procedure by which information from the GIS is presented in a form suitable to the user. Data are output in one of three formats: Hardcopy, softcopy and electronic. Hardcopy outputs are permanent means of display like paper, mylar, photographic film or other similar materials. Softcopy output is in the format viewed on a computer monitor. Output in electronic formats consists of computer-compatible files. The most common type of data out in GIS format as follows show in box.

Maps: Everyone recognizes this most common output from a GIS.
Cartograms: These special maps that distort geographic features based on their output values rather than their size.
Charts: GIS can produce pie charts, histograms (bar charts), line charts, and even pictures in addition to maps.
Directions: Another common output, directions show you how to get from one place to another.
Customer lists: Business GIS applications often produce customer lists, sometimes with printed mailing labels.
3D diagrams and movies: These forms of GIS output help you see the results of your work realistically and dramatically.

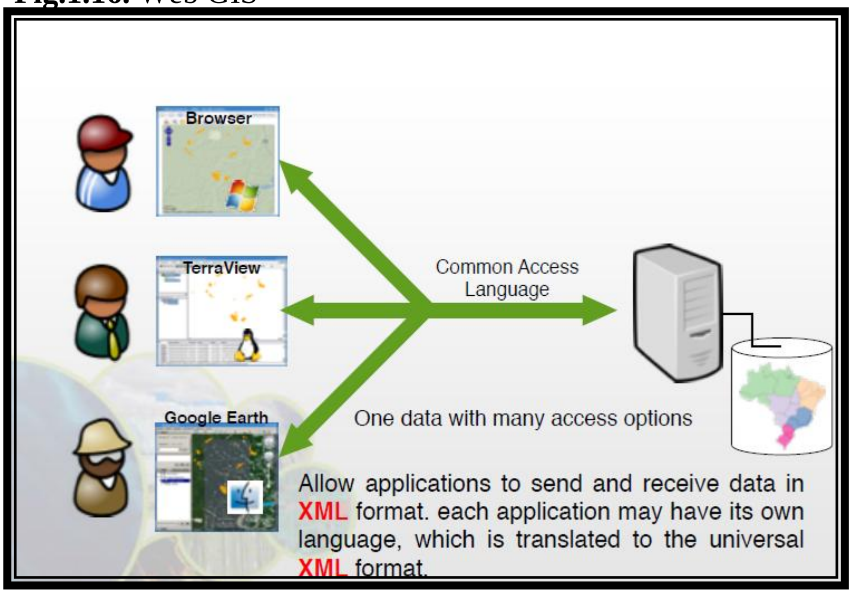
A dynamically produced map is a highly effective device and efficient storage mechanism for summarizing and communicating to the user the results of such analyses. A map presentation is output format usually has number of elements: title, subtitle, body, legend, north arrow, scale, bar, acknowledgement, neatline and border. The effective choice of color, pattern, shading, symbology, text fonts, and placement of text in an uncluttered but accurate way is one of the classical challenges of map making. Window based GIS have simplified the processes by providing choices for each elements through menus and palettes. Further, without basic understanding of map symbols, colour, and typology can distort the information in map making. Again map design is a creative process cannot be replaced by default templates and computers code. Hence, Cartography is the design and production of maps, or visual representations of spatial data.

1.9. Web based GIS Technology

World Wide Web (www) has changed every aspect of our life from our daily activities to our professions activities and changes have happened in GIS technology, which is called Web based technology. We use this technology in our daily life but do not notice it. For example, finding hotels, shortest path and addresses in an unknown city using Google earth or online interactive maps are available in internet for use. There are many usage which we can name internet base GIS or web base GIS. This leads to the question, is there a difference between these two terms? What is the difference between Web GIS and Internet GIS?

The six basic components of GIS are of Hardware, Software, data, method, network and users. These components were joined together in one computer during 1960s and 1970s but later distributed GIS emerged with the adoption of a local area network (LAN). Further, development of web based GIS, the end users sitting on one side of the globe can access a server located on the other side of the globe

Fig.1.16. Web GIS



Source: Webinar Series on Remote Sensing Technology for Disaster Management

Web based GIS

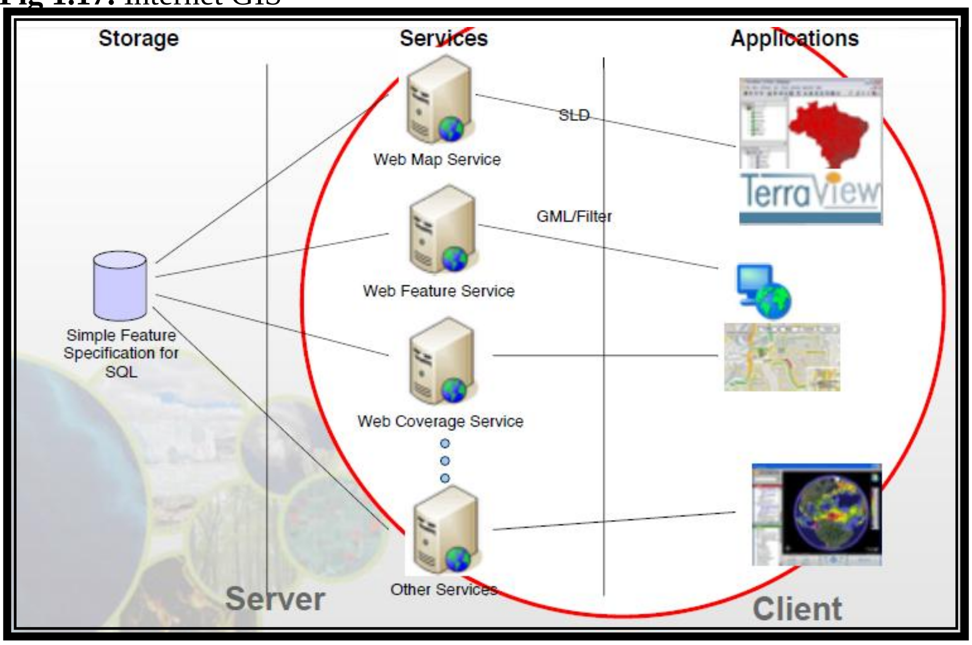
As you might know Web GIS is a GIS system that uses web technologies. It often uses web technologies to communicate among different components of the system. Web GIS originates from a combination of web technology and the Geographical Information System, which is a recognized technology that is mainly composed of data handling tools for storage, recovery, management and analysis of spatial data Web GIS is a kind of distributed information system. The simplest architecture of a Web GIS must have at least one client and one server that client is a desktop application or web browser application that allows users to communicate with server, and the server is a web server application (Fig.1.16.).

Internet GIS

Web GIS is a close term to Internet GIS. These two words are always used as synonymous with each other. There is a slight difference between these two words. The Internet supports many services with the Web being one of these services. So we can call a system as Internet GIS if it uses many of services of Internet not only Web service and if it uses only Web we should name it Web GIS. This definition makes Internet GIS boarder than Web GIS. In real world Web is the most attractive service of Internet and it is why Web GIS is more common than Internet GIS (Fig. 1.17.).

The geospatial Web, or GeoWeb, is another term that uses to refer Web GIS , However the definition of Web GIS is not identical to Web GIS . GeoWeb can be defined by merging geospatial information with none geospatial information such as news, photos, stories and so on.

Fig 1.17. Internet GIS



Source: Webinar Series on Remote Sensing Technology for Disaster Management

Check Your Progress I

Note: a) Use the space provided for your answers.

b) Check your answers with the possible answers provided at the end of this unit.

1) What do you mean by GIS?

Ans.

2) Define spatial data. Describe different type of spatial data model?

Ans.

3) Explain the meaning of Map Projection.

4) Write the name of common datum used globally.

5) Name the components of GIS.

6) Give some examples of open source GIS software.

7) What are the analytical capabilities available in GIS platforms?

8) Write the name of different Overlay function in GIS.

9) Discuss the different types of GIS models.

10) Write the difference between Internet GIS and Web GIS.

1.10. Let Us Sum Up

This block covers topics on Geographical Information System, Concept Space and Time, Spatial Data, Map Projection and Datum, Components of GIS, GIS functionalities, etc. Student will learn about basic concept of Geographical Information Systems (GIS) and how it has been evolved to the present level and its importance in handling real world problems. It also explains about importance of map, and a brief comparison about map and present GIS map. Similarly, the subject geography and geographical space is also adopted new trends to meet the changing scenario in the society and geography in particular. The components explain its role and importance in GIS. Every component is interdependent without which GIS can't be run. Like any other system, geographical information system is also capable of converting data into useful information for effective decision making. The basic components of GIS include data, hardware, software, method/procedures and people. Further, GIS operation are classified into 6 functional components, viz. data acquisition, data input, data management, data analysis, data modeling and data output. The analysis system caters to the analysis requirement of the GIS and consists of the operation pertaining to geometrical analysis, topological analysis, interpolation & approximation besides planning & simulation operations. The fast changing scenario in computer technology is paving the way to adopt new trends such as Web based GIS.

1.11. Key Words

Geographic Information System: A computer system for capturing, storing, querying, analyzing and displaying geographical reference data.

Geospatial Data: Data that describe both location and charcterstics of spatial features on Earth's surface.

Map Projection: The process of transforming the spatial realtion on earth surface to a flat map.

Datum: The basis of calculating geographical coordinate of a location.

Buffering: A GIS operation that creates zones consisting of areas within a specified distance of select features.

Overlay: A GIS operation that combines geometries and attributes of input layers to create output

1.12. References/ Further Reading

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1.13. CHECK YOUR PROGRESS – POSSIBLE ANSWERS

Check Your Progress I

1) **Geographic Information System** is a set of tools that allow for the processing of spatial data into information.
   A GIS is designed for the collection storage, and analysis of objects and phenomena where geographic location is an important characteristic or critical to the analysis.

2) **Spatial data in GIS** represents features that have a known location on the earth. The data model represents a set of guidelines to convert the real world (called entity) to the digitally and logically represented spatial objects consisting of the attributes and geometry. There are two spatial data model.
   Raster data model are based on grid or pixels in sequence.
   Vector model are based on points, lines and polygon.

3) **Map Projections** are attempts to portray a three dimensional earth surface on flat map sheet.

4) The commonly used datum globally are
   WGS84 (World Geodetic Survey, 1984)
   GRS80 (Global Reference System, 1980)
   Clarke 1866 ellipsoid (used with California's State-wide Teale Albers projection)
   NAD83 or 27 datum (North American Datum, 1983 or 1927).

5) A working GIS integrates five key components:

   Hardware
   Software
   Data,
   People
   Procedure

6) The examples of open source GIS software are
GRASS, FLOW MAP, QUANTUM, MAP WINDOW and SPRING

7) The analytical capabilities of GIS are

1. Vector data Analysis

Buffering – It creates buffer zones by measuring straight line distances from selected features**.**

Overlay – It is a tool to combine geometrics and attributes from different layers to create outputs**.**

Distance Measurement – It calculate straight line distance between spatial features.

Spatial Statistics – It detect spatial dependence and pattern of concentration among features.

Map Manipulation – It is tool available in GIS package for managing maps and altering layers in data base.

2. Raster Data Analysis

Local - It operate on individual cells.

Neighborhood – It operate by specified neighborhood such as a 3-by-3 windows.

Zonal – It operate with group of value with same value or like features

Global – It operate on entire raster data set.

8) **Types of Overlay function are** point in polygon, Line in Polygon and Polygon in Polygon.

9) GIS modeling refers to the use of GIS functionalities in building a model with geospatial data. The different type of GIS model are

Descriptive or prescriptive: A descriptive model describe the existing condition of spatial data but prescriptive model offers a prediction of what condition could or should be.

Deterministic or Stochastic: A Deterministic model provide no assessment of errors with predicted value but Stochastic model offers assessment of prediction errors with estimated variance.

Dynamic or Static: A dynamic model emphasizes the changes of spatial data and interaction between variables whereas static model deal with state of spatial data at a given time.

Deductive or Inductive: A deductive model represents the conclusion derived from set of premises but inductive model represents the conclusions derived from empirical data and observations.

10) **Web GIS** is a close term to **Internet GIS**. These two words are always used as synonymous with each other. There is a slight difference between these two words. The Internet supports many services with the Web being one of these services.

****

Unit – 2

Remote Sensing

Objectives

After completion of this unit, you should be able to:

- *Understand the basic science behind Remote Sensing.*
- *Discuss about electromagnetic radiation and their interaction with atmosphere and earth surface.*
- *Identify various interpretation element and basic operation of Visual Image Interpretation and Digital Image Processing.*
- *Explain the capability of Remote Sensing data in disaster monitoring and hazard mapping.*

Structure

2.1 Introduction

2.2 Fundamental in Remote Sensing

2.3 Electromagnetic Radiation

2.4 Electromagnetic Spectrum

2.5 Energy interaction with Atmosphere

2.6 Energy interaction with Earth Surface

2.7 Platform and Sensor

2.8 Characteristics of Images

2.9 Image Interpretation and Analysis

2.9.1. Visual Image Interpretation

2.9.2. Digital Image Processing

2.10 Microwave Remote Sensing

2.11 Remote Sensing Application in Disaster Management

2.12 Scenario of Indian Remote Sensing Satellite in Future

2.8 Key Words

2.9 References

2.10 Check Your Progress – Possible Answers

2.1. Introduction

Remotely sensed images are now prevalent in many aspects of our daily lives. Thanks to Google Earth, even lay persons do appreciate the power of remote sensing. Remote sensing refers to the activities of recording/observing/perceiving (sensing) objects or events at far away (remote) places. In simplest word, remote sensing means acquiring information about an object without touching the object itself. We perceive the surrounding world through our five senses. Some senses (touch and taste) require contact of our sensing organs with the objects. However, we acquire much information about our surrounding through the senses of sight and hearing which do not require close contact between the sensing organs and the external objects. In another word, we are performing remote sensing all the time. The sun provides the direct source of illumination to the earth's surface. The electromagnetic radiation is normally used as an information carrier in remote sensing. The output of a remote sensing system is usually an image representing the scene being observed. A further step of image analysis and interpretation is required in order to extract useful information from the image. The human visual system is an example of a remote sensing system in this general sense.

Planet earth is under huge stress due to climate variability and exponential growth of global population. The human and economic loss will continue to grow in coming days will be the result increase in global urbanization and increase in number of extreme events. The question of the hour is “Do we have right information available at right time at right place to take adequate decisions?”. Earth observations from space are instrumental in gathering reliable, detail, timely affordable geospatial data. The development in satellite remote sensing and complimentary technology mainly linked with computing and internet technology will be the tool for grassroots requirement of the developmental process. The remote sensing images forms the basic component of spatial information for mapping, monitoring and forecasting changes of natural and constructed world of earth systems. The basic objective of the unit is introduce principle of remote sensing, platform, sensor, satellite images, techniques and applications in simple language to cater the beginners with various academic background. The content is organized in such a way that it would help the participants to understand the science of remote sensing and its applications in a comprehensive manner.

2.2. Fundamental in Remote Sensing

Remote Sensing means acquiring information about Earth Surface without touching it. When you are looking outside your class room through the window, you are gathering information about objects with actually being in contact with it. In this case eyes act as sensing devices and objects information of landscape are target being sensed. The Sunlight illuminates these targets in day time. The senses like sight, hearing and smell are considered source of remote sensors where the source of information at some distance.

Definition of Remote Sensing

Remote Sensing is the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation **(Lillesand, 2004)**.

Remote Sensing is the technique of acquiring information about an object by a recording device (Sensor) that is not in physical contact with object by measuring portion of reflected or emitted electromagnetic radiation from earth surface **(Kumar, 2001).**

Remote Sensing means sensing of the earth's surface from space by making use of the properties of electromagnetic wave emitted, reflected or diffracted by the sensed objects, for the purpose of improving natural resource management, land use and the protection of the environment **(United Nations, 1986).**

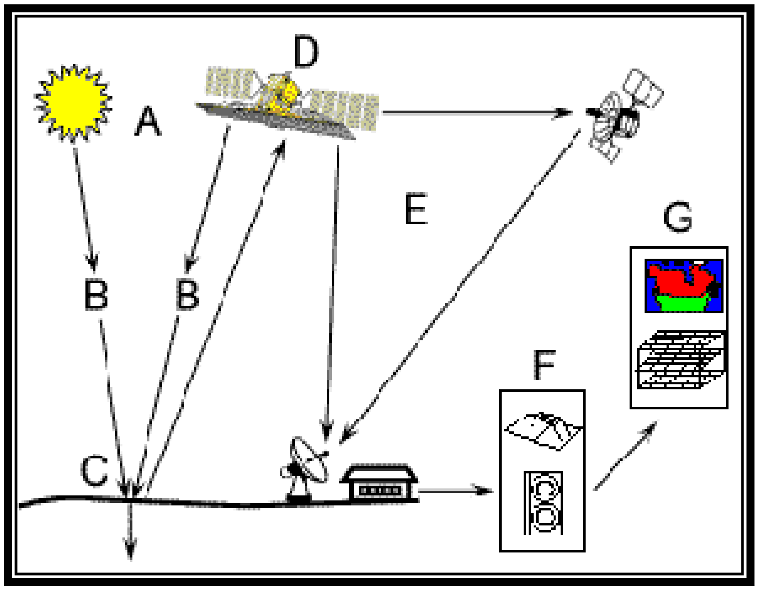
As you are reading the definition from the material, we are doing the process of remote sensing. Here the sensor (eye) and target (texts in material)) are located remotely apart and electromagnetic radition serve as link between eye (Sensor) and object (text in materials). The fundamental principle involved here different object in earth surface reflect different amount of energy in different wavelength range of electromagnetic spectrum. The part of energy is reflected, scattered, absorbed and transmitted by the surface. Here, our eyes acquire impulses corresponding to the amount of light reflected from the dark and light areas on the page. These data are analyzed, or interpreted, in our brain and converted to meaningful information for use.

Remote Sensing process can be summarized into following seven steps and depicted in Fig 2.1

1. **Energy Source or Illumination (A)** - the first requirement for remote sensing is to have an energy source which illuminates or provides electromagnetic energy to the target of interest.
2. **Radiation and the Atmosphere (B)** - as the energy travels from its source to the target, it will come in contact with and interact with the atmosphere it passes through.

This interaction may take place a second time as the energy travels from the target to the sensor.

Fig. 2.1. Fundamental Process in Remote Sensing



Source - Canada Centre for Remote Sensing, Fundamentals of Remote Sensing

3. **Interaction with the Target (C)** - once the energy makes its way to the target through the atmosphere, it interacts with the target depending on the properties of both the target and the radiation.

4. **Recording of Energy by the Sensor (D)** - after the energy has been scattered by, or emitted from the target, we require a sensor (remote - not in contact with the target) to collect and record the electromagnetic radiation.

5. **Transmission, Reception, and Processing (E)** - the energy recorded by the sensor has to be transmitted, often in electronic form, to a receiving and processing station where the data are processed into an image (hardcopy and/or digital).

6. **Interpretation and Analysis (F)** - the processed image is interpreted, visually and/or digitally or electronically, to extract information about the target which was illuminated.

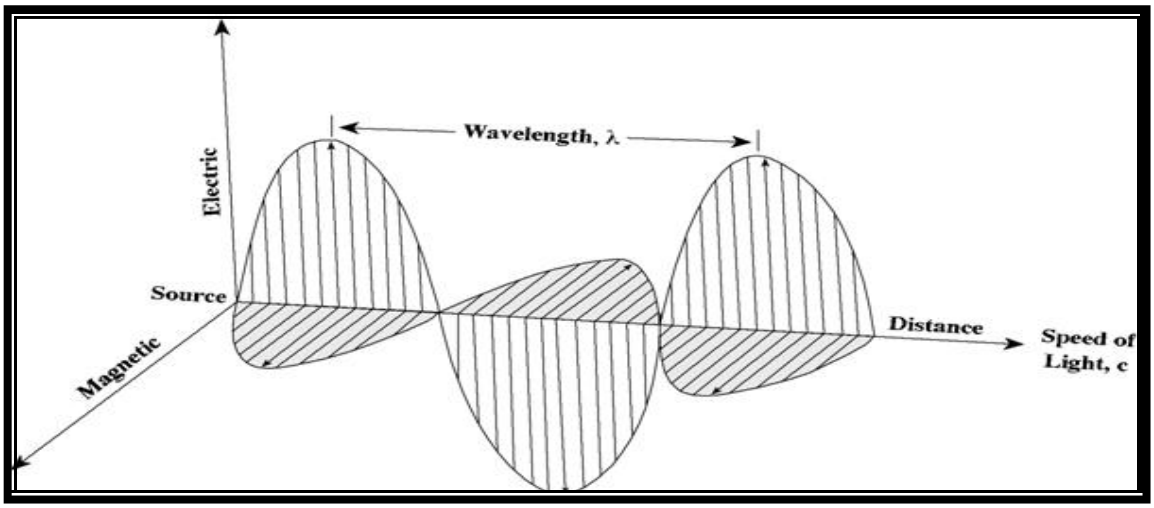
7. **Application (G)** - the final element of the remote sensing process is achieved when we apply the information we have been able to extract from the imagery about the target in order to better understand it, reveal some new information, or assist in solving a particular problem.

2.3. Electromagnetic Radiation

The first and foremost requirement for remote sensing is to have an energy source to illuminate the object on earth surface. This energy are produced by nuclear reaction inside sun are inform of electromagnetic radiations.

Electromagnetic radiation consists of an electrical field (E) which varies in magnitude in a direction perpendicular to the direction in which the radiation is traveling, and a magnetic field (M) oriented at right angles to the electrical field. Both these fields travel at the speed of light (c) (shown in fig. 2.2). Wave length and frequency are two important characteristics of electromagnetic radiation for better understanding of remote sensing.

Fig. 2.2. Electromagnetic Wave



Source: Lillesand T.M. and Kiefer R.W., 2000. Remote Sensing and Image Interpretation. Wiley (Chichester). p4.

Wave Length: It is distance between two successive wave crest and measured in the unit of length such as Nanometers (nm, 10^{-9}metres), Micrometres (µm, 10^{-6} metres) or Centimeters (cm). Wavelength is usually represented by the Greek letter lambda **(λ)**.

Frequency: It is measured the number of cycles of a wave passing a fixed point per unit of time. The unit of measurement is Hertz which is equal to equivalent to one cycle per second and denoted by **ν.**

Amplitude: It is the height of each wave peak.

Wavelength and frequency are related by

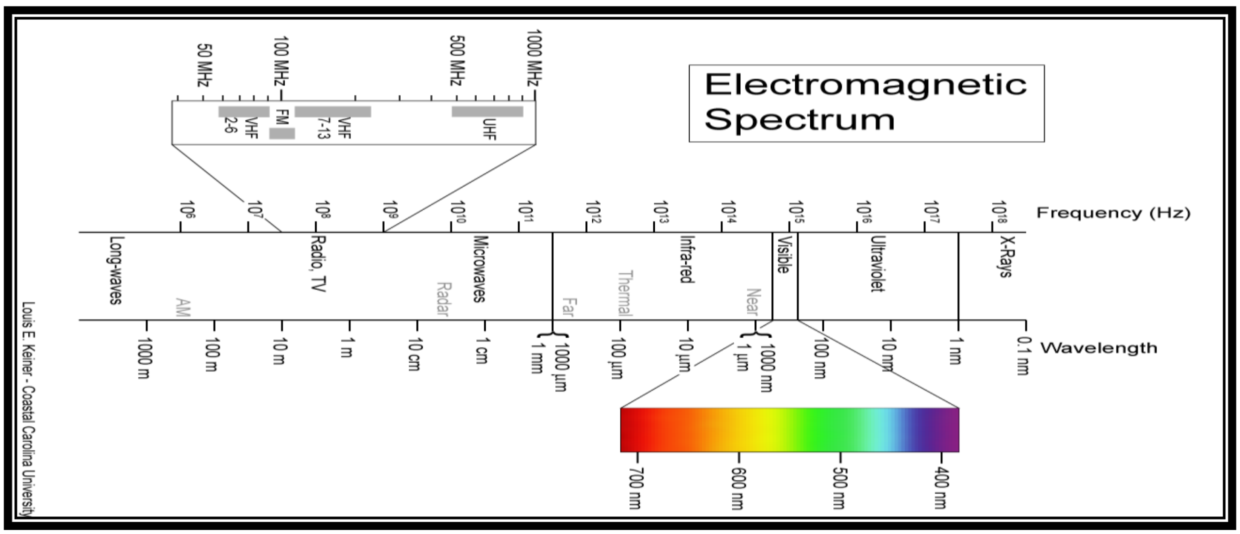
$$C = \lambda \nu$$ Where C = Velocity of light

Or $$\lambda = C / \nu$$ (Wave frequency and wavelength are inversely related to each other

2.4. Electromagnetic Spectrum

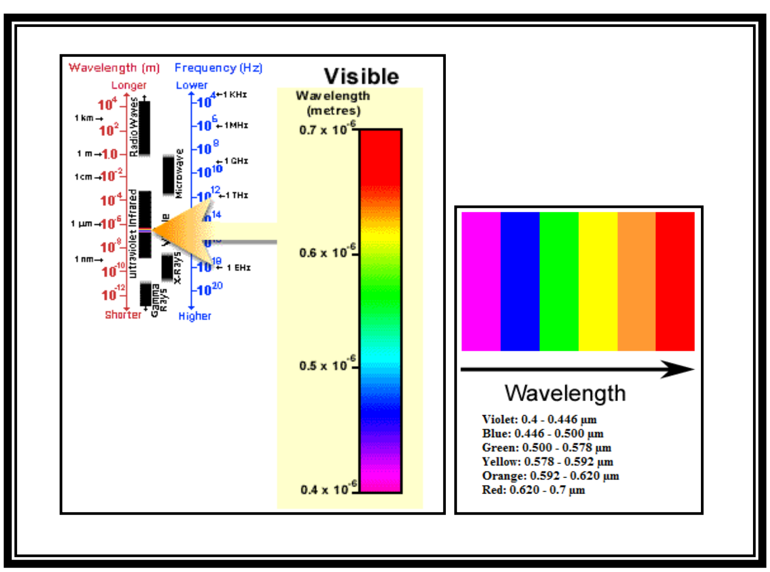
Electromagnetic Spectrum refers to distribution of radiant energy arranged on basis of wave length and frequency. The chemical elements, when excited by thermal or electrical energy, give off Electromagnetic radiation at discrete (particular) wavelength values unique to each element species; these may appear as lines in a spectrogram made by dispersing the radiation using a prism or diffraction grating in form of electromagnetic spectrum. The Electromagnetic Spectrum ranges from the shorter wavelengths (gamma and x-rays) to the longer wavelengths (microwaves and broadcast radio waves) (Fig. 2.3).

Fig 2.3. The Electromagnetic Spectrum



There are several regions of the electromagnetic spectrum which are useful for remote sensing**.** The light which our eyes - our "remote sensors" - can detect is part of the visible spectrum (Fig. 2.4).

Fig. 2.4. Visible Spectrum of EMR



Source:
Canada Center for Remote Sensing, Fundamental of Remote Sensing

The regions of EMR are summarized in table 2.1.

Table 2.1. Regions of Electromagnetic Spectrum

Wavelength Region	Description
Ultraviolet Region .30 µm - .38 µm 1 µm = 10^{-6}	This region is beyond the violet portion of the visible wavelength and hence its name. Some earth surface material primarily rocks and minerals emit visible UV radiation. However UV radiation is largely scattered by earth's atmosphere and hence not used in field of remote sensing.
Visible Spectrum .4 µm - .7 µm Violet .4 µm - .446µm Blue .446 µm - .5µm Green .5 µm - .578µm Yellow .578 µm - .599µm Orange .592 µm - .62µm Red .592 µm - .62µm	This is the light which our eyes can detect. This is the only portion of the spectrum that can be associated with concept of colour. Blue, Green and Red are the three primary colours of visible spectrum. They are defined as such because no single primary colour can be created from the other two, but all other colours can be formed by combining the three in various portions. The colour of an object is defined by colour of the light it reflects.
Infrared Spectrum .7 µm - .100 µm	Wavelengths longer than red portion of the visible spectrum are designed as the infrared spectrum. The infrared spectrum can be divided into two categories based on their radiation properties. Reflected IR (.7 µm – 3.0 µm) is used for remote sensing. Thermal IR (.3 µm – 100 µm) is the radiation emitted from earth's surface in form of heat.
Microwave Region 1 µm – 30 cm	This is the longest wavelength used in remote sensing. The shortest wavelengths in this range have properties similar to thermal infrared region. The main advantage of this spectrum is its ability to penetrate through clouds.
Radio Waves > **30 cm**	This is the longest portion of the spectrum mostly used for commercial broadcast and metrology

Source: Kumar, 2001 pp 10

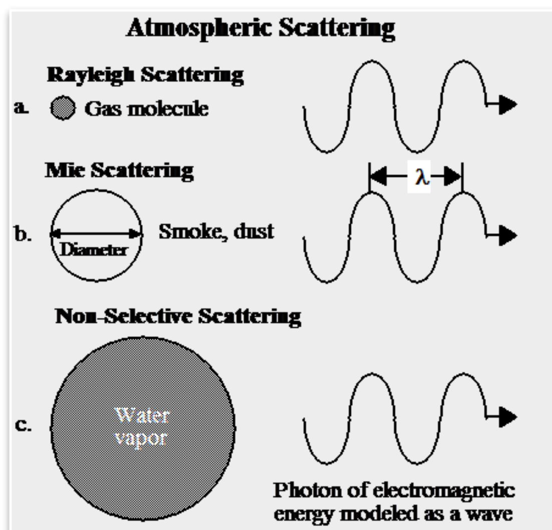
2.5. Energy interaction with Atmosphere

The electromagnetic radiation passes through atmosphere twice before captured by remote sensor on board satellites. Dust particles, gasses and water vapors in the atmosphere affect the incoming radiation by mechanism of **scattering and absorption**.

Scattering is the unpredictable diffusion of radiation by particles in the atmosphere**.** The effect of scattering is to redirect some portion of incoming radiation back to space and some towards earth surface.

Types of Scattering

- **Rayleigh** scattering occurs when particles are very small compared to the wavelength of the radiation. These could be particles such as small specks of dust or nitrogen and oxygen molecules. It is also the cause of blue colour of sky and red and orange colour often seen sunrise and sun set.



- **Mie** scattering occurs when the particles are just about the same size as the wavelength of the radiation. Dust, pollen, smoke and water vapour are common causes of Mie scattering which tends to affect longer wavelengths than those affected by Rayleigh scattering.
- **Non-selective** scattering occurs when the particle size are much longer than the radiation wave length. Large dust particles and larger water droplets help to scatter wavelength equally. This type of scattering causes fog and clouds to appear white to our eyes because blue, green, and red light are all scattered in approximately equal quantities (blue+green+red light = white light).

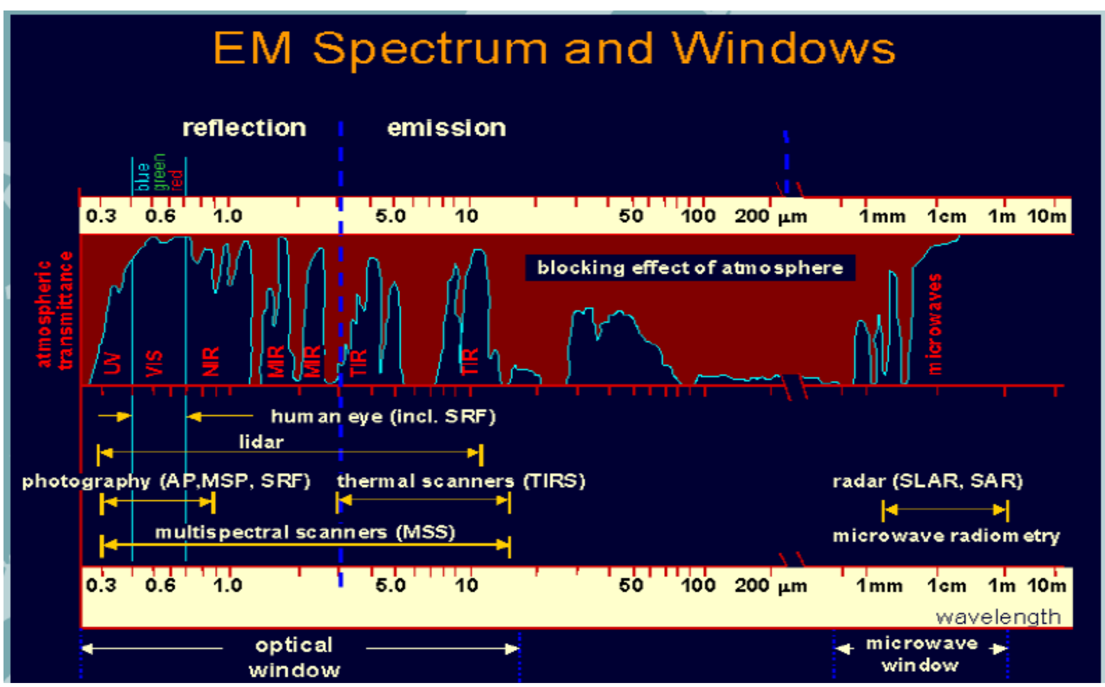
Absorption

Absorption is the process by which radiant energy is absorbed and converted into other forms of energy. An absorption band is a range of wavelengths (or frequencies) in the electromagnetic spectrum within which radiant energy is absorbed by substances such as water (H_2O), carbon dioxide (CO_2), oxygen (O_2), ozone (O_3), and nitrous oxide (N_2O). Ozone absorbs the harmful ultraviolet radiations from Sun and without this protection our skin would have burn. Carbon dioxide tend to absorb far infrared portion of the spectrum. Water vapour absorbs much of the incoming infrared and microwave radiations. The cumulative effect of the absorption by the various constituents can cause the atmosphere to close down in certain regions of the spectrum. This is bad for remote sensing because no energy is available to be sensed.

Atmospheric Window

These are regions in electromagnetic spectrum which are not severely influenced by atmospheric absorption and thus, are useful to remote sensors, are called atmospheric windows. By comparing the characteristics of the two most common energy/radiation sources (the sun and the earth) with the atmospheric windows available to us, we can define those wavelengths that we can use most effectively for remote sensing. The visible portion of the spectrum, to which our eyes are most sensitive, corresponds to both an atmospheric window and the peak energy level of the sun. Note also that heat energy emitted by the Earth corresponds to a window around 10 µm in the thermal IR portion of the spectrum, while the large window at wavelengths beyond 1 mm is associated with the microwave region.

Fig.2.5. Atmospheric Window and Remote Sensing Sensors in different wavelength

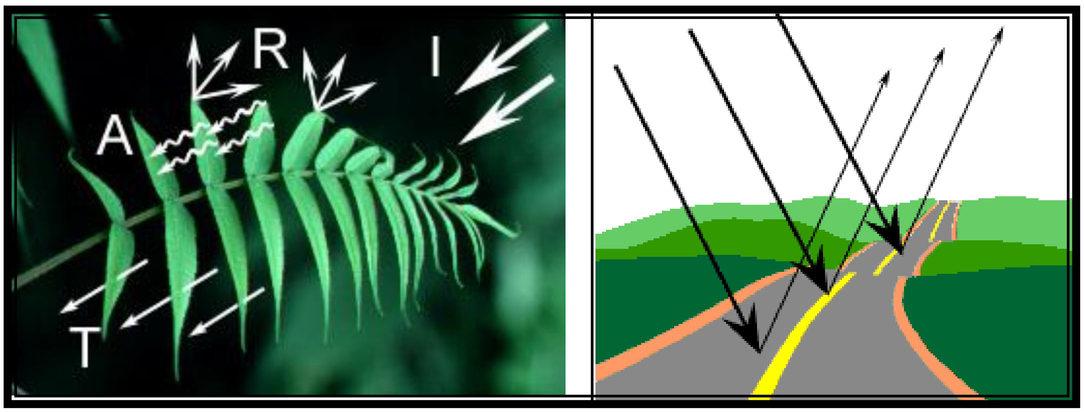


Source: Murayama, 2010

2.6. Energy interaction with Earth Surface

Radiation that is not absorbed or scattered in the atmosphere can reach and interact with the Earth's surface. There are three (3) forms of interaction that can take place when energy strikes, or **is incident (I)** upon the surface. These are: **absorption (A); transmission (T) and reflection (R) (Fig.2.6).** The total incident energy will interact with the surface in one or more of these three ways. The proportions of each will depend on the wavelength of the energy and the material and condition of the feature. **Absorption (A)** occurs when radiation (energy) is absorbed into the target while **transmission (T)** occurs when radiation passes through a target. **Reflection (R)** occurs when radiation "bounces" off the target and is redirected. In remote sensing, we are most interested in measuring the radiation reflected from targets. We refer to two types of reflection, which represent the two extreme ends of the way in which energy is reflected from a target: specular reflection and diffuse reflection.

Fig. 2.6. Interaction of energy with the target

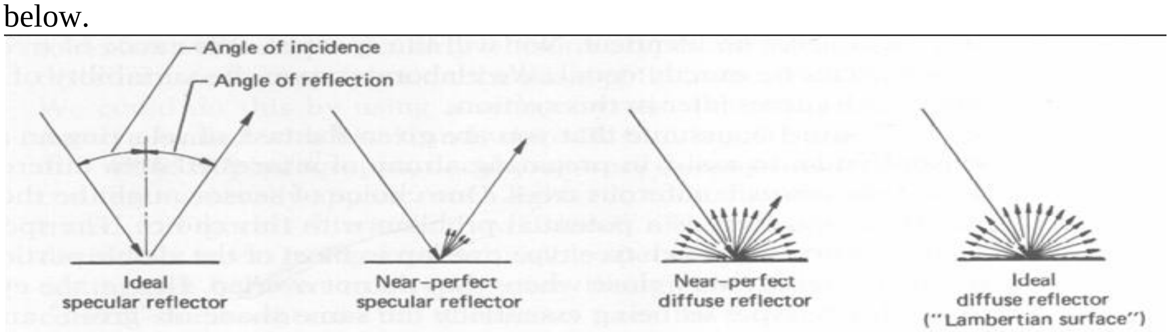


Source - Canada Centre for Remote Sensing, Fundamentals of Remote Sensing

In remote sensing reflectance is also described with respect to the direction of the returned energy. In general, two extremes exist in terms of the type of surface reflectance that occurs for solar electromagnetic radiation:

1. **Specular** - where the angle of reflection equals the angle of incidence.
2. **Diffuse (or Lambertian) -** where reflectance is equal in all directions.

An illustration of these two extreme types of directional reflectors is presented in Figure 2.7 below.



2.7. Platform and Sensor

There is a requirement of sensing device residing in stable platform to record the reflected or emitted energy from earth surface.

Platform is a stage to mount sensor to collect information remotely about an object on earth surface. Platforms for remote sensors may be situated on the ground, on an aircraft or balloon (or some other platform within the Earth's atmosphere), or on a spacecraft or satellite outside of the Earth's atmosphere (Fig.2.7).

- **Ground-based sensors**: Sensors are placed on a ladder, scaffolding, tall building, cherry-picker, and crane to record details information about the surface.
- **Aerial Platforms:** Air craft, helicopters are primarily used to acquire aerial photographs. Aircraft are often used to collect very detailed images and facilitate the collection of data over virtually any portion of the Earth's surface at any time.
- **Platform on Space (Satellite)**: These are satellite outside earth atmosphere which moved around the earth and any part of the earth can be covered at specific interval. Further, these satellites captures enormous amount of remotely sensed data about earth surface.

Fig. 2.7. Platform for Remote Sensor

Source - Canada Centre for Remote Sensing, Fundamentals of Remote Sensing

Sensors are electronic devices used to record the reflected or emitted energy from earth surface. The sun provides a very convenient source of energy for remote sensing. The sun's energy is either reflected, as it is for visible wavelengths, or absorbed and then re-emitted, as it is for thermal infrared wavelengths. Remote sensing systems which measure energy that is naturally available are called **passive sensors**. Passive sensors can only be used to detect energy when the naturally occurring energy is available. **Active sensors**, on the other hand, provide their own energy source for illumination. The sensor emits radiation which is directed toward the target to be investigated. The radiation reflected from that target is detected and measured by the sensor. Advantages for active sensors include the ability to obtain measurements anytime, regardless of the time of day or season. Some examples of active sensors are a laser fluoro sensor and synthetic aperture radar (SAR).

2.8. Characteristics of Images

Electromagnetic energy may be detected either photographically or electronically. The photographic process uses chemical reactions on the surface of light-sensitive film to detect and record energy variations. It is important to distinguish between the terms **images** and **photographs** in remote sensing. **An image** refers to any pictorial representation, regardless of what wavelengths or remote sensing device has been used to detect and record the electromagnetic energy. **A photograph** refers specifically to images that have been detected as well as recorded on photographic film. The black and white photo to the left, of part of the city of Ottawa, Canada was taken in the visible part of the spectrum. Photos are normally recorded over the wavelength range from 0.3 µm to 0.9 µm - the visible and reflected infrared. Based on these definitions, we can say that all photographs are images, but not all images are photographs. Therefore, unless we are talking specifically about an image recorded photographically, we use the term image.

Fig.2.8. Image, Digital number, Pixels

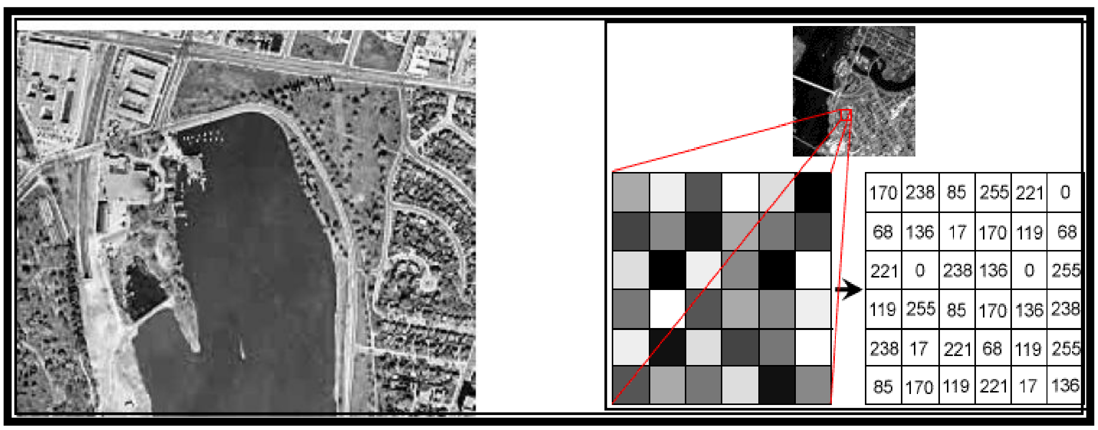


Image Resolution: An ability of remote sensing system to record and display fine details over area.

Type of Resolution

Spatial Resolution: The details visible in an image is depend on the spatial resolution of the sensor and refers to size of the smallest possible features that can be detected.

Spectral Resolution: It describes the ability of a sensor to define the fine wavelength interval. Each discrete, distinctly recorded wavelength interval measured by a sensor is referred to as a 'band' or 'channel.'

Radiometric Resolution: It describes its ability to discriminate very slight differences in energy. The finer the radiometric resolution of a sensor, the more sensitive it is to detecting small differences in reflected or emitted energy.

Temporal Resolution: It refers to the frequency of obtaining data over given area. It is related to revisit period, which refers to length of time taken by satellite to complete one entire orbit cycle.

2.9. Image Interpretation and Analysis

Meaningful information can be extracted from remote sensing data by identification and measurement of various targets in an image. Targets are features or objects located in earth surface can be extracted by trained image interpreter who uses prior knowledge of the area covered by the image, ancillary information about the area, and a set of interpretation elements using which the image content can be visually understood. Image interpretation is the process of identifying different land use/land cover categories, specific objects of interest or identifying areas impacted by natural disasters in images and determining their meaning or significance. There are two different method of interpretation and analysis of remote sensing data:

1. **Visual Image Interpretation**: The ability of human interpreter to relate colours and patterns in an image to real world features. The image used in such analysis is in a pictorial form (Photograph type) also known as analog image. In this process human vision plays a crucial role in extracting information from the images.
2. **Digital Image Processing:** It is a process of digital images with help of computers. The images can be represented in digital form composed of tiny areas known as pixels can be processed and analyzed using computers to extract meaningful information. In this process human operator instruct the computers to perform an interpretation according to certain condition.

2.9.1. Visual Image Interpretation

Visual Image Interpretation is one technique of extracting information from images using human vision system with help of computer screen or hard copy form. Human vision goes beyond the perception of colour by drawing conclusion from visual observation. In analyzing an image, we are somewhere between direct and spontaneous recognition or using several clue to draw conclusion by reasoning process (logical inference). Further, we can only see visible wavelength and interpretation of imagery outside is more difficult for us to imagine.

Interpretation element

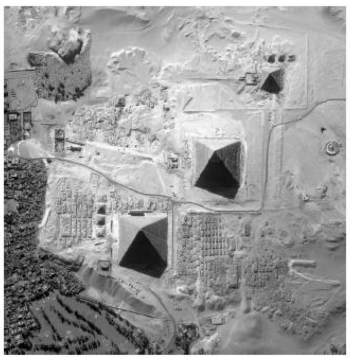
Eight fundamental parameters are used in the interpretation of remote sensing images: **size, shape, tone, texture, site, association, shadow, and pattern.** **"Size" and "shape"** are pretty much self-explanatory; **"tone"** is the brightness of a black-and-white image or the color in a color image; **"texture"** is distinctive variation of tone across a single object; for some objects, their location **("site"**) is a valuable datum in interpretation, as might also be any "**association**" with nearby, readily-identifiable objects; **"shadow"** can at times reveal diagnostic details otherwise invisible in a vertical image; and **"pattern"** is a distinctive array of objects.

Shape and Size

The shape of this particular building is a certain give-away, particularly once its size is understood (by comparison with the recognizable parking lots and nearby highway).

How would one estimate the number of people working here?

Size, Shape, Pattern, Shadow: The Pyramids

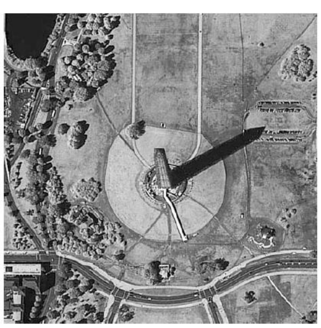


Roads in this image are readily identifiable, which helps the observer get a sense of size. But the key elements here are shape and shadow. These are the famous Pyramids near Alexandria, Egypt. But what else can you determine from this image? Note the pattern of rectangular objects to the right of the lower pyramid. What might they be? What about the medium gray-toned set of elongated features in the lower-left corner? (Hint: if the image were wider, you would see 18 of these elongate features. Who'd have thought, in the shadow of the Pyramids….. !

Association: Hoover Dam

Sometimes objects that are difficult to identify on their own can be understood from their association with objects that are more easily identified. For example, the distinctive curved shape of the object in this image, the apparent difference in height of the dark surfaces on either side of it, and other details all suggest that it is a dam. In that context, the open lattice structure along the bottom of the images is much more likely to be recognized as a transformer yard electrical station than it would be if it were not seen in association with a nearby source of hydroelectric power.

Shadow: The Washington Monument



Here shadow reveals shape. Both shape and site can be used to readily reveal its identity; in this case the Monument also resembles a sundial. If one knows the altitude of the Sun when the image was acquired, then it is simple trigonometry to calculate the height of the monument. (North is to the right in this picture, making this a mid-morning view, and it was taken when renovation scaffolding was in place.) Since the height of the Washingtn Monument is well known, it the problem can be worked in reverse to calculate the date and time at which the image was acquired.

http://www.smithsonianconference.org/climate/wp-content/uploads/2009/09/ImageInterpretation.pdf

2.9.2. Digital Image Processing

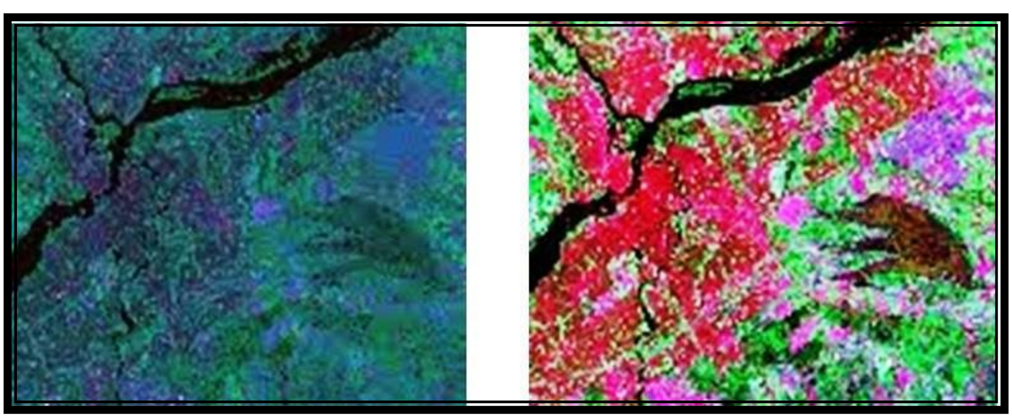
In today's world of advanced technology where most remote sensing data are recorded in digital format, virtually all image interpretation and analysis involves some element of digital processing. Digital image processing may involve numerous procedures including formatting and correcting of the data, digital enhancement to facilitate better visual interpretation, or even automated classification of targets and features entirely by computer. In order to process remote sensing imagery digitally, the data must be recorded and available in a digital form suitable for storage on a computer tape or disk. Obviously, the other requirement for digital image processing is a computer system, sometimes referred to as an image analysis system, with the appropriate hardware and software to process the data. Several commercially available software systems have been developed specifically for remote sensing image processing and analysis.

For discussion purposes, most of the common image processing functions available in image analysis systems can be categorized into the following four categories:

- **Pre-processing**
- **Image Enhancement**
- **Image Transformation**
- **Image Classification and Analysis**

Preprocessing functions involve those operations that are normally required prior to the main data analysis and extraction of information, and are generally grouped as radiometric or geometric corrections. Radiometric corrections include correcting the data for sensor irregularities and unwanted sensor or atmospheric noise, and converting the data so they accurately represent the reflected or emitted radiation measured by the sensor. Geometric corrections include correcting for geometric distortions due to sensor-Earth geometry variations, and conversion of the data to real world coordinates (e.g. latitude and longitude) on the Earth's surface.

Fig. 2.9. Image Enhancement



The objective of the second group of image processing functions grouped under the term of image enhancement is to solely to improve the appearance of the imagery to assist in visual interpretation and analysis. Examples of enhancement functions include contrast stretching to increase the tonal distinction between various features in a scene, and spatial filtering to enhance (or suppress) specific spatial patterns in an image (Fig.2.9.).

Image transformations are operations similar in concept to those for image enhancement. However, unlike image enhancement operations which are normally applied only to a single channel of data at a time, image transformations usually involve combined processing of data from multiple spectral bands. Arithmetic operations (i.e. subtraction, addition, multiplication, division) are performed to combine and transform the original bands into "new" images which better display or highlight certain features in the scene. We will look at some of these operations including various methods of spectral or band rationing, and a procedure called principal components analysis which is used to more efficiently represent the information in multichannel imagery.

Fig.2.10. Image classification

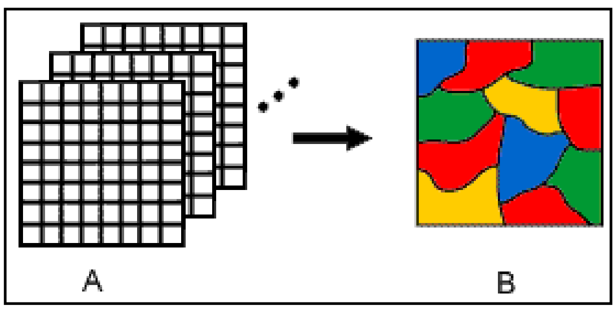


Image classification and analysis operations are used to digitally identify and classify pixels in the data. Classification is usually performed on multi-channel data sets (A) and this process assigns each pixel in an image to a particular class or theme (B) based on statistical characteristics of the pixel brightness values. Two generic approaches which are used most often, namely supervised and unsupervised classification.

Supervised classification is the process of using knowing identity that is using pixels which are already assigned to some informational classes to classify the pixels, which identity is not yet known. The sample areas are known as training areas. The selection of appropriate training areas is based on the analyst's familiarity with the geographical area and their knowledge of the actual surface cover types present in the image. Thus, the analyst is "supervising" the categorization of a set of specific classes.

Unsupervised classification can be defined as identification of natural groups within the data. In this the identity of land areas is not known, for example, in areas which cannot be accessed due to high mountains, floods or foreign area. Programs, called clustering algorithms, are used to determine the natural (statistical) groupings or structures in the data. Usually, the analyst specifies how many groups or clusters are to be looked for in the data.

2.10. Microwave Remote Sensing

Microwave sensing encompasses both active and passive forms of remote sensing of the spectrum covers the range from approximately 1cm to 1m in wavelength. Because of their long wavelengths, compared to the visible and infrared, microwaves have special properties that are important for remote sensing. Longer wavelength microwave radiation can penetrate through cloud cover, haze, dust, and all but the heaviest rainfall as the longer wavelengths are not susceptible to atmospheric scattering which affects shorter optical wavelengths. This property allows detection of microwave energy under almost all weather and environmental conditions so that data can be collected at any time.

A passive microwave sensor detects the naturally emitted microwave energy within its field of view. This emitted energy is related to the temperature and moisture properties of the emitting object or surface. The microwave energy recorded by a passive sensor can be emitted by the atmosphere (1), reflected from the surface (2), emitted from the surface (3), or transmitted from the subsurface (4).

Applications of passive microwave

- Meteorology: determine water and ozone content in the atmosphere.
- Hydrology: measure soil moisture
- Oceanography: map sea ice, currents, surface winds, detection of pollutants, such as oil slicks.

Source: http://rst.gsfc.nasa.gov/Sect14/Sect14_5.htm

Active microwave sensors provide their own source of microwave (MW) radiation to illuminate the target. Active MW sensors are generally divided into two categories: imaging and non-imaging. The sensor transmits a microwave (radio) signal towards the target and detects the backscattered portion of the signal.

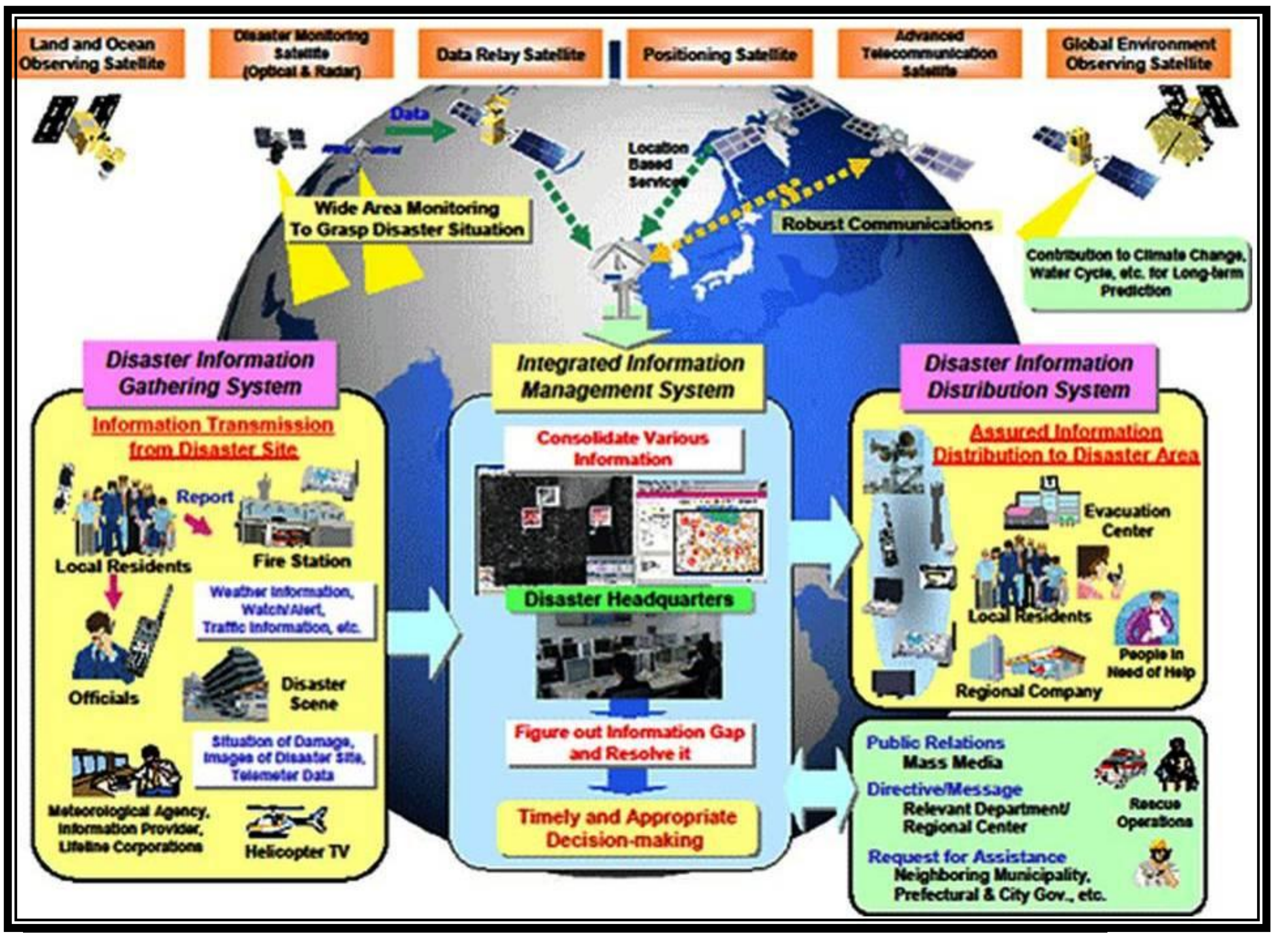
Mostly used Active Microwave Remote Sensing

RADAR (RAdio **D**etection **and R**anging**)**, which is based on the transmission of long-wavelength microwave (e.g., 3-25 cm) through the atmosphere and then recording the amount of energy backscattered from the terrain.
LIDAR (LIght **D**etection **A**nd **R**anging**)**, which is based on the transmission of relatively shortwavelength laser light (e.g., 0.90 μm) and then recording the amount of light backscattered from the terrain.
SONAR (SOund **NA**vigation **R**anging), which is based on the transmission of sound waves through a water column and then recording the amount of energy backscattered from the bottom or from objects within the water column.

2.11. Remote Sensing Application in Disaster Management

Disaster management planning is structured around cycle consists of four stages – reduction, readiness, response and recovery. Remotely sensed data can provide a valuable source of information at each of these stages, helping to understand spatial phenomena, and providing scientists and authorities with objective data sources for decision making. The challenge with disaster management is that the inherent unpredictability and range of hazards does not allow for a single all-encompassing solution to be developed and explored. Instead, there are a multitude of different remote sensing platforms and sensors that can and should be employed for image acquisition. There are few examples where remote sensing is incorporated seamlessly into all stages of the disaster management cycle for planning purposes. This requires a collaborative effort from emergency managers, policy planners and remote sensing technical staff that may not always be co-located, or even working for the same organization (Fig.2.11).

Fig. 2.11. – Application of Remote Sensing in Disaster Monitoring



Source: http://www.nec.com/en/global/solutions/space/remote_sensing/index.html?

Remote sensing has many application in disaster management, from risk modeling and vulnerability analysis, to early warning, to damage assessment (Table 2.2).

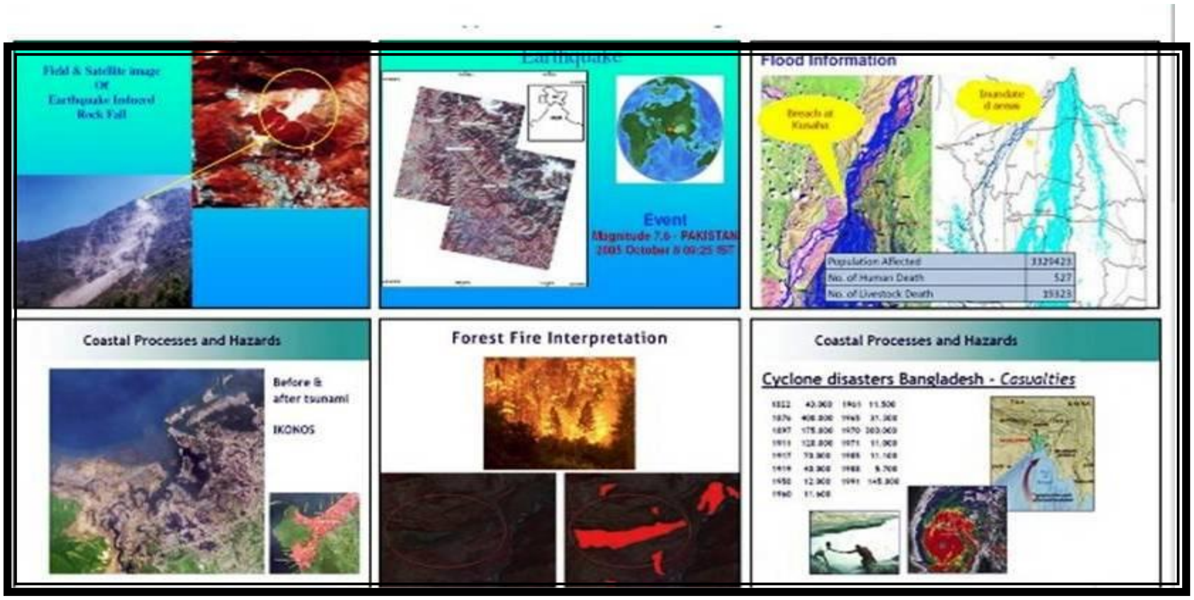
Table 2.2. Application of Remote Sensing in Disaster Management

Disaster	Mitigation	Preparedness	Response	Recovery
Cyclone	Risk modeling; Vulnerability analysis.	Early warning; Long-range climate modeling.	Identifying escape routes; crisis mapping; impact assessment; cyclone monitoring; Storm surge predictions.	Damage assessment; Spatial planning.
Drought	Risk modeling; vulnerability analysis; Land and water management planning.	Weather forecasting; vegetation monitoring; crop water requirement mapping; early warning.	Monitoring vegetation; Damage assessment.	Informing drought mitigation.
Earthquake	Building stock assessment; Hazard mapping.	Measuring strain accumulation.	Planning routes for search and rescue; damage assessment; evacuation planning; Deformation mapping.	Damage assessment; Identifying sites for rehabilitation.
Fire	Mapping fire-prone areas; monitoring fuel load; Risk modeling.	Fire detection; predicting spread/direction of fire; Early warning.	Coordinating firefighting efforts.	Damage assessment.
Flood	Mapping flood-prone areas; delineating flood-plains; Land-use mapping.	Flood detection; early warning; Rainfall mapping.	Flood mapping; evacuation planning; Damage assessment.	Damage assessment; Spatial planning.
Landslide	Risk modeling; hazard mapping; Digital elevation models.	Monitoring rainfall and slope stability.	Mapping affected areas;	Damage assessment; spatial planning; Suggesting management practices.
Volcano	Risk modeling; hazard mapping; Digital elevation models.	Emissions monitoring; Thermal alerts.	Mapping lava flows; Evacuation planning.	

Source:http://www.scidev.net/global/earth-science/feature/remote-sensing-for-natural-disasters-facts-and-figures.html

Remote sensing can be used to assist risk reduction initiatives through identification of hazard zones associated with active fault zone, flood plains, coastal inundation and erosion, and forest fires (Fig.2.12). Each satellite carries one or more sensors on board that take measurements in different wavelengths. Many are useful for disaster monitoring — thermal sensors spot active fires, infrared sensors can pick up floods, and microwave sensors (that penetrate clouds and smoke) can be used to measure earth deformations before and during earthquakes or volcanic eruptions (Table 2.3.).

Fig.2.12. Application of Remote Sensing in Hazard monitoring and risk mapping



Source: http://www.slideshare.net/SISPL/applications-of-remote-sensing

Table 2.3. Applications of different wavebands for disaster management

Wavelength	**Waveband**	**Useful for**	**Example sensors**
Visible	0.4-0.7mm	Vegetation mapping	SPOT; Landsat TM
		Building stock assessment	AVHRR; MODIS; IKONOS
		Population density	IKONOS; MODIS
		Digital elevation model	ASTER; PRISM
Near infrared	0.7-1.0mm	Vegetation mapping	SPOT; Landsat TM; AVHRR; MODIS
		Flood mapping	MODIS
Shortwave infrared	0.7-3.0mm	Water vapour	AIRS
Thermal infrared	3.0-14mm	Active fire detection	MODIS
		Burn scar mapping	MODIS
		Hotspots	MODIS; AVHRR
		Volcanic activity	Hyperion
Microwave (radar)	0.1-100cm	Earth deformation and ground movement	Radarsat SAR; PALSAR
		Rainfall	Meteosat; Microwave Imager (aboard TRMM)
		River discharge and volume	AMSR-E
		Flood mapping and forecasting	AMSR-E
		Surface winds	QuikScat radar
		3D storm structure	Precipitation radar (aboard TRMM)

Source:http://www.scidev.net/global/earth-science/feature/remote-sensing-for-natural-disasters-facts-and-figures.html

Forecasting famine: The Famine Early Warning Systems Network (FEWS NET), funded by USAID, monitors food security via satellites. It uses vegetation indices, calculated from sensors including AVHRR, MODIS and those aboard SPOT, to monitor vegetation vigor and density and spot problems as they develop. It estimates rainfall using Meteosat infrared data, combined with rain gauge reports and microwave satellite observations, so as to model hydrological systems and how weather patterns might affect agriculture. FEWS NET also compares rainfall trends over time. By combining satellite data with regional analyses of prices, grain stores, political conditions and agricultural inputs, FEWS NET provides effective early warnings for when drought might bring food shortages.

Flood monitoring: Satellites such as the Tropical Rainfall Monitoring Mission can measure and map rainfall, helping forecast heavy rains and floods. Sentinel Asia — a team of 51 organisations from 18 countries — delivers remote sensing data via the Internet as easy-to-interpret information for both early warning and flood damage assessment across Asia. It uses the Dartmouth Flood Observatory's (DFO's) River Watch flood detection and measurement system, based on AMSR-E data, to map flood hazards and warn disaster managers and residents in flood-prone areas when rivers are likely to burst their banks. NASA also uses DFO analyses for river basins across the world in its flood sensorWeb. The sensorWeb's role is to automatically alert disaster managers and government agencies to impending floods. It detects anomalies in river discharges and volumes from the DFO's Active Atlas of Large Floods. This triggers requests to satellites such as MODIS for high-resolution data over the area of interest. These are then immediately processed and forwarded to scientists and local interested partners.

Fire mapping: Thermal alerts from MODIS also feed in to a fire sensorWeb. The MODIS Rapid Response System provides daily satellite images in near real time (within a few hours of data collection). These identify hotspots and trigger requests to other satellites to collect additional information on the active fire. And MODIS produces global fire maps that show active fires over the past ten days . This active fire mapping system is used by a wide array of fire monitoring programmes, including Sentinel Asia, the Global Fire Monitoring Center and the regional visualisation and monitoring system SERVIR that covers Latin America and the Caribbean.

Earthquake response: At present, earthquakes are hard to predict. But remote sensing could improve forecasts using Interferometric Synthetic Aperture Radar (InSAR). This technique combines two or more sequential radar images to measure ground motion between them very accurately — on the scale of a few centimetres (or even millimetres). InSAR instruments, such as PALSAR, are already routinely used after earthquakes to assess damage and the extent of ground movement and deformation.

Source:http://www.scidev.net/global/earth-science/feature/remote-sensing-for-natural-disasters-facts-and-figures.html

2.12. Indian Space Programme

With a humble beginning in early 60s, Indian space program has matured as a symbol of the country's sophisticated technological capabilities and its growing regional and global prestige. Over the last four decades, Indian Space program has made remarkable progress towards building the space infrastructure as the community resource to accelerate various developmental processes and harness the benefits of space applications for socio-economic development.

The Indian Space programme has the primary objective of developing space technology and application programmes to meet the developmental needs of the country. Towards meeting this objective, two major operational systems have been established – the Indian National Satellite (INSAT) for telecommunication, television broadcasting, and meteorological services and the Indian Remote Sensing Satellite (IRS) for monitoring and management of natural resources and Disaster Management Support.

The Indian Remote sensing programme is driven by the user needs. In fact, the first remote sensing based pilot project was carried out to identify coconut root-wilt disease in Kerala way back in 1970. This pilot project led the development of Indian Remote Sensing (IRS) satellites. These IRS satellites have been the workhorse for several applications - encompassing the various sectors such as agriculture, land and water resources, forestry, environment, natural disasters, urban planning and infrastructure development, rural development, and forecasting of potential fishing zones.

A well knit network "Natural Resources Management System (NNRMS)" involving central & state Governments, private sectors, academia and Non-Governmental Organizations is in place for enabling the integration of Remote Sensing, contemporary technologies and conventional practices for management of natural resources.

The first two IRS spacecraft, IRS-1A (March' 1988) and IRS-1B (August, 1991) were launched by Russian Vostok boosters from the Baikonur Cosmodrome. IRS-1A failed in 1992, while IRS-1B continued to operate through 1999. From their 22-day repeating orbits of 905 km mean altitude and 99 degrees inclination, the two identical IRS spacecraft hosted a trio of Linear Imaging Self-Scanning (LISS) remote sensing COD instruments working in four spectral bands: 0.45-0.52 µm 0.52-0.59 µm, 0.62-0.68 µm, and 0.77-0.86 µm. The 38.5-kg LISS-I images a swath of 148 km with a resolution of 72.5 m while the 80.5-kg LISS-IIA and LISS-IIB exhibit a narrower field-of-view (74-km swath) but are aligned to provide a composite 145-km swath with a 3-km overlap and a resolution of 36.25 m.

Each IRS spacecraft is 975 kg at launch with a design life of 2.5-3 years. The 3-axis stabilized spacecraft is essentially rectangular (1.1m by 1.5 m by 1.6 m) with two narrow solar arrays producing less than 1 kW electrical power. The Spacecraft Control Center at Bangalore oversees ail spacecraft operations, but the principal data reception station for the remote sensing payload is located at Shadnagar. Spacecraft data transmissions are effected via X-band and S-band antennas at the base of spacecraft.

By the year 1999 five IRS satellites were operating, and more were scheduled for launch by the year 2000. IRS-1C, successfully launched on December 28, 1995 on board a Molniya rocket of Russia, was the last Russian launch of the program (Molniya rather than Vostok, while IRS-1D was orbited by India's PSLV. IRS-P3 was launched by PSLV in 1996 with a German modular electro-optical scanner and an Indian visible-lR scanner.

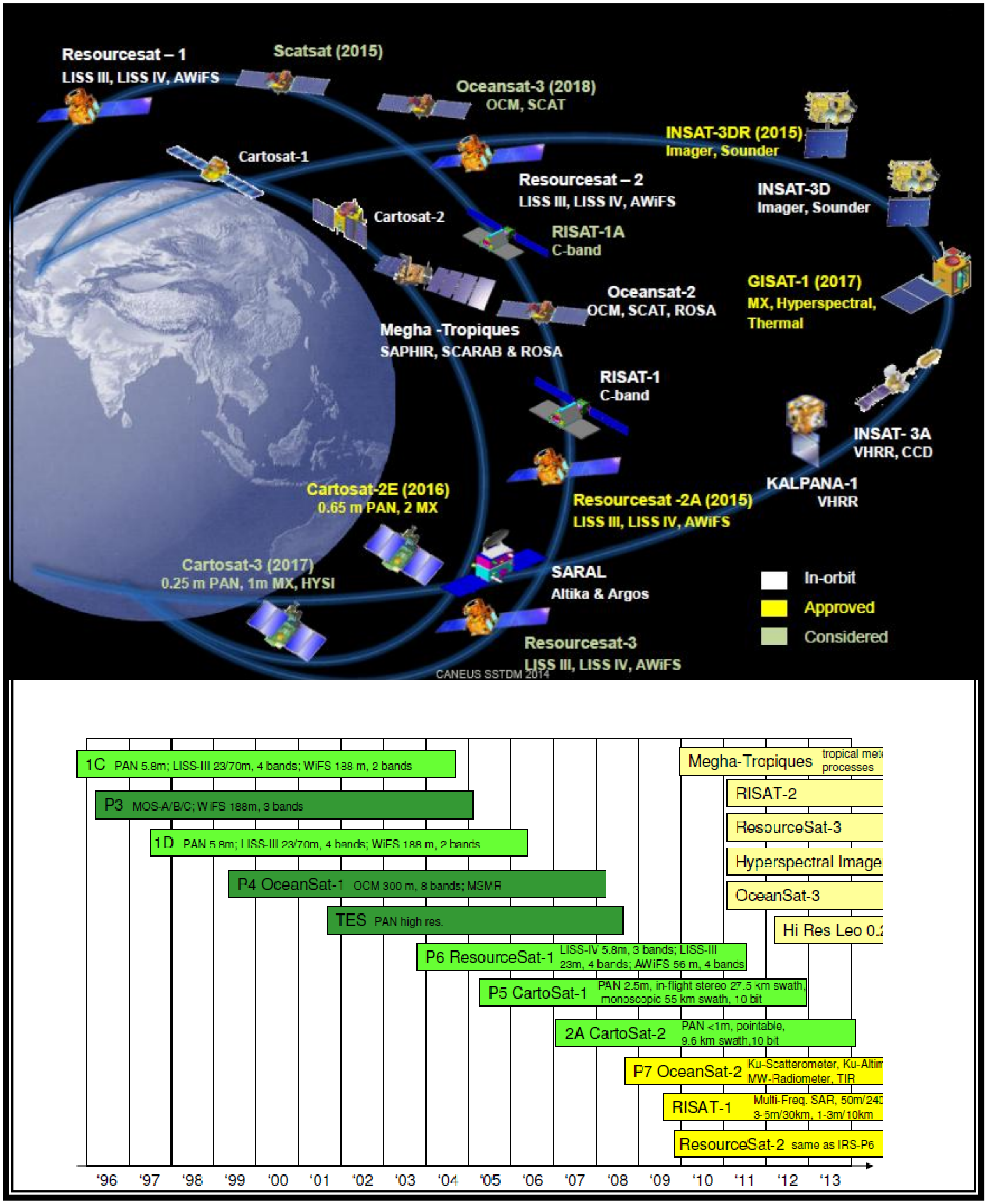
The Indian Space Research Organization (ISRO) and its commercial marketing arm, ANTRIX Corp. Ltd., successfully launched the IRS-1D Earth imaging satellite on 29 September 1997 from Sriharikota, India. The satellite is an identical twin to the IRS-1C, launched in December 1995. The dual use of these satellites provides 5.8-meter resolution images to customers twice as often as was possible with just the IRS-1C. IRS-P4 (OCEANSAT-1) , IRS-P5 (CARTOSAT-1) , IRS-P6 (RESOURCESAT-1) came up with more advanced features.

A step towards initial Satellite based Navigation Services in India: GAGAN & IRNSS:

The Indian Space Research Organization (ISRO) and Airports Authority of India (AAI) have implemented the GPS Aided Geo Augmented Navigation-GAGAN project as a Satellite Based Augmentation System (SBAS) for the Indian Airspace. The objective of GAGAN to establish, deploy and certify satellite based augmentation system for safety-of-life civil aviation applications in India has been successfully completed. The system is inter-operable with other international SBAS systems like US-WAAS, European EGNOS, and Japanese MSAS etc. GAGAN GEO footprint extends from Africa to Australia and has expansion capability for seamless navigation services across the region. GAGAN provides the additional accuracy, availability, and integrity necessary for all phases of flight, from enroute through approach for all qualified airports within the GAGAN service volume. GAGAN Payload is already operational through GSAT-8 and GSAT-10 satellites. GAGAN though primarily meant for aviation, will provide benefits beyond aviation to many other user segments such as intelligent transportation, maritime, highways, railways, surveying, geodesy, security agencies, telecom industry, personal users of position location applications etc.

IRNSS, the Indian Regional Navigation Satellite System, is an ISRO initiative to design and develop an independent satellite-based navigation system to provide positioning, navigation and timing services for users over Indian region. The system is designed with a constellation of 7 spacecraft and a vast network of ground systems operating. The first three satellites (IRNSS-1A, 1B &1C) were launched in 2013-14.IRNSS-1D, the last satellite of IRNSS constellation was successfully launched in 2016 on board PSLV-C27. The initial tests of the spacecraft have been successfully completed and it has joined the family of IRNSS space segment. The unique Geostationary Earth Orbit (GEO) /Geo Synchronous Orbit (GSO) constellation design provides a position accuracy of better than 15 metre for longer duration of 20 hours in a day even with 4 satellites. While GAGAN will redefine navigation over Indian Airspace, IRNSS will provide independent and self reliant satellite based navigation services over Indian region.

2.12. Scenario of Indian Remote Sensing Satellite in Future



Source: Navalgund, 2014 (Workshop on Small Satellites & Sensor Technology for Disaster Management, Indo-US S&T Forum)

Check Your Progress II

Note: a) Use the space provided for your answers.

b) Check your answers with the possible answers provided at the end of this unit.

1) Define remote sensing. How is passive remote sensing different from active sensing? Give an example of each?

Ans.

2) What are the fundamental steps in Remote Sensing processes?

Ans.

3) What are the different ways in which the Energy interacts with the Earth Surface?

Ans.

4) Write difference between visual image interpretation and Digital Image Processing?

5) What are 4 types of image resolution that we are concerned about when interpreting remote sensing data?

6) What do you mean by microwave remote sensing? What are most commonly used microwave remote sensing?

Ans.

7) Write a detail description about Indian Regional Navigation Satellite System.

Ans.

2.13. Let Us Sum Up

Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object and thus in contrast to on site observation. Humans with the aid of their eyes, noses, and ears are constantly seeing, smelling, and hearing things from a distance as they move through an environment. Thus, humans are naturally designed to be remote sensors. For monitoring the earth surfaces, scientist use remote sensor on platforms like helicopters, planes, and satellites. Thus, sensor and target is located remotely apart and electromagnetic radiation serve as link between sensor and object and sun being the major sources of illuminating energy. The part of this energy is scattered, absorbed, reflected or transmitted in atmosphere and earth surface. Again, the sensor is used to record the reflected or emitted energy from earth surface. The recorded energy is then transmitted to user and which process to form an image. The images are interpreted and analyzed qualitatively (visually) and quantitatively (digitally) to extract meaningful information of the target. Finally the information extracted can be applied in decision making for solving problems.

2.14. Key Words

Remote Sensing: The technology of acquiring data and information about an object or phenomena by a device that is not in physical contact with it. In other words, remote sensing refers to gathering information about the Earth and its environment from a distance, a critical capability of the Earth Observing.

Electromagnetic Spectrum: Continuous sequence of electromagnetic energy arranged according to wave length or frequency.

Absorption: The process in which radiant energy is retained by a substance. A further process always results from absorption, that is, the irreversible conversion of the absorbed radiation into some other form of energy within and according to the nature of the absorbing medium. The absorbing medium itself may emit radiation, but only after energy conversion has occurred.

Reflection: The return of light or sound waves from a surface. If a reflecting surface is plane, the angle of reflection of a light ray is the same as the angle of incidence.

Microwave: Electromagnetic radiation with wavelengths between about 1000 micrometers and one meter.

Sensor: Device that can receives electromagnetic radiations and converts it into a signal that can be recorded and displayed as either numerical data or an image.

Image: Pictorial representation of data acquired by satellite systems, such as direct readout images from environmental satellites. An image is not a photograph. An image is composed of two-dimensional grids of individual picture elements (pixels). Each pixel has a numeric value that corresponds to the radiance or temperature of the specific ground area it depicts. See gray scale.

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2.16. CHECK YOUR PROGRESS – POSSIBLE ANSWERS

Check Your Progress II

1) **Remote Sensing** is the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation.

   Passive remote sensing measurements involve observing the atmosphere in various regions of the electromagnetic spectrum while active remote sensing involves interacting with the atmosphere and measuring the response. An example of active remote sensing is the lidar (light detection and ranging) techniques which employs a laser as a light source to probe the atmosphere. Direct measurement of ultraviolet light from the Sun scattered by the atmosphere is passive.

2) The **fundamental steps in remote sensing** process are

   - Energy
   - Energy interaction with atmosphere
   - Energy interaction with earth surface
   - Recording energy with sensor
   - Data transmission and processing
   - Image processing and analysis
   - Application

3) There are three ways in which the total incident energy will interact with earth's surface materials. These are

   - **Absorption**
   - **Transmission**
   - **Reflection**

   Absorption (A) occurs when radiation (energy) is absorbed into the target while **transmission (T)** occurs when radiation passes through a target. **Reflection (R)** occurs when radiation "bounces" off the target and is redirected

4) **Visual Image Interpretation**: The ability of human interpreter to relate colours and patterns in an image to real world features. The image used in such analysis is in a pictorial form (Photograph type) also known as analog image. In this process human vision plays a crucial role in extracting information from the images.

   Digital Image Processing: It is a process of digital images with help of computers. The images can be represented in digital form composed of tiny areas known as pixels can be processed and analyzed using computers to extract meaningful information. In this process human operator instruct the computers to perform an interpretation according to certain condition.

5) The four type of image resolution are

Spatial Resolution: The details visible in an image is depend on the spatial resolution of the sensor and refers to size of the smallest possible features that can be detected.
Spectral Resolution: It describes the ability of a sensor to define the fine wavelength interval. Each discrete, distinctly recorded wavelength interval measured by a sensor is referred to as a 'band' or 'channel.'
Radiometric Resolution: It describes its ability to discriminate very slight differences in energy. The finer the radiometric resolution of a sensor, the more sensitive it is to detecting small differences in reflected or emitted energy.
Temporal Resolution: It refers to the frequency of obtaining data over given area. It is related to revisit period, which refers to length of time taken by satellite to complete one entire orbit cycle.

6) **Indian Regional Navigation Satellite System (IRNSS)** is an independent regional navigation satellite system being developed by India. It is designed to provide accurate position information service to users in India as well as the region extending up to 1500 km from its boundary, which is its primary service area. An Extended Service Area lies between primary service area and area enclosed by the rectangle from Latitude 30 deg South to 50 deg North, Longitude 30 deg East to 130 deg East. IRNSS will provide two types of services, namely, Standard Positioning Service (SPS) which is provided to all the users and Restricted Service (RS), which is an encrypted service provided only to the authorised users. The IRNSS System is expected to provide a position accuracy of better than 20 m in the primary service area.

7) **Microwave sensing** encompasses both active and passive forms of remote sensing of the spectrum covers the range from approximately 1cm to 1m in wavelength. Because of their long wavelengths, compared to the visible and infrared, microwaves have special properties that are important for remote sensing.

Mostly used Active Microwave Remote Sensing

RADAR (RAdio Detection and Ranging), which is based on the transmission of long-wavelength microwave (e.g., 3-25 cm) through the atmosphere and then recording the amount of energy backscattered from the terrain.
LIDAR (LIght Detection And Ranging), which is based on the transmission of relatively shortwavelength laser light (e.g., 0.90 μm) and then recording the amount of light backscattered from the terrain.
SONAR (SOund NAvigation Ranging), which is based on the transmission of sound waves through a water column and then recording the amount of energy backscattered from the bottom or from objects within the water column.

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Unit – 3

Advanced Technologies for Early Warning System

Objectives

After completion of this unit, you should be able to:

- *Demonstrate a critical understanding of key concepts in Early Warning System and People centered Early Warning System.*
- *Develop an understanding of core component of Early Warning System.*
- *Understand and appreciate the contributions of technology like wireless, blue tooth, Ham Radio, GPS, GIS and Remote Sensing in emergency management.*
- *Critically understand the strengths and weaknesses of Cyclone Warning System and Tsunami Warning System in India.*

Structure

3.1 Introduction

3.2. Definition of Early Warning System

3.3. Community Early Warning System

3.4. Core Components of People centered Early Warning System

3.5. Emergency Communication System

3.6. Wireless Communication

3.7. Bluetooth Wireless Technology

3.8. HAM Radio

3.9. GPS Application in Emergency Communication

3.10. Remote Sensing and GIS Application in Warning System

3.11. Cyclone Early Warning System in India

3.12. Tsunami Early Warning System in India:

3.13. Let Us Sum Up

3.14. Key Words

3.15. References

3.16. Check Your Progress – Possible Answers

3.1. Introduction

More than millions of people have lost their lives in last decade due to disasters like cyclones, storm surge, droughts, floods, earthquake and tsunami. Majority of the times material losses are unavoidable but loss of human lives could have avoided if effective warning system is active in the area. Super Cyclone 1999 and December 26, 2004 Indian Ocean tsunami which provoked casualties more 10,000 and 100,000 human lives are examples of not having warning system. Smart warning systems were used during Phailin and Hud hud reducing causalities of human lives below 10. At a time of global environmental changes, the planet earth is striving to face and adapt to inevitable, possibly profound, alteration and extreme events. Climate change will further add environmental stresses and societal crises to the regions which are already vulnerable to natural hazards, poverty and conflicts. The need of time is about developing global multi-hazard early warning system to inform us about pending threats. Like other South Asian countries, India continues to suffer from an excess of natural hazards and disasters like earthquakes, tsunamis, landslides, desertification, droughts, floods, impacts of climate variability, severe weather, storms, tropical cyclones, epidemics and food insecurity that threaten to affect the lives and livelihood of its citizens. Warnings are still not effectively communicated, and not sufficiently acted upon, even as agencies in developed and developing countries are now more aware of the nature, frequency, locations and intensity of various hazards. The uncertainty inherent in scientific information is one of the reasons for failing to act on disaster warnings.

The purpose of the unit is to provide definition of early warning system and community early warning system in lay man language to create interest in students. It tries to scientifically discuss the core component of community early warning system. Further, it explain the about advance technology like GPS, Ham Radio, Wireless Technology, Bluetooth Technology and Remote Sensing and also application in emergency management. Finally concept, design and architecture of Cyclone Warning System and Tsunami Warning in India are discussed in details covering their advantage and limitations. Thus, the effort is to empower students as volunteers to take an active role in monitoring risks that influence their communities. As they do so, they learn both issue and response to warning alerted by tracking agencies in their areas.

3.2. Definition of Early Warning System

The term EWS signifies **Early, Warning System or end to end system**

Early implies getting information prior to the arrival of a hazard or extreme events. There is still to reduce the potential harm of disaster.

Warning is a message to be alerted using sounds, symbols, images or bulletins that are announced of the fatalities and threats.

A **System** is an ordered and standardized compilation of elements that remain in constant fluctuation with movement in multiple directions.

Hence, end-to-end warning systems is a complete set of functionalities of compiling and tracking hazard information and also connect to those communities who need to hear the message and act.

Defining EWS

Early warning systems are those systems which collect, process, store, analyze and distribute information in case of emergency during disasters. They include hardware, software's, networks, business processes and human interactions (**Martin & Rice, 2012**)

A EWS represents the set of capacities needed to generate and disseminate timely and meaningful warning information that enables at-risk individuals, communities and organizations to prepare and act appropriately and in sufficient time to reduce harm or loss **(adapted from UNISDR 2009 and others)**.

An EWS is an integrated system for monitoring, collecting data, analyzing, interpreting, and communicating monitored data, which can then be used to make decisions early enough to protect public health and the environment and to minimize unnecessary concern and inconvenience to the public (**USEPA, 2005a**).

3.3. Community Early Warning System

Community represents a network of social interaction that are exposed to multiple social and/or physical impacts from one or more hazards frequently and also related to place (i.e., village, neighbourhood, watershed, etc.).

CEWS is understood to be an effort to systematically collect, compile and analyze risk information and dissemination systems that reach those community at risk, and followed by practical knowledgeable responses by those communities to reduce threat and harm.

A EWS can be based in a community without being owned or driven by that community. The most lasting impact, however, occurs when a community has a strong understanding of the EWS. Effective early warning systems must be embedded in an understandable manner and relevant to the communities which they serve. The main distinction between a community-based and a community-driven EWS are outline in table 3.1. below. Further, there is also distinction between **national EWS** and **CEWS** are highlighted in table 3.2. The local government has to work with community at ground zero level and with information flowing in both directions.

Table 3.1. Community involvement in Early Warning System

Key elements	COMMUNITY	
	Based EWS	**Driven EWS**
Orientation	With the people	By the people
Character	Democratic	Empowering
Goals	Evocative, Consultative	Based on needs, participatory
Outlook	Community as partners	Community as managers
Views	Community is organized	Community is empowered
Values	Development of people's abilities	Trust in people's capacities
Result/impact	Initiates social reform	Restructure in the community
Key players	Social entrepreneurs, community workers and leaders	Everyone in the community
Methodology	Coordinated with technical support	Self managed
Active early warning components (out of the four)	At least one is active (e.g. response capability)	All are active, especially the monitoring of indicators

Source: Community Early Warning System Guiding Principle, 2012

Table 3.2. Seamless Integration of National and Community EWS

Key factors	National EWS	Community EWS
Design	Deliberate based on legal mandate by government of other agencies	Flexible design based on need and adapted by trial and error
Human resources	Technicians specialists	Ad hoc volunteers to individuals appointed by local leaders
Characteristics	Formal staged warning	Ad hoc to staged warning
Documented	Legislation, policies, standard operating procedures, MoUs, diagrammatic representations of information flow, etc	Informal and rarely documented
Technology	High-tech to telephone, VHF, HF radios	Telephone to traditional (none)
Trigger	Indicators, prediction, technology	Personal local detection of a hazard or receipt of a warning from outside the community
Warning process	Cascading or fanned (in phases) in systematic manner	Ad hoc, but may be naturally well organized and cascading/fanned
Messages	Impersonal	Personal
Timing	Not always the first to be received by community; produced to share with official systems at all levels	Rapid (when message created at community level) or when there are good linkages between all levels
Primary needs targeted	Reduce economic and other loss	Safety, reduce stress, emotional support
Evaluation criteria	Hazard details; lead-time provided; proportion of false warnings	Timeliness of receipt of warning, actionable message in warning

Source: Community Early Warning System Guiding Principle, 2012

3.4. Core Components of People centered Early Warning System

A complete and effective, people-centered early warning system – EWS – comprises four inter-related components - risk knowledge, warning services, dissemination and communication and response capability **(shown in Fig, ISDR 2006b)**. Each component has to function effectively for the whole system to be successful.

1. **Risk Knowledge**: It is about developing baseline information about risk (Hazard and vulnerability). Further, scientific assessment and mapping of risk will prioritize and guide the emergency manager for preparations of response and disaster prevention activities.

2. **Warning Services:** It is the logical follow-on activity to keep up-to-date on how those risks and vulnerabilities change through time. Constant monitoring of possible disaster precursors is necessary to generate accurate warnings on time.
3. **Dissemination and Communication:** It is package of translating monitored risk information into actionable messages in common language that enables for response by community at ground level. Regional, national and community level communication channels must be identified in advance and one authoritative voice established.
4. **Response Capability:** It is the follow of action by communities to reduce risk once trends are spotted and announced like evacuation or duck-and-cover reflexes, depending on the lead-time of a warning. It is also essential that disaster management plans are in place, well-practiced and tested. The community should be well informed on options for safe behavior, available escape routes, and how best to avoid damage and loss to property

Fig.3.1. Component of a people centered early warning system

Source: ISDR 2006b

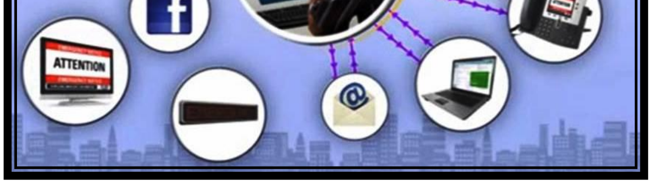
3.5. Emergency Communication System

An Emergency communication system (ECS) is a typically computer based system commonly designed to integrate the cross communication risk message between a variety of communication technologies and also part of unified communication system intended to optimize communications during emergencies. Message prioritization, automation of communication, fast message delivery, communication audit trails, and other capabilities are function of emergency communication services (Fig.3.2).

Emergency communications consists of six primary elements:

1. **Operability** - The ability of emergency responders to establish and sustain communications in support of mission operations.
2. **Interoperability** The ability of emergency responders to communicate among jurisdictions, disciplines, and levels of government, using a variety of frequency bands, as needed and as authorized. System operability is required for system interoperability.
3. **Continuity of Communications** - The ability of emergency response agencies to maintain communications in the event of damage to or destruction of the primary infrastructure.
4. **Timeliness and speed of delivery -** The ability of emergency response agencies is to communicate to responder about emergency timely and followed action to mitigate damage or loss of life.
5. **Ease of use -** The ability of emergency responders to feel comfortable in handling the advance systems. An emergency communication system that's designed for nontechnical users will ensure successful administration and usage during some life threatening emergency situations.
6. **Affordability -** The ability of emergency response agencies to more affordable the cost of procuring, installing, and maintaining an emergency communication system.

Fig.3.2 Type of Communication System



3.6. Wireless Communication

The term wireless refers to the communication or transmission of information over a distance without requiring wires, cables or any other electrical conductors. Wireless communication is one of the important mediums of transmission of data or information to other devices. The Communication is set and the information is transmitted through the air, without requiring any cables, by using electromagnetic waves like radio frequencies, infrared, satellite, etc., in a wireless communication technology network. Today, the term wireless refers to a variety of devices and technologies ranging from smart phones to laptops, tabs, computers, printers, Bluetooth, etc. The devices used for wireless communication are cordless telephones, mobiles, GPS units, ZigBee technology, wireless computer parts, and satellite television, etc (Fig.3.3.)

Fig.3.3. Types of Wireless Technology

Types of Wireless Technology

1. **Satellite -** Satellite communication is one of the wireless technologies, which is widely spread all over the world allowing users to stay connected virtually anywhere on the Earth. The Satellites used in this mode of communication, communicate directly with the orbiting satellites via radio signals.

2. **Wi-Fi** – Wi-Fi is a form of low-power wireless communication used by many electronic devices such as laptops, systems, smart phones, etc. In a Wi-Fi setup, a wireless router serves as the communication hub. These networks are extremely limited in range due to low power of transmissions allowing users to connect only within close proximity to a router or signal repeater.

3. **Wireless Router** - Wireless routers accepts an incoming Internet connection and sends the data as RF signals to other wireless devices that are near to the router. A network set up with a wireless router is called as a Wireless Local Area Network

(WLAN).Many routers have built-in security features such as 1rewalls that help protect devices connected to the router against malicious data such as computer viruses.

4. **Microwave -** Microwave is an effective type of wireless data transmission that transfers information using two separate methods. One method which is used to transmit data through the wireless media of a microwave is the satellite method that transmits information via a satellite that orbits 22,300 miles above the Earth. Stations on the ground send and receive data signals to and from the satellite with a frequency ranging from 11 GHz to 14 GHz and with a transmission speed of 1 Mbps to 10 Mbps. Another method is a terrestrial method, in which two microwave towers with a clear line of sight between them are used ensuring no obstacles to disrupt that line of sight.

5. **Infrared (IR) -** Infrared is a media transmission system that transmits data signals through light emitting diodes (LEDs) or Lasers. Infrared is an electromagnetic energy at a wavelength which is longer than that of the red light. The information cannot be travelled through obstacles in an infrared system, but can be inhibited by light. One type of infrared is the point to point system in which transmission is possible between two points limited to a range and line of sight.

6. **Wireless Phones -** The evolution of cellular networks is enumerated by generations. Many different users communicate across a single frequency band through Cellular and cordless phones. Cellular and cordless phones are two more examples of devices that make use of wireless signals. Cordless phones have a limited range but cell phones typically have a much larger range than the local wireless networks since cell phone use large telecommunication towers to provide cell phone coverage. Some phones make use of signals from satellites to communicate, similar to Global Positioning System (GSP) devices.

7. **Radio -** Radio is the technology of using radio waves to carry information, such as sound, by systematically modulating some property of electromagnetic energy waves transmitted through space, such as their amplitude, frequency, phase, or pulse width. When radio waves strike an electrical conductor, the oscillating fields induce an alternating current in the conductor. The information in the waves can be extracted and transformed back into its original form. The radio equipment involved in communication systems includes a transmitter and a receiver, each having an antenna and appropriate terminal equipment such as a microphone at the transmitter and a loudspeaker at the receiver in the case of a voice-communication system

3.7. Bluetooth Wireless Technology

Bluetooth is a method for data communication that uses short-range radio links to replace cables between computers and their connected units. This technology allows you to connect a variety of different electronic devices wirelessly to a system for the transfer and sharing of data. The objective of Bluetooth wireless technology was to eliminate the cable connection between devices such as personal computers, laptops, printers, cell phone, cameras and other electronic devices.

Bluetooth

The Bluetooth Special Interest Group adopted the code name as a tribute to the Harald Blaatand “Bluetooth” II, king of Denmark 940–981A.D. who peacefully united Denmark and Norway. Harald liked to eat blueberries, which gave his teeth the coloration that lead to the nickname "Bluetooth."

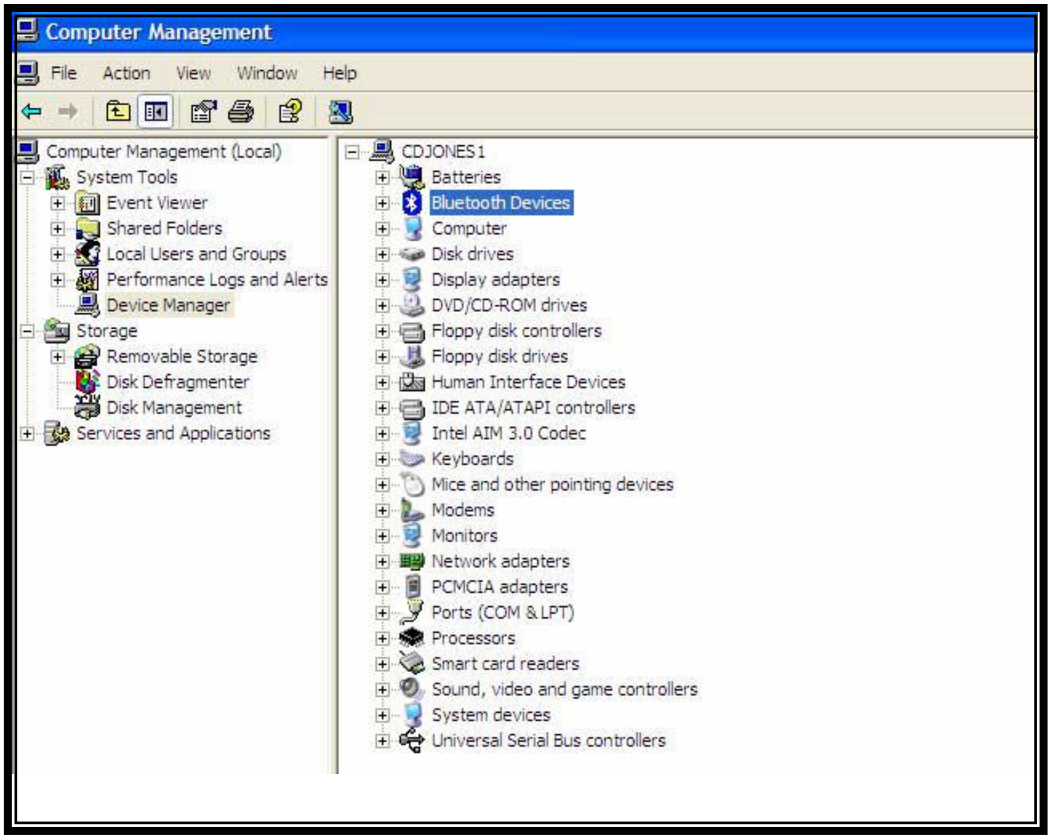
BWT-enabled devices operate in the unrestricted 2.4-gigahertz (GHz) Industrial, Science, Medical (ISM) band. Further, this technology uses a technique called frequency hopping to minimize interference from other networks that use the ISM band. The data are divided into small pockets and exchange of these data between transmitter and receiver are done at one frequency followed by another frequency to exchange another packet. They repeat this process until all the data is transmitted. BWT devices randomly hop between frequencies up to 1600 times per second—much faster than other types of devices that use the ISM band.

Establishing Blue tooth connections

Step 1 - Activating Blue tooth devices

1. Select the Start button in the lower-left corner of the screen.
2. Then select Control Panel > Performance and Maintenance > System > Hardware tab.
3. Select the Device Manager Button.
4. If your notebook supports BWT, you will see Bluetooth Devices in the Device Manager window.

Confirming Bluetooth capability via Device Manager



Step 2 - Install the Bluetooth software

1. Select Start > All Programs > Software Setup.
2. When the Software Setup Welcome window is displayed, select Next.
3. Select the check box next to Bluetooth by company to enable the software for installation, and then select Next.
4. Select Finish to complete the installation and to restart the computer

Step 3 - Enable Blue functionality

If the wireless light (ICON) is off, turn it on by pressing the wireless button on your device. Refer to your device user documentation if you need help locating the wireless button and light. When you turn on the wireless device for the first time, then the found new hardware wizard opens. Follow the instructions in the wizard to load the Blue driver.

Step 3 - Set up the Blue software

After the software is installed and Bluetooth functionality is enabled, a Bluetooth icon will appear in the Windows System Tray located in the lower-right part of the screen. The Bluetooth icon provides easy access to Bluetooth operations. The color of the icon indicates the status of the connection shown below.

Disabled	Enabled	Connected
Blue with red logo	Blue with white logo	Blue with green logo

Blue tooth status

If BWT is disabled (red logo), enable it by right-clicking the Bluetooth icon and selecting Start the Bluetooth Device. The logo will change from red to white. Then you can use the Bluetooth Setup wizard to configure the service and security features as follows:

1. Right-click the Bluetooth icon, and then select Explore My Bluetooth Places.
2. Right-click the My Bluetooth Places icon in the Folders pane of Windows Explorer and select Bluetooth Setup Wizard to begin the configuration process.

3.8. HAM Radio

HAM Radio or Amateur radio is a combined unit of radio transmitter and receiver two-way communication system where radio operators can put their voice on-the-air to be listened into and at the same time replied back by their fellow radio operators around the world.

Ham radio is an exciting way to discover new friends and disseminate knowledge on-the-air. One interesting fact about ham radio communication is that hams don’t have to pay any money to the authority for their on-the-air conversation. It is a highly specialized technical hobby and requires no special qualification. However, it demands immense interest and commitment in operating radio stations of your own because ham radio, also known as "Amateur Radio" does not provide you pecuniary gain. What you gain from being a ham is more than what money can give and for that you got to be imaginative!.

Why an Amateur Radio Operator is called a ham?

The word "HAM" as applied to **1908** was the station CALL of the first amateur wireless station operated by some amateurs of the **Harvard Radio Club**. They were **ALBERT S. HYMAN**, **BOB ALMY** and **POOGIE MURRAY**. At first they called their station "**HYMAN- ALMY-MURRAY**". Tapping out such a long name in code soon became tiresome and called for a revision. They changed it to "**HY-AL-MY**", using the first two letters of each of their names. **Early in 1901** some confusion resulted between signal from amateur wireless station "HY-ALMU" and a Mexican ship named "HYALMO". They then decided to use only the first letter of each name and the station call became "**HAM**".

Ham radio have played a significant part in disaster management and emergencies when wire line, cell phones and other conventional means of communications fail and also without "choke points" such as cellular telephone sites that can be overloaded. Amateur radio operators can use hundreds of frequencies and can quickly establish networks tying disparate agencies together to enhance interoperability. Recent examples include the 2001 attacks on the World Trade Center in Manhattan, the 2003 North America blackout and Hurricane Katrina in September, 2005, where amateur radio was used to coordinate disaster relief activities when other systems failed. The central government in India send teams of ham radio operators to the epicenter of 1993 Latur and 2001 Gujarat earthquakes to provide vital communication links. In December 2004, a group of amateur radio operators on DXpedition on the Andaman Islands witnessed the 2004 Indian Ocean Tsunami. With communication lines between the islands severed, the group provided the only way of relaying live updates and messages to stations across the world.

India launch an amateur radio satellite called as HAMSAT using microsatellite as an auxiliary payload on the PSLV6.

What is the minimum qualification to become a ham?

No educational qualification is specified to become a ham. Anybody who has attained 12 years of age can become a ham radio operator after passing the Amateur Station Operator's Certificate (ASOC) Examination conducted by the Ministry of Communications, Govt. of India. You have to send a "Birth Certificate" or the "High School Leaving Certificate" (which mentions your date-of-birth) as a proof of your age. There are four different grades of Amateur Wireless Telegraph Station Licence. Those between the age group of 14-18 years can apply for Grade-I, Grade-II, Restricted Grade or a Short Wave Listener's licence (listening to the ham radio operators without this licence is considered illegal). Those between the age group of 12-14 years can apply for Grade-II, Restricted Grade or a Short Wave Listener's Licence. The application for the grant of such licences should be accompanied by a certificate from the head of the educational institution recognized by a board or university in India, attended by the applicant or from his legal guardian that the applicant is interested in and is competent to conduct experiment in wireless communication.

HAM Radio

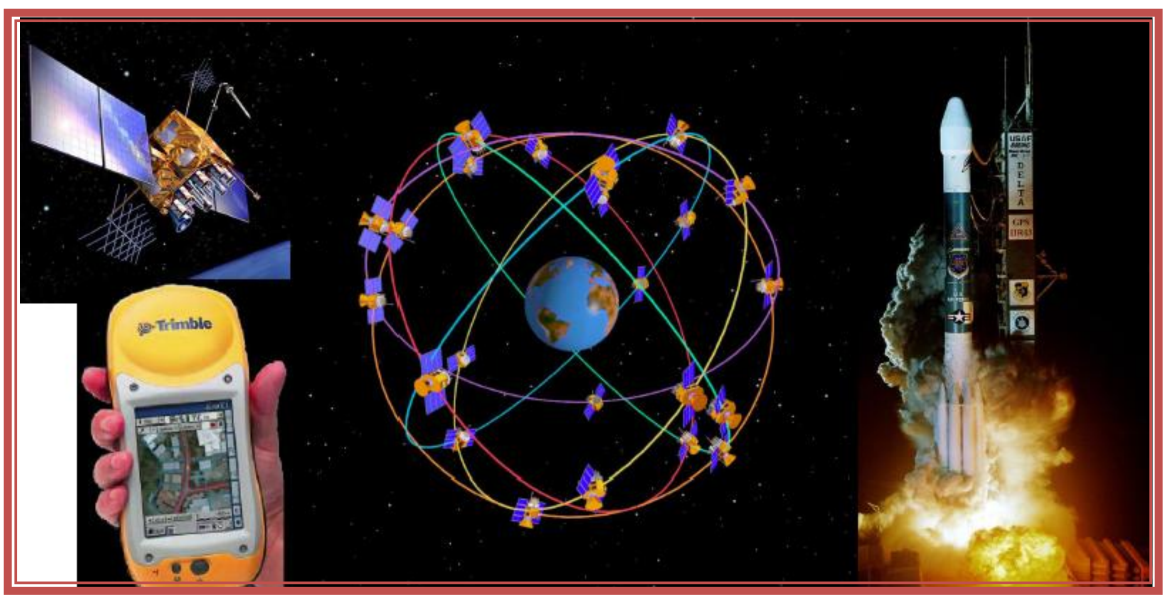
3.9. GPS Application in Emergency Communication

Global Navigation Satellite Systems (GNSS) is the generic term for space-based systems that transmit signals that can be used to provide three services: Position, Navigation, and Timing - known collectively as PNT. The most popular used in world is GNSS is the US Global Positioning System (GPS). Though, Russian GLONASS system is regaining its strength and other systems are being developed, most notably Galileo in Europe and Compass in China. All these systems work approximately in same way so only a description of GPS follows for brevity.

Global Positioning System: The global positioning system is a satellite based navigation system consisting of a network of 24 orbiting satellites that are eleven thousand nautical miles in space and in six different orbital paths. A network of satellites that continuously transmit coded information, which makes it possible to precisely identify locations on earth by measuring distance from the satellites.

GPS consists of three components: **ground, space and user segment** (Fig.3.4).

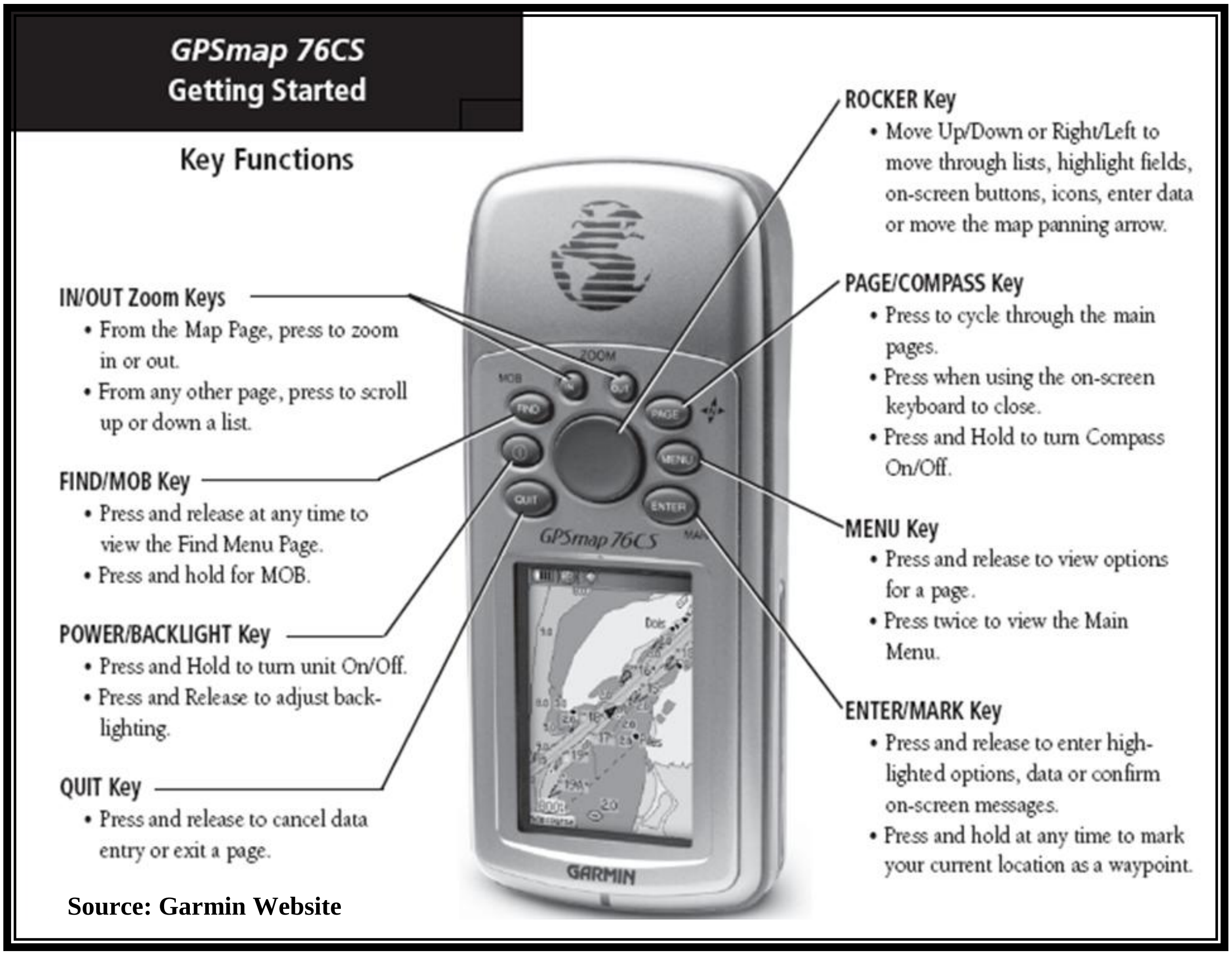
Fig.3.4. Component of GPS Technology



- The ground, or control, segment is used to upload data to the satellites, to synchronize time across the constellation and to track the satellites to enable orbit and clock determination.
- The space segment consists of the GPS satellites in six orbital planes. 24 satellites make a full constellation, although there are currently 32 in service, 2 of which have been declared unusable until further notice. The satellite's code is used to identify it in orbit (it should be noted that this is the fundamental difference between GPS and GLONASS which differentiates satellites by frequency channel).

- The user segment consists of the receivers and associated antennas, used to receive and decode the signal to provide PNT information

Fig.3.5. Key functionalities of Garmin GPS



Source: Garmin Website

Basic GPS Function

Location - determining a basic position

Navigation - getting from one location to another

Tracking - monitoring the movement of people and things

Mapping - creating maps of the world

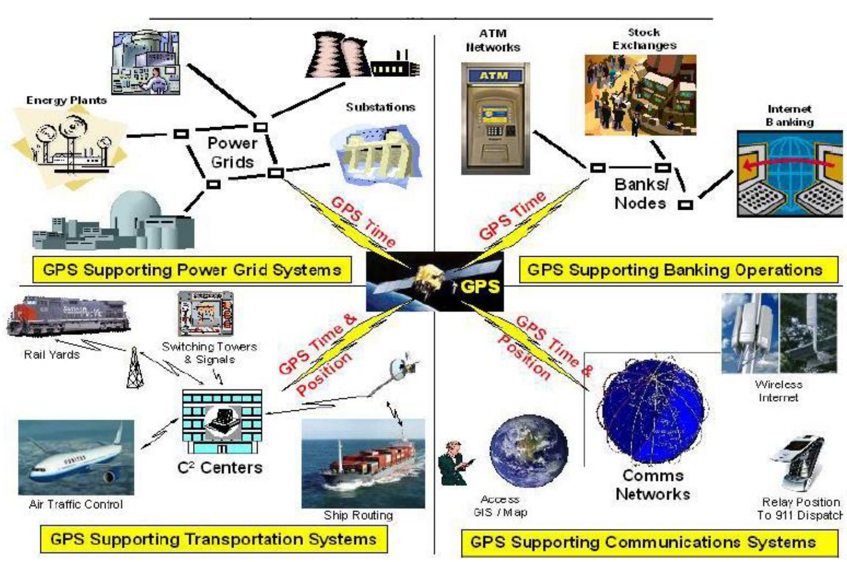
Timing – making sure an event is performed at the exact time

Application

The Global Positioning System (GPS) are knowing the precise location of landmarks, streets, buildings, emergency service resources, and disaster relief sites reduces that time -- and saves lives. The modernize system translates to more lives saved and faster recovery for victims of global tragedies. The critical applications in emergency response system are as follows

- GPS played vital role in relief, rescue and search operation during Indian Ocean region in 2004, Hurricanes Katrina and Rita that wreaked havoc in the Gulf of Mexico in 2005, and the Pakistan-India earthquake in 2005. Further, it is integrated with GIS and Remote Sensing to create map of disaster area for damage assessment and search operation.
- Meteorologists responsible for storm tracking and flood prediction also rely on GPS. They can assess water vapor content by analyzing transmissions of GPS data through the atmosphere.
- GPS is playing an increasingly prominent role in helping scientists to anticipate earthquakes. Using the precise position information provided by GPS, scientists can study how strain builds up slowly over time in an attempt to characterize, and in the future perhaps anticipate, earthquakes.
- The other potent application is about management of wild fires in forest. The air craft combined with GPS with infrared scanner help to map the fire boundaries and hot spots. This information is transmitted to potable field computers at the firefighters' camp. With help of this geographical information the chances of winning against the battle are quite high in front of fire fighter team.
- Location information provided by GPS, coupled with automation, reduces delay in the dispatch of emergency services of police, fire, rescue, and individual vehicles or boats.

Fig.3.6. Other Application of GIS



Source: **http://www.gps.gov/multimedia/presentations/2012/10/USTTI/graham.pdf**

3.10. Remote Sensing and GIS Application in Warning System

Remote sensing is the measurement or acquisition of information about an object or phenomenon, by a recording device that is not in physical or intimate contact with the object. In practice, remote sensing is the remote utilization (as from aircraft, spacecraft, satellite or ship) of any device for gathering information about the environment. GIS can be loosely defined as a system of hardware and software used for storage, retrieval, mapping and analysis of geographic data. GIS and remote sensing are examples of ICT tools being widely used in almost all the phases of warning systems. The different sensors used for hazard mapping, warning system and emergency management are shown in Table 1.3.

Table 1.3. Use of Remote Sensing Sensor in Warning Systems

Wavelength	Waveband	Applicable for	Sensors example
Visible (VIS)	0.4-0.7mm	Vegetation mapping	SPOT: Landsat TM
		Building stock assessment	AVHRR: MODIS:IKONOS
		Population density	IKONOS: MODIS
		Digital elevation model	ASTER:PRISM
Near infrared (NIR)	0.7-1.0mm	Vegetation mapping	SPOT: Landsat TM: AVHARR: MODIS
		Flood mapping	MODIS
Shortwave infrared (SWIR)	0.7-3.0mm	Water vapour	AIRS
Thermal infrared (TIR)	3.0-14 mm	Active fire detection	MODIS
		Burn scar mapping	MODIS
		Hotspots	MODIS: AVHRR
		Volcanic activity	Hyperion
Microwave (Radar)	0.1-100mm	Earth deformation and ground movement	Radarsat SAR:PALSAR
		Rainfall	Meteosat: Microwave imager (aboard TRMM)
		River discharge and volume	AMSR-E
		Flood mapping and forecasting	AMSR-E
		Surface Winds	Quik Scat radar
		3D storm structure	Precipitation radar (aboard TRMM)

Source:http://www.scidev.net/global/earth-science/feature/remote-sensing-for-natural-disasters-facts-and-figures.html

The uses of GIS in different phases of the Warning System include:

- **Planning** - Using a GIS, it is possible to pinpoint hazard trends and initiate evaluation of the consequences of potential emergencies or disasters.
- **Preparedness** - GIS can accurately support better response planning in areas such as determining evacuation routes or locating vulnerable infrastructure and vital

lifelines, etc. It also supports logistical planning to be able to provide relief supplies by displaying previously available information on roads, bridges, airports, railway and port conditions and limitations. The applications of integrated Remote Sensing and GIS in four components of Early warning System are shown in Table 1.4.

Table 1.4. Application of Integrated Remote Sensing & GIS in Emergency Warning System

RISK KNOWLEDGE	
Sub- Components	**Supporting GIS tools**
Hazard Mapping	Digital hazard maps Database of bio-physical resources
Vulnerability Assessment	Database of vulnerable human and environmental resources
Risks Assessment	Production and maintenance of disaster risk maps
Data Management	Database management system
Organizational Development	Not Applicable
HAZARD MONITORING AND WARNING SERVICES	
Sub- Components	**Supporting GIS tools**
Monitoring Systems Developed	Satellite remote sensing of the environment
Forecasting and Warning Systems Established	Hazard modeling systems
Institutional Mechanisms Established	Not applicable
INFORMATION DISSEMINATION AND COMMUNICATION	
Sub- Components	**Supporting GIS tools**
Effective Communication Systems and Equipment Installed	Web-based GIS
Warning Messages Recognized and Understood	Not applicable
Organizational and Decision-making Processes Institutionalized	Not applicable
RESPONSE CAPABILITY	
Sub- Components	**Supporting GIS tools**
Warnings Respected	Not applicable
Disaster Preparedness and Response Plans Established	Risk mapping Disaster resources mapping
Community Response Capacity Assessed and Strengthened	Not applicable
Public Awareness and Education Enhanced	Web-based mapping Virtual reality-GIS mapping

Source: Opadeyi, 2009

3.11. Cyclone Early Warning System in India

The cyclone warning services of India Meteorological Department (IMD) are one of the most important function and the first service undertaken by the Department which is more than 135 years old. Cyclone warnings are provided by IMD from the Area Cyclone Warning Centers (ACWCs) at Calcutta, Chennai and Mumbai and Cyclone Warning Centers (CWCs) at Bhubaneswar, Visakhapatnam and Ahmedabad. The entire cyclone warning work is coordinated by the Deputy Director General of Meteorology (Weather Forecasting) at Pune and Deputy Director General of Meteorology (Services) at New Delhi.

Tracking devices used by IMD for tropical cyclones

1. Conventional surface and upper air observations from inland and island stations, coastal Automatic Weather Station (AWS), ships and buoy observations;
2. Cyclone detection radar including Doppler Weather Radar;
3. Satellite cloud pictures from the Geostationary Satellite (INSAT 3A & Kalpana1).

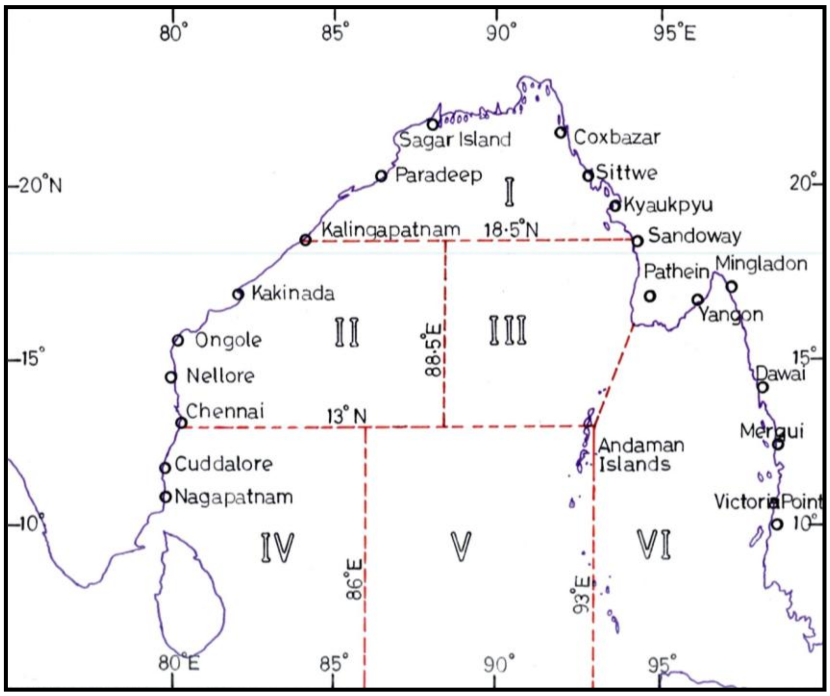
Tropical cyclone warnings by IMD

1. Warning bulletins for shipping on the high seas.
2. Warning bulletins for ships plying in the coastal waters.
3. Port warnings.
4. Fisheries warnings. (Fishermen & Fisheries Officials)
5. Four stage warnings for the State and Central Government officials.
6. Warnings for recipients who are registered with the department (Designated/registered users).
7. Aviation.
8. Warnings for the general public through All India Radio, Doordarshan and the Press.
9. Warning for Indian Navy.
10. Bulletins for Print / Electronic media

Bulletins for the high seas

These bulletins are for the shipping interests on the high seas. The area covered by these bulletins is the sea area between the Asian Coast and the line joining the points 240 N 680 E, 200 N 680 E, 200 N 600 E, 50 N 600 E, 50 N 950 E, 100 N 950 E, 100 N 940 E, 130 30'N 940 E, 130 30'N 920 E, 180 N 920 E and 180 N 940 30'E. The exact area of coverage is shown below (Fig. 3.7).

Fig.3.7. Exact Coverage Area in Bay of Bengal



Source: Review of the Tropical Cyclone Operational Plan (WMO Secretariat)

These bulletins are issued by the Area Cyclone Warning Centres at Kolkata and are broadcast by the Coastal Radio Stations of the Department of Telecommunication (DoT) and ”NAVTEX Chennai”. These bulletins are issued by the Area Cyclone Warning Centres; Mumbai is available to the users through e-mail/fax and uploaded in the website of RMC Mumbai. The bulletins for the Arabian Sea broadcast from Mumbai Radio are issued by the Area Cyclone Warning Centre at Mumbai, whilst those for the Bay of Bengal, broadcast from Kolkata and Chennai Radio, are issued by the Area Cyclone Warning Centre at Kolkata. Under the GMDSS programme of WMO/IMO, India is issuing GMDSS bulletins for met area VIII (N) daily at 0900 UTC and 1800 UTC with additional warning during cyclone period.

Tropical storm warnings to government officials (Four stage warnings)

A "pre-cyclone watch" bulletin is issued by DGM himself soon after the formation of a depression informing senior central government officials including chief secretary of coastal maritime States about likely development of a cyclonic storm, its movements, coastal belt of India likely to experience adverse weather. No fixed format is used. At the second stage, a "cyclone alert" is issued 48 hours in advance of the expected commencement of adverse weather in association with the cyclonic storm over the coastal area. The third stage of the warning, known as "cyclone warning" is issued 24 hours in advance of commencement of severe weather. The last stage of warning covering the post-landfall scenario is included in the cyclone warnings issued just before landfall and is continued till the cyclonic wind force is maintained in the core area of the cyclonic storm over land.

Dissemination of tropical cyclone warnings in India by IMD

1. Telefax
2. Telephones
3. Automatic Message Switching System (AMSS)
4. All India Radio
5. Television
6. Cyclone Warning Dissemination System (CWDS), Digital Cyclone Warning Dissemination System (DCWDS) one way communication system
7. W/T (especially police W/T)
8. Internet, by keeping information on IMD website (http://:www.imd.gov.in).
9. Microwave link of the railways
10. IVRS
11. e-mail
12. SMS
13. GMDSS

3.12. Tsunami Early Warning System in India

"Tsunami" is a system of ocean gravity waves formed as a result of large scale disturbance of the sea bed in a short duration of time, mostly due to earth quake (or volcanic eruption or submarine landslides).

The Andaman-Nicobar-Sumatra Island Arc in the Bay of Bengal and the Makran Subduction Zone in the North Arabian Sea are two Tsunamigenic zones in Indian Ocean recognized by international and national research organization shown in Fig The east and west coasts of India and the island regions are likely to be affected by tsunamis generated mainly due to earthquakes in these subduction zones. Hence there was a need for developing Tsunami Warning System.

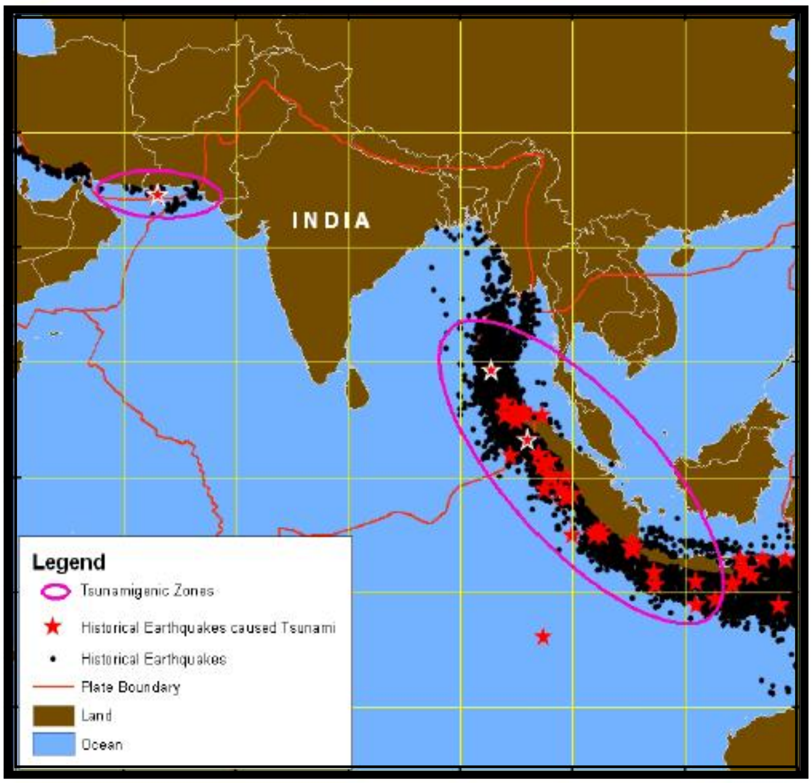


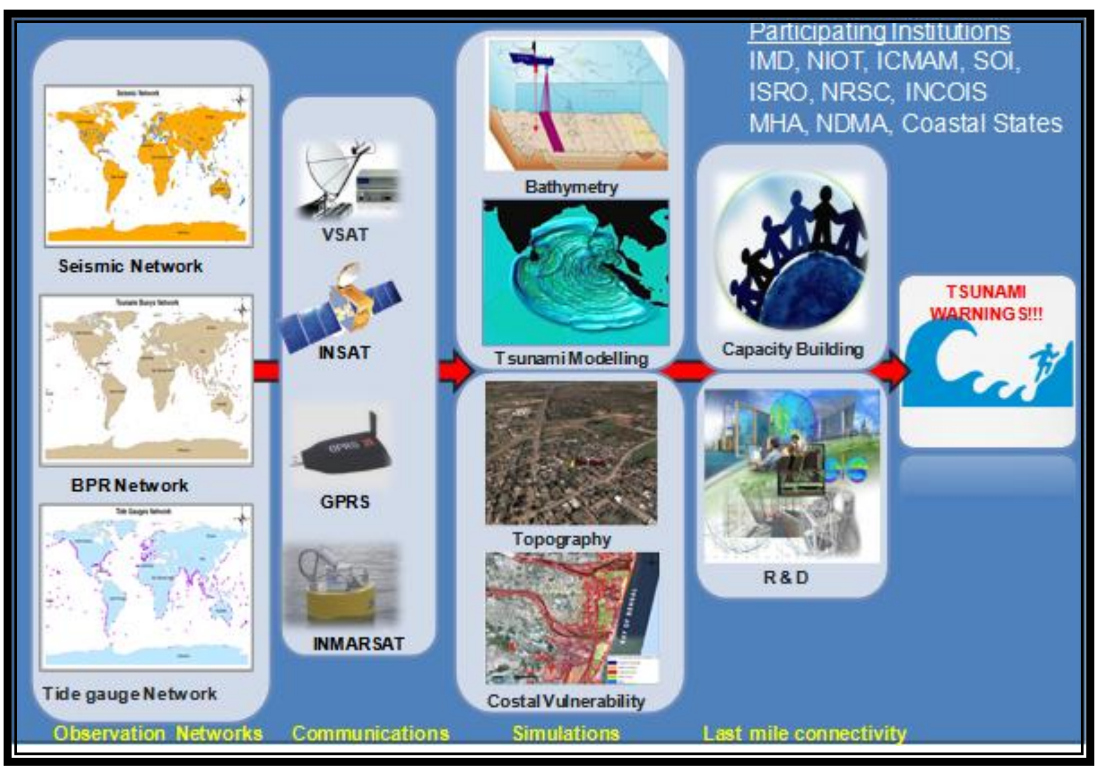
Fig. 3.8. Tsunamigenic zones in the Indian Ocean

Source: Nayak and Kumar, 2008

A Tsunami Warning System (TWS) is used to detect tsunamis in advance and issue warnings to prevent loss of life and damage. It is made up of two equally important components: a network of sensors to detect tsunamis and a communications infrastructure to issue timely alarms to permit evacuation of the coastal areas. The December 26, 2004 earthquake and the subsequent tsunami exposed the vulnerability of the Indian coastline to Oceanic hazards. Following the event, India started its own interim tsunami warning center in the first quarter of 2005 to issue tsunami bulletins generated from seismic information. The interim services were succeeded by setting up of a state-of-the-art Indian Tsunami Early Warning System (ITEWS) at the Indian National Centre for Ocean Information Services (INCOIS), Hyderabad, under the Earth System Sciences Organization (ESSO), Govt. of India. The system implemented in phases became full-fledged 24X7 operational early warning system in October 2007.

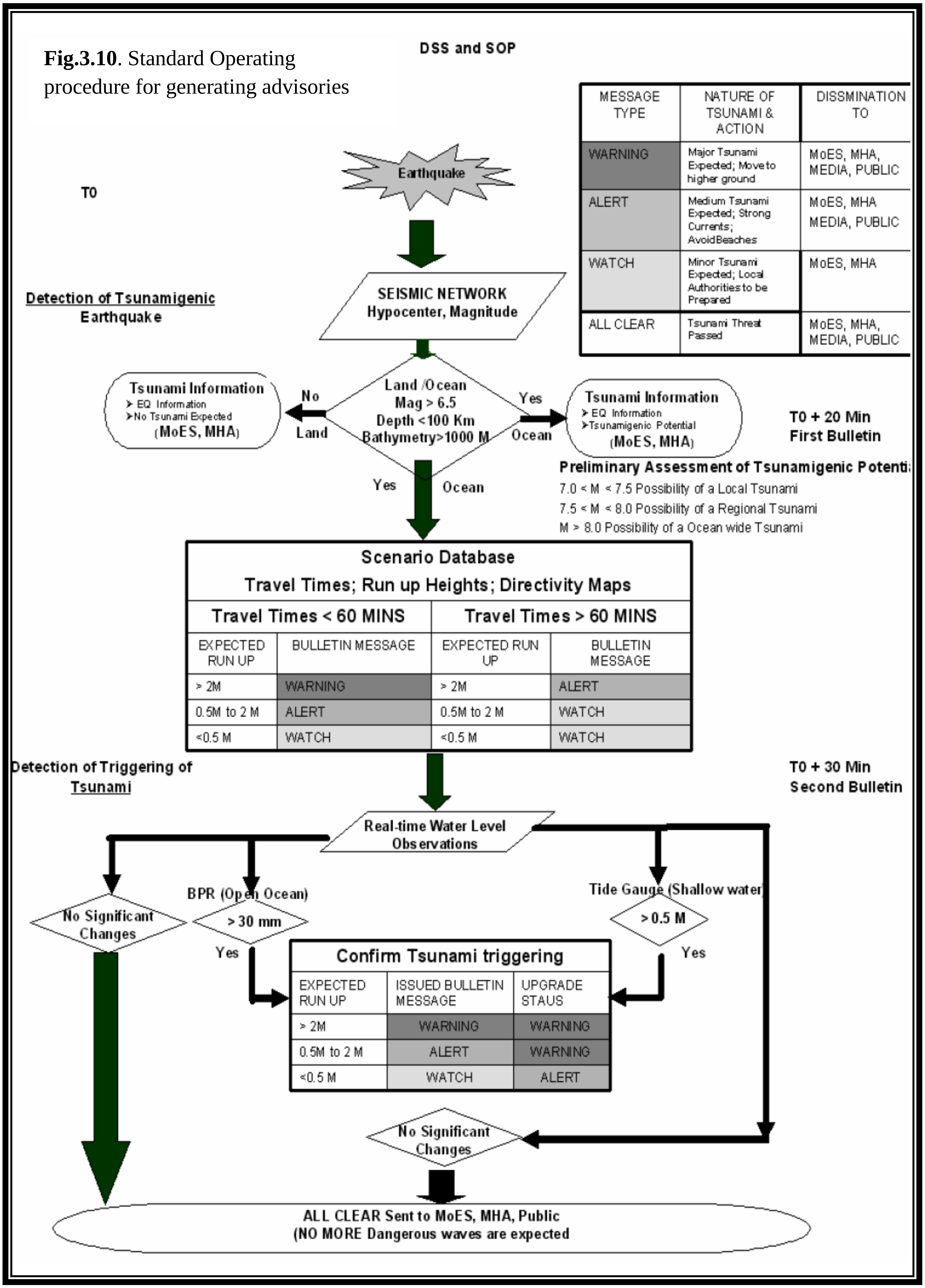
The Tsunami Early Warning System comprises a real-time network of seismic stations, Bottom Pressure Recorders (BPR), tide gauges and 24 X 7 operational warning centre to detect tsunamigenic earthquakes, to monitor tsunamis and to provide timely advisories following the Standard Operating Procedure (SOP), to vulnerable community by means of latest communication methods with back-end support of a pre-run model scenario database and Decision Support System (DSS) (Shown in Fig.3.10). The Warning Centre is capable of issuing Tsunami bulletins in less than 10 minutes after any major earthquake in the Indian Ocean thus leaving us with a response/lead time of about 10 â□“ 20 minutes for near source regions in the Andaman & Nicobar and a few hours in the case of mainland. Currently Warning Centre disseminates tsunami bulletins to various stakeholders through multiple dissemination modes simultaneously (Fax, Phone, Emails, GTS and SMS etc.). Users can also register on the website for receiving earthquake alerts and tsunami bulletins through emails and SMS. The standard operating procedures for generating adversaries of Tsunami Early Warning Centre are shown in Fig.3.9.

Fig.3.9. Component of Indian Tsunami Early Warning System



Source: Indian National Centre for Ocean Information Services (INCOIS) Website

Fig.3.10. Standard Operating procedure for generating advisories



Source: Indian National Centre for Ocean Information Services (INCOIS)

Check Your Progress III

Note: a) Use the space provided for your answers.
b) Check your answers with the possible answers provided at the end of this unit.

1) What are the core elements in Early Warning System?

Ans.

2) What do you mean by Community Early Warning System?

Ans.

3) What do you mean by Bluetooth Wireless Technology?

Ans.

4) What are the basic functions of GPS?

Ans.

5) What is the name of Ham Radio satellite launch by India?

Ans.

6) What are name of centers providing cyclone warning in India?
Ans.

7) What do you mean by GNSS?
Ans.

8) What are the tracking devices used by IMD for cyclone tracking?

Ans.

9) What are the methods used to detect tsunamigenic Earthquakes?

Ans.

10) What is the name of institute providing interim services in Tsunami Warning in India?

Ans.

3.13. Let Us Sum Up

This block covers topics on concept on Early Warning System, Community Early Warning System and advance technologies like Wireless Technology, Bluetooth Technology, Ham Radio, Global Positioning System, Remote Sensing and GIS application for emergency management. Student will learn about the need of early warning system in 21^{st} century due to increase in incidence of natural hazard and also resulting many fold increase in loss of life and property. Early warning is the provision of timely and effective information, through identified institutions, that allows individuals exposed to hazard to take action to avoid or reduce their risk and prepare for effective response and is the integration of four main elements: knowledge of the risk, a technical monitoring and warning service, dissemination of meaningful warnings to at-risk people, and public awareness and preparedness to act. Scientific and technological advances have driven marked improvements in the quality, timeliness and lead time of hazard warnings, and in the operation of integrated observation networks. Advance technology like Remote Sensing, Global Positioning System, Ham Radio, Wireless technology, mobile phone technology and Satellite communication are playing major role in emergency management. Warning systems are in place and have proved beneficial for a variety of hazards. Effective Cyclone warning in India has reduced death dramatically during Phallin and Hudhud. In the case of tsunamis, the benefit of an internationally coordinated system was shown in the 2011 earthquake and tsunami in Tohoku, Japan, which threatened many Pacific islands: warnings were more coordinated than in the devastating Indian Ocean Tsunami in 2004, providing time for many people to evacuate to high ground. Further, But advances in technology alone are not enough — and in some cases they can even create obstacles to the capacity of vulnerable populations to respond.

3.14. Key Words

Early warning system – The set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss.

Hazard – A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

Bluetooth - It is a wireless technology standard for exchanging data over short distances (using short wavelength UHF radio waves in the ISM band from 2.4 to 2.485 GHz.

Global Positioning System - It is a network of satellites and receiving devices used to determine the location of something on Earth. GPS receivers provide location in latitude, longitude, accurate time and altitude.

Remote sensing - It is the science (and to some extent, art) of acquiring information about the Earth's surface without actually being in contact with it.

HAM Radio - It is a combined unit of radio transmitter and receiver two-way communication system where radio operators can put their voice on-the-air to be listened into and at the same time replied back by their fellow radio operators around the world.

Tsunami - It is a system of ocean gravity waves formed as a result of large scale disturbance of the sea bed in a short duration of time, mostly due to earth quake (or volcanic eruption or submarine landslides).

3.15. References/Further Readings

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3.16. CHECK YOUR PROGRESS – POSSIBLE ANSWERS

Check Your Progress III

1) The core element of Early Warning System are

- **Risk knowledge,**
- **Warning services,**
- **Dissemination and Communication**
- **Response Capability**

2) **Community Early Warning System** is understood to be an effort to systematically collect, compile and analyze risk information and dissemination systems that reach those community at risk, and followed by practical knowledgeable responses by those communities to reduce threat and harm.

3) **Bluetooth** is a method for data communication that uses short-range radio links to replace cables between computers and their connected units.

4) The basic function of GPS are

- **Location - determining a basic position**
- **Navigation - getting from one location to another**
- **Tracking - monitoring the movement of people and things**
- **Mapping - creating maps of the world**
- **Timing – making sure an event is performed at the exact time**

5) **HAMSAT**

6) **Cyclone warnings** are provided by IMD from the Area Cyclone Warning Centers (ACWCs) at Calcutta, Chennai and Mumbai and Cyclone Warning Centers (CWCs) at Bhubaneswar, Visakhapatnam and Ahmedabad**.**

7) **Global Navigation Satellite Systems (GNSS)** is the generic term for space-based systems that transmit signals that can be used to provide three services: Position, Navigation, and Timing - known collectively as PNT. The most popular used in world is GNSS is the US Global Positioning System (GPS). Though, Russian GLONASS system is regaining its strength and other systems are being developed, most notably Galileo in Europe and Compass in China.

8) Tracking devices used by IMD for monitoring tropical cyclones are

- Conventional surface and upper air observations from inland and island stations, coastal Automatic Weather Station (AWS), ships and buoy observations;
- Cyclone detection radar including Doppler Weather Radar.
- Satellite cloud pictures from the Geostationary Satellite (INSAT 3A & Kalpana1).

9) The methods are real-time network of **seismic stations, bottom pressure Recorders (BPR), tide gauges** are used to detect tsunamigenic earthquakes.

10) The interim services of Tsunami Warning are provided by **Indian Tsunami Early Warning System (ITEWS)** at the **Indian National Centre for Ocean Information Services (INCOIS)**, Hyderabad, under the **Earth System Sciences Organization (ESSO),** Govt. of India

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