GEOSPATIAL / GEOGRAPHIC INFORMATION SYSTEMS (GIS)

UNIT-1 Basics of GIS

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08MTRS-14: GEOGRAPHIC INFORMATION SYSTEM

1.Basics of GIS: Definition - Usefulness of GIS - Components of GIS - Computer Hardware, Software Modules and Organisational Context of GIS.

2.Data Structure: Data Structure in GIS - Types of Data (Points, Lines and Polygons)- Data Base Structures (Raster Data Structures and Vector data Structures) - Data Conversion, (Vector to Raster and Raster to Vector).

3.Data Input, Verification, Storage and Output: Spatial Data Input Processes and Devices (Sources of data, - Different Types of Data Entry methods, viz., Manual input, Run length code, Digitization, Automated Scanning, etc. – Vector to Raster conversion – Raster to Vector conversion - Input devices) - Entry of non-spatial data – Linking of Spatial & Non-spatial data – Data Verification (Errors of different types) – Correction (Rubber Sheet Transformation, Bilinear interpolation, Cubic Convolution, etc.) – GIS capabilities for Data correction – Data output (Types of Output, GIS Capabilities for output, Output devices).

4.Methods of Spatial Interpolation: Basic Principles of Interpolation – Methods of Interpolation (Interpolation by Joining Boundaries, viz., Simple vector maps, Theisson polygons) – Global Methods of Interpolation, Local Interpolation (Trend Surface Analysis) – Local Interpolation (Splines) - Optimal Interpolation (Kriging).

5.Digital Elevation Modeling: Need For Three Dimensional Models - Methods of DEM - Products of DTM (Contour Maps, Shaded Relief Map, Maps Related To Slopes, Line Sight Maps, Drainage Analysis, Volume Estimation etc.) Usefulness of DEM/DTM.

6. **Data Analysis and Spatial Modeling:** Simple data retrieval – Data retrieval through Boolean Logic – Map Overlaying and Cartographic Modeling (Two layers, Multiple layers, Binary, Index, Regression, and Process Models) – Overlay analysis, Capabilities (Point Operations, Regional Operations, Neighbourhood Operations) – Buffering – Cartographic Modeling using Natural Language Commands – Advantages and disadvantages of Carto modelling.

7. **Network Modeling:** Networking and Dynamic Segmentation – Applications, Minimum Distance Model, Maximum Covering Model (P-median model), Urban Transportation Planning Model.

8. **Classification & Advanced GIS:** Principles – Types of Classification (Exogenous, Arbitrary, Idiographic & Serial) – Multivariate Analysis. Artificial Intelligence - Expert Systems - Object Oriented GIS.

9. **Data Quality – Errors and Natural Variation:** Sources of Errors – Errors due to Natural Variation – Errors during measurement – Errors during entry – Errors during measurement – Errors during Process & Analysis.

10. **GIS Case studies.**

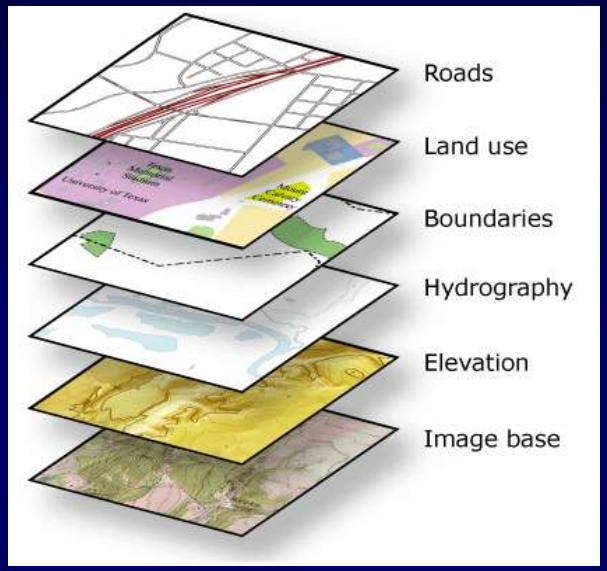
GIS: Defined simply

- **A spatially referenced information system on resources and hazards**

GIS can also be defined based on it's Capabilities or Virtues or Usefulness or credibility

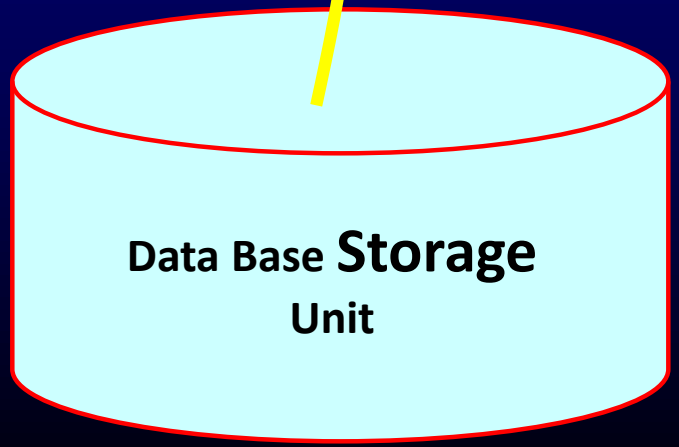
GIS Can hold large amount of geospatial data / maps and non-spatial data

Geospatial data / maps



Non spatial / Attribute / Aspatial data

	BLOCK_NAME	BK_AREA	SALI_AREA	PERCENTAGE	SALINITY_TYPE
2	AGASTESWARAM	97765036.16	47651257.35	48.75	COASTAL SALINE SOIL
3	ALWARTHIRUNAGARI	314987693.28	13483201.16	4.29	COASTAL SALINE SOIL
4	ARANTANGI	546979186.79	19699964.93	3.60	COASTAL SALINE SOIL
5	ARIMALAM	362442584.63	36099.29	0.01	COASTAL SALINE SOIL
6	AVUDAIYARKOIL	317311598.56	124505284.05	39.24	COASTAL SALINE SOIL
7	BHUVANAGIRI	196728518.35	26522096.91	13.35	COASTAL SALINE SOIL
8	CHENNAI	173276620.57	116210289.56	67.07	COASTAL SALINE SOIL
9	CHITHAMUR	266707327.11	82036036.70	30.76	COASTAL SALINE SOIL
10	CUDDALORE	301090086.77	234349321.02	77.83	COASTAL SALINE SOIL
11	GUMMIDIPOONDI	418232625.80	198469820.69	47.46	COASTAL SALINE SOIL
12	KADALADI	801377568.81	518714069.26	64.73	COASTAL SALINE SOIL
13	KANDAMANGALAM	230537210.04	3561936.61	1.53	COASTAL SALINE SOIL
14	KEELAIYUR	173072850.20	9083648.32	5.25	COASTAL SALINE SOIL
15	KEERAPALAYAM	120866985.35	50194462.65	40.78	COASTAL SALINE SOIL
16	KILLIYOOR	27797205.53	975230.86	3.51	COASTAL SALINE SOIL
17	KOLLIDAM	272680537.73	465289.90	0.17	COASTAL SALINE SOIL
18	KOTTUR	321190878.64	437663.63	0.14	COASTAL SALINE SOIL
19	KURINJIPADI	403874698.25	102104013.42	25.28	COASTAL SALINE SOIL
20	KURUNTHENCODE	150643684.38	76575441.17	50.83	COASTAL SALINE SOIL
21	LATHUR	378322678.78	227214144.85	60.06	COASTAL SALINE SOIL
22	MANAMELKUDI	187989286.34	90731286.29	48.27	COASTAL SALINE SOIL
23	MANDAPAM	221958482.90	221958449.74	100.00	COASTAL SALINE SOIL
24	MARAKKANAM	423770925.99	169722836.96	40.05	COASTAL SALINE SOIL
25	MINJUR	489683083.78	462608481.54	99.46	COASTAL SALINE SOIL
26	MUNCHIRAI	187488797.71	123207679.80	65.74	COASTAL SALINE SOIL
27	MUTHUPETTAI	372762749.08	275672726.32	73.95	COASTAL SALINE SOIL
28	NANARKOIL	265298425.88	5883174.16	2.21	COASTAL SALINE SOIL
29	OTTAPIDARAM	769995062.30	59580178.42	7.42	COASTAL SALINE SOIL
30	PARANGIPETTAI	232530511.68	202813776.86	87.22	COASTAL SALINE SOIL
31	PATTUKKOTTAI	414210092.49	142415280.27	34.38	COASTAL SALINE SOIL
32	PONDI	304809120.44	168067160.76	55.14	COASTAL SALINE SOIL
33	PUDHAL	134992930.49	77617267.23	57.51	COASTAL SALINE SOIL
34	RADHAPURAM	309678174.59	151774863.02	49.01	COASTAL SALINE SOIL
35	RAJAKKAMANGALAM	147954170.04	88395022.01	59.69	COASTAL SALINE SOIL



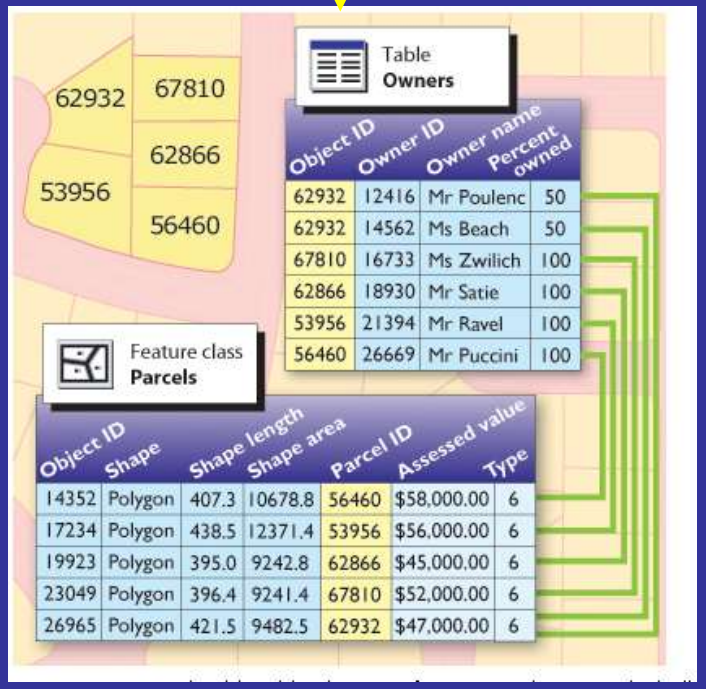
GIS can Store, Edit, Manage, Manipulate and Retrieve data / maps

Data Base Management

Spatial Data

Non Spatial Data

Provide Link using Join & Relate methods



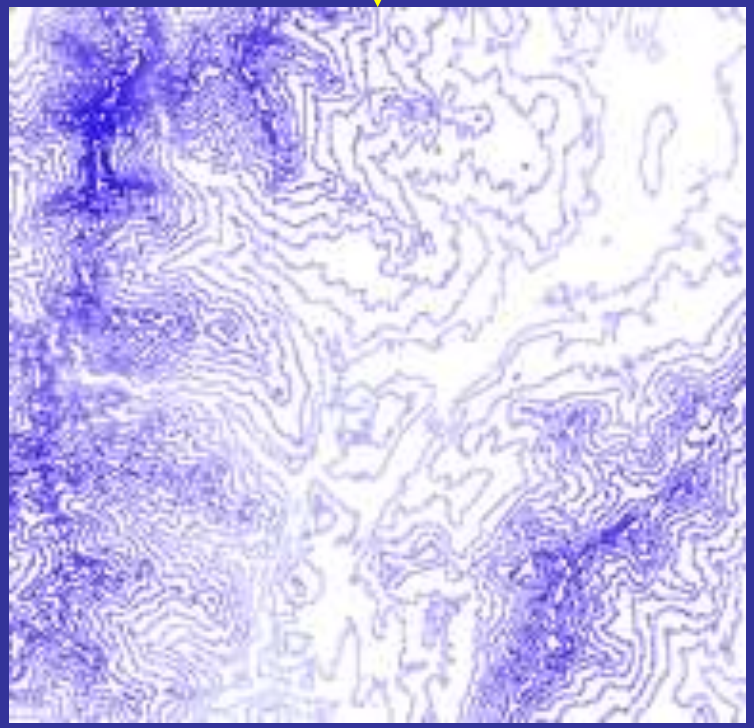
Preferential display of map

National Highway
State Highway
District Road
Panchayat Road
Unmetalled Road
Cart Track
Pack Track
Foot Path
Concrete pavement
Village Road - Metal

State Highway alone

DATA MANIPULATION

Contouring



Filling of Data Gaps
Providing continuity
Viewing 3 Dimensionally

DATA SORTING and PERFORMING STATISTICAL OPERATIONS

Data Sorting

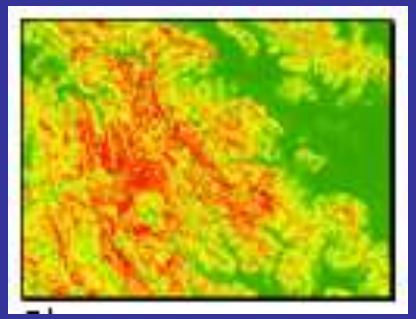
Classification of Data

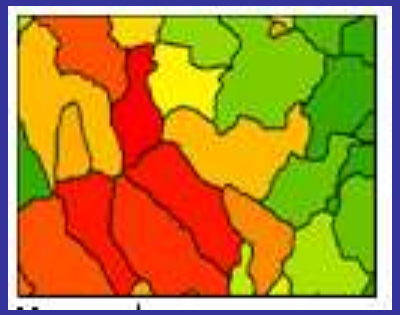
Mean, Mode, Average, Regression

Bring out relationship amongst Data

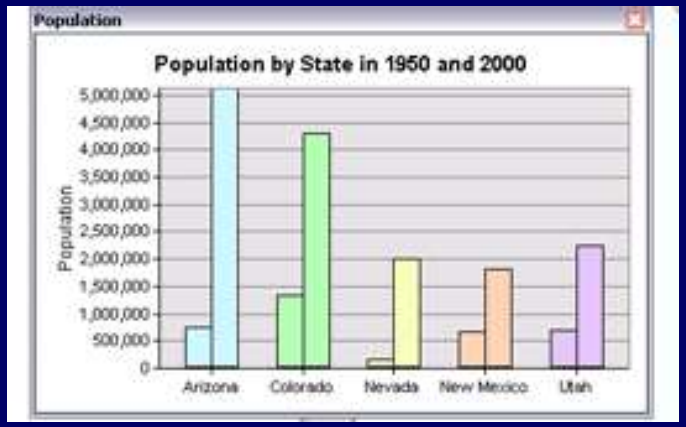
DATA CONVERSION

Raster ⇄ **Vector**

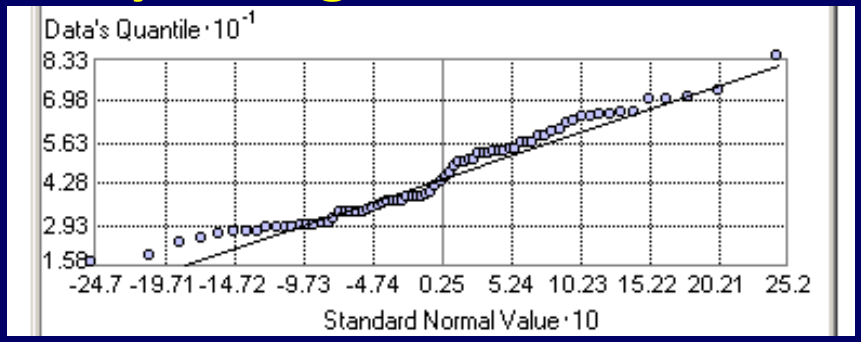




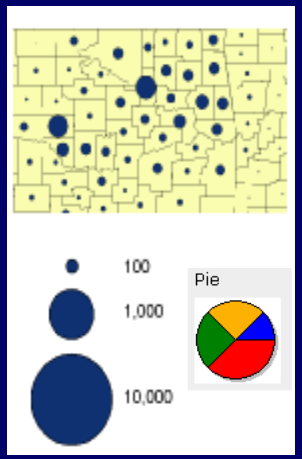
GIS can Display data (Output) in multiple forms - Maps, Charts, Histograms, 3D visualized output, DEM, Fly through models, etc,.

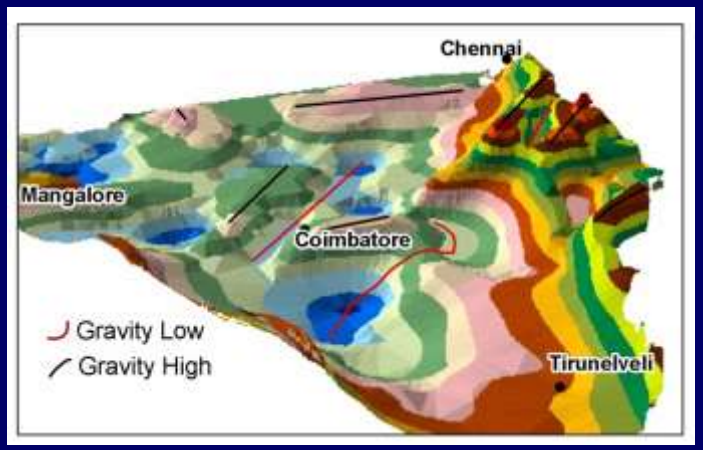


Charts

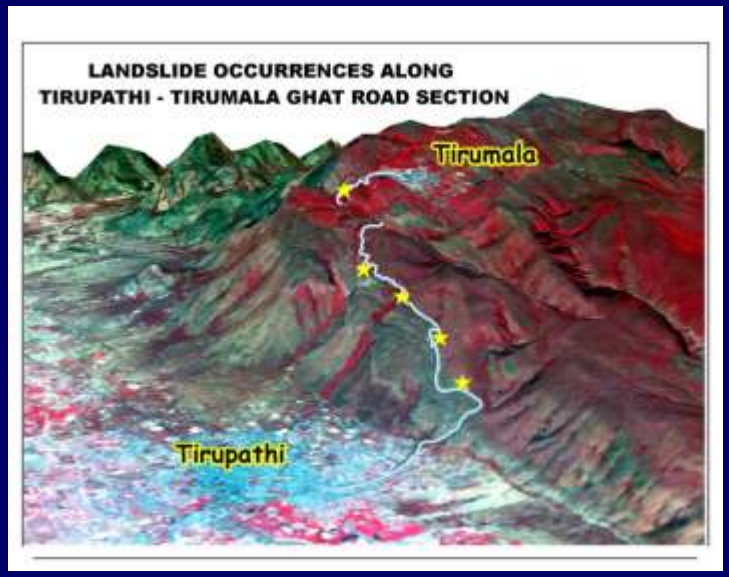


Histograms

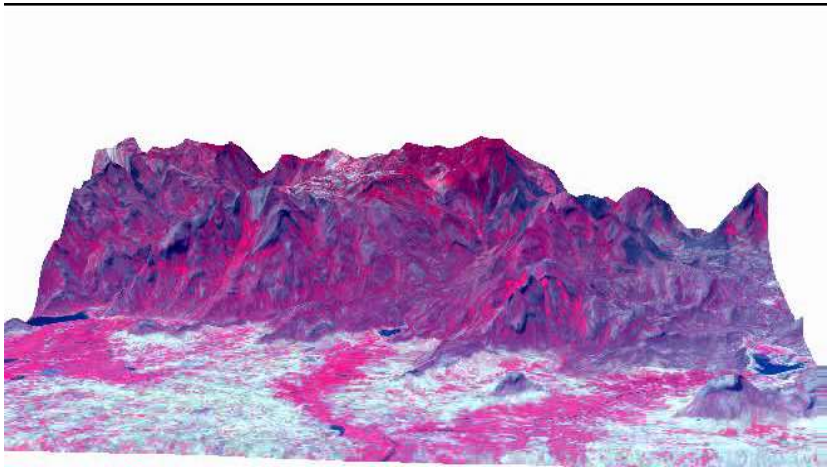


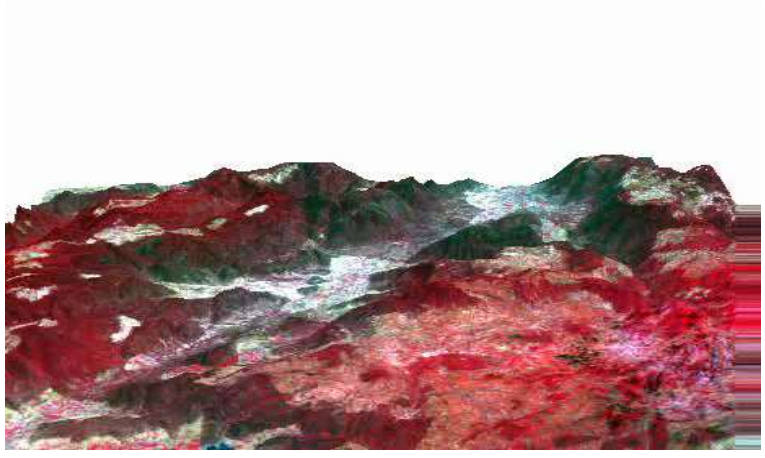


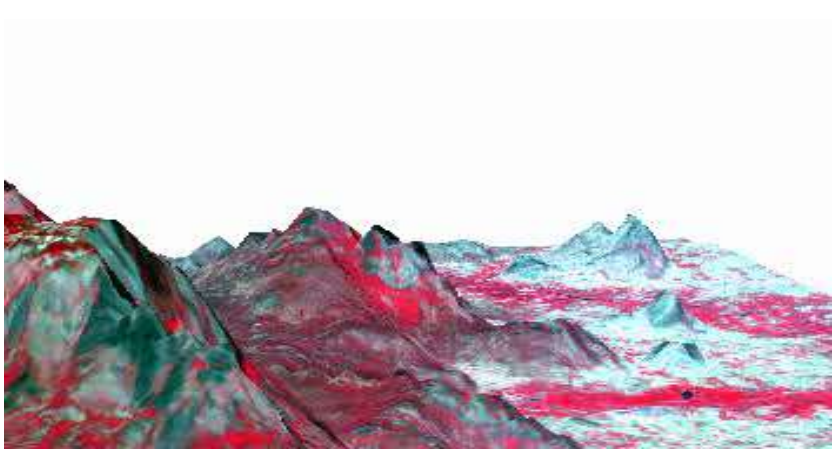
3D - DEM

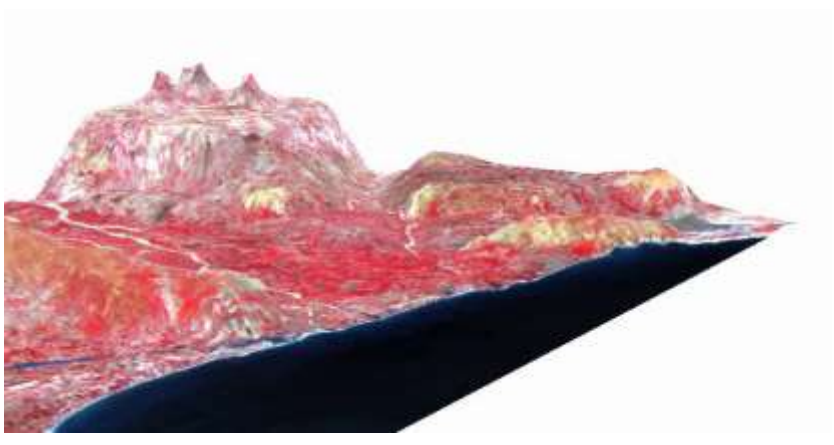


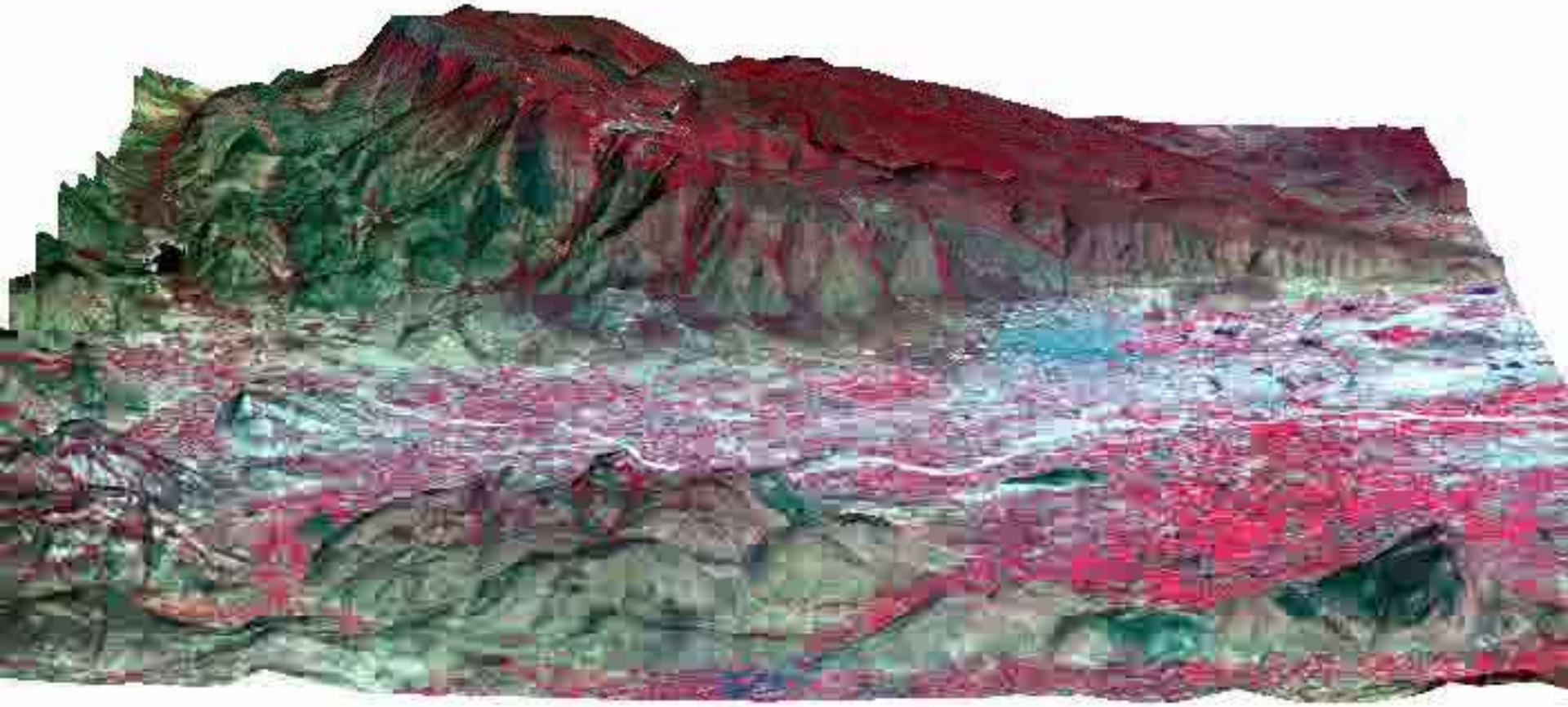
3D - DTM











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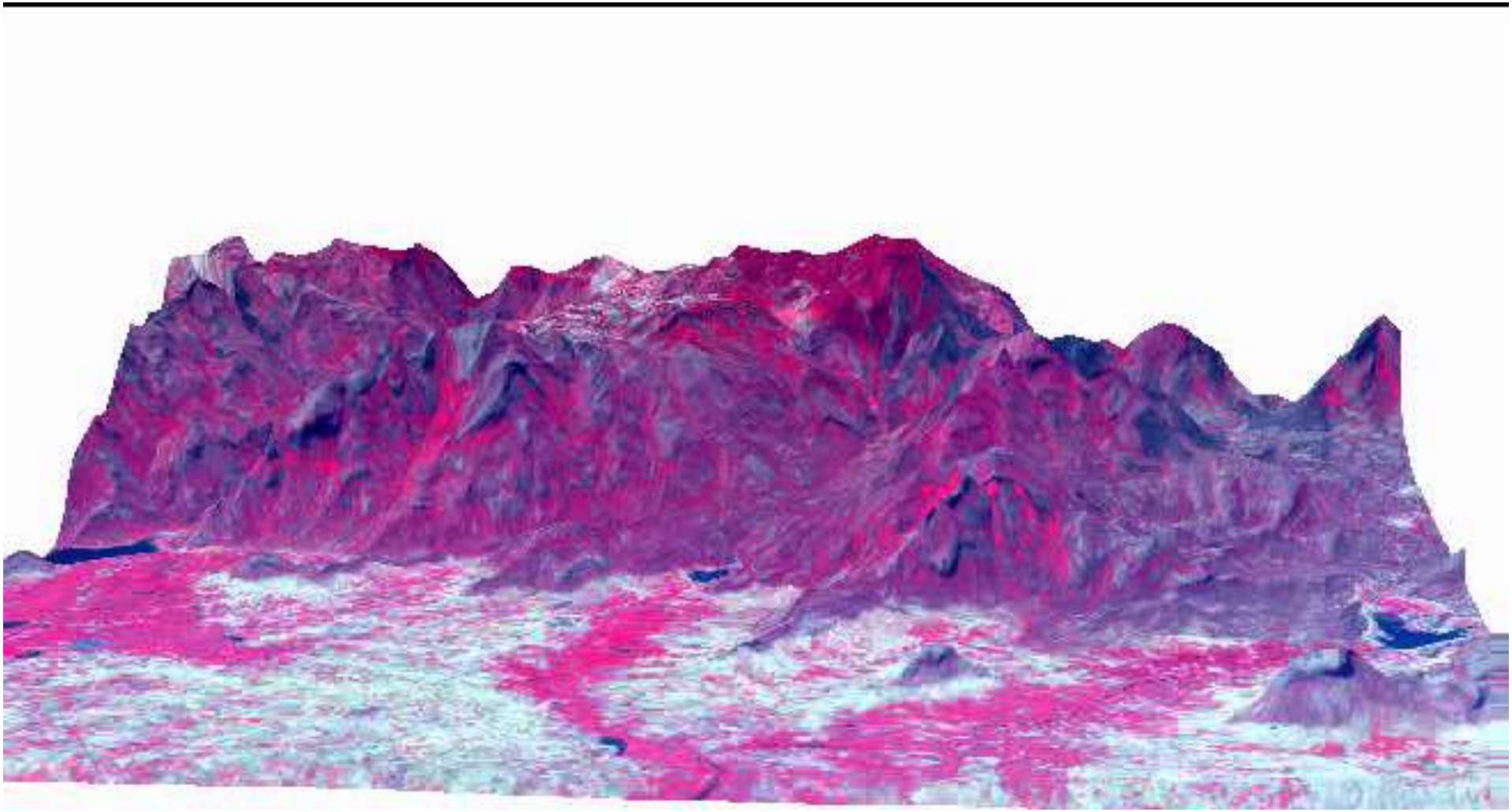
3D FLY THROUGH

BACK



BACK

GIS Can do many operations / Analyses like add, subtract, multiply, divide, square, buffer, corridor, integrate multiple layers, etc.

Raster Based Addition

1	1	2	2	2
3	1	3	4	4
3	3	2	4	4
3	2	2	1	4
3	2	2	1	1

+

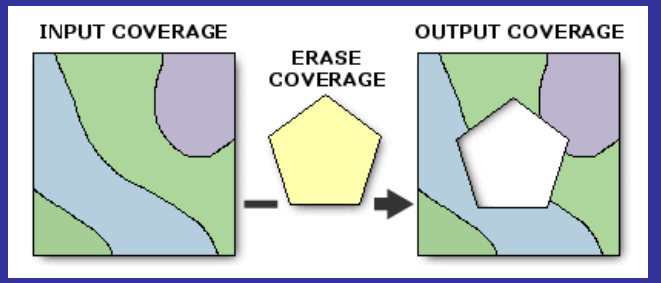
3	3	1	2	2
2	3	1	1	1
2	4	3	3	1
2	2	3	4	4
1	2	1	1	4

=

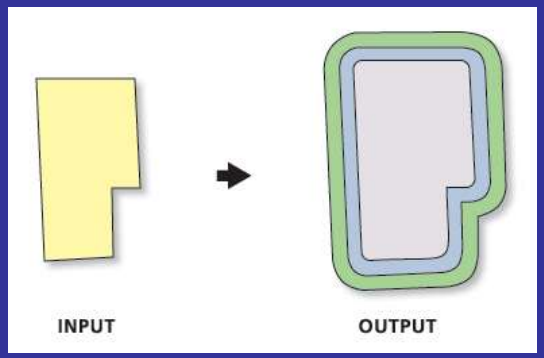
4	4	3	4	4
5	4	4	5	5
5	7	5	7	5
5	4	5	5	8
4	4	3	2	5

InRaster1 + InRaster2 = OutRaster

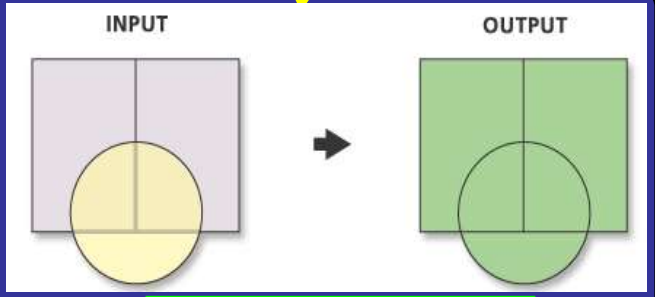
Vector Based Layer Integration



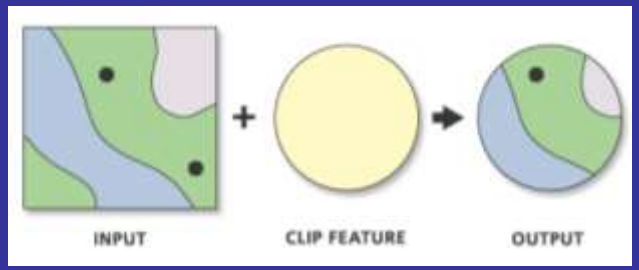
ERASE



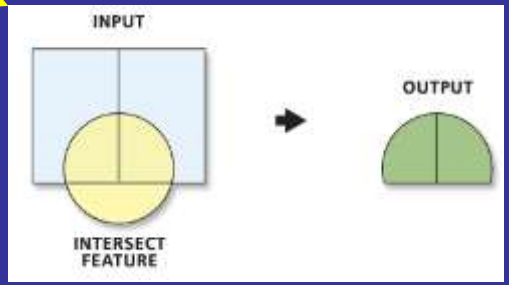
BUFFER



UNION



INTERSECT

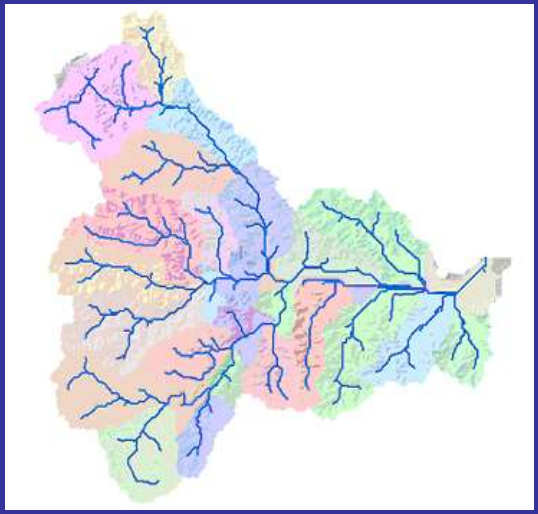


CLIP

NETWORK ANALYSIS

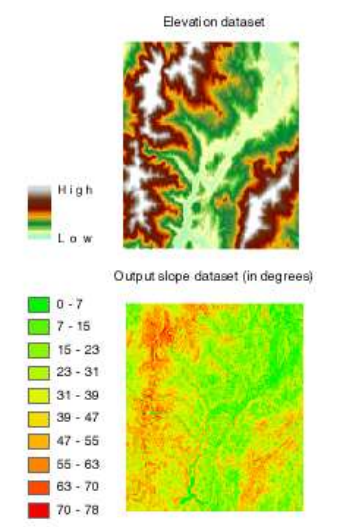
Route Identification

DRAINAGE ANALYSIS



Identification of drainages, Demarcation of drainage basins, Watershed mapping, Runoff estimation, etc.

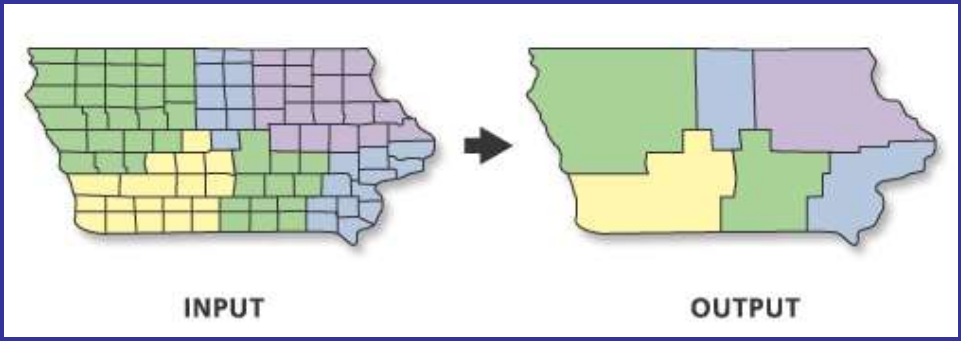
SLOPE ANALYSIS



Slope Categories, Slope Length, 3D Fly-through, Inter-visibility / Line-of-sight Analysis, etc.

Data Preprocessing and Postprocessing capabilities

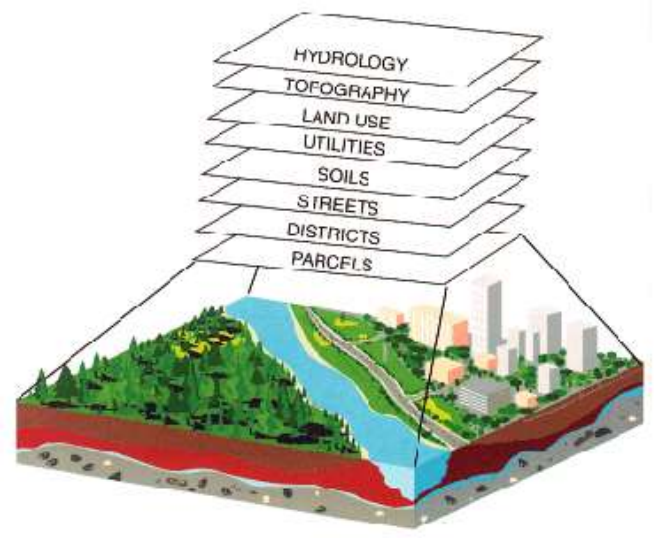
Classification/Grouping , Regrouping,/Reclassification



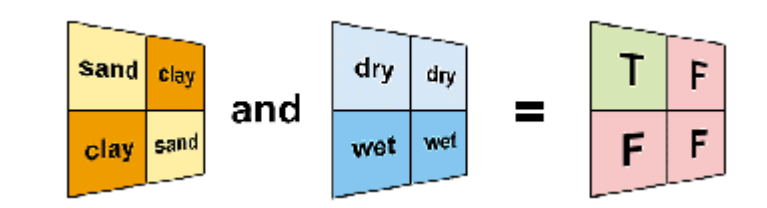
GIS MODELLING

For e.g.,

Representation Model



Process Model



Yes / No, True / False, 1 / 0, etc.

CUSTOMIZATION

Building up of new working environments through programming in GIS as backend using frontends such as VB, Dartnet, Python, etc.

AUTOMATION

GIS Can provide AUTOMATION OF SEVERAL ANALYSIS COMPONENTS FOR VARIOUS NATURAL RESOURCES / DISASTERS MITIGATION

For, example,

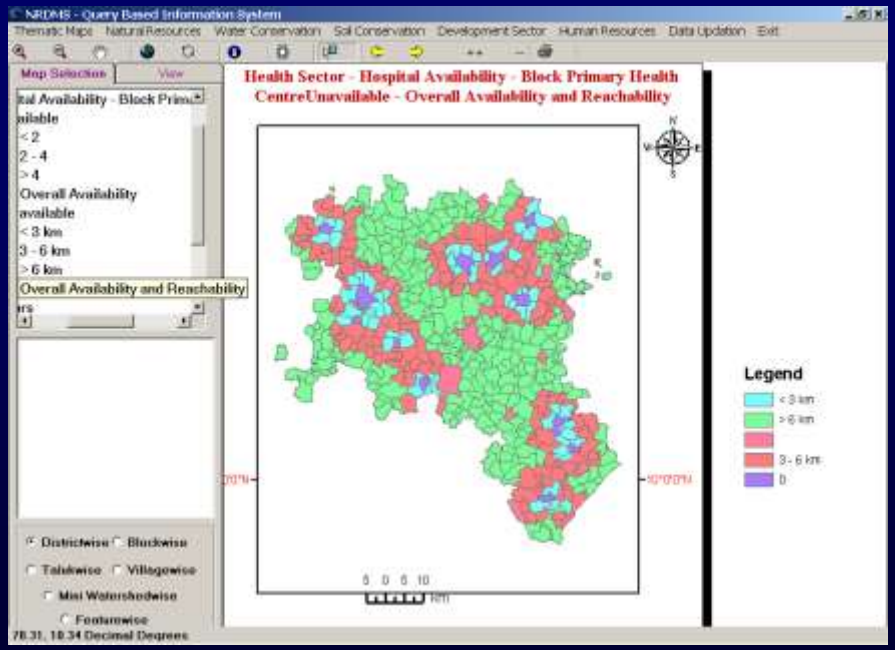
AUTOMATED RUNOFF ESTIMATION MODEL can do,

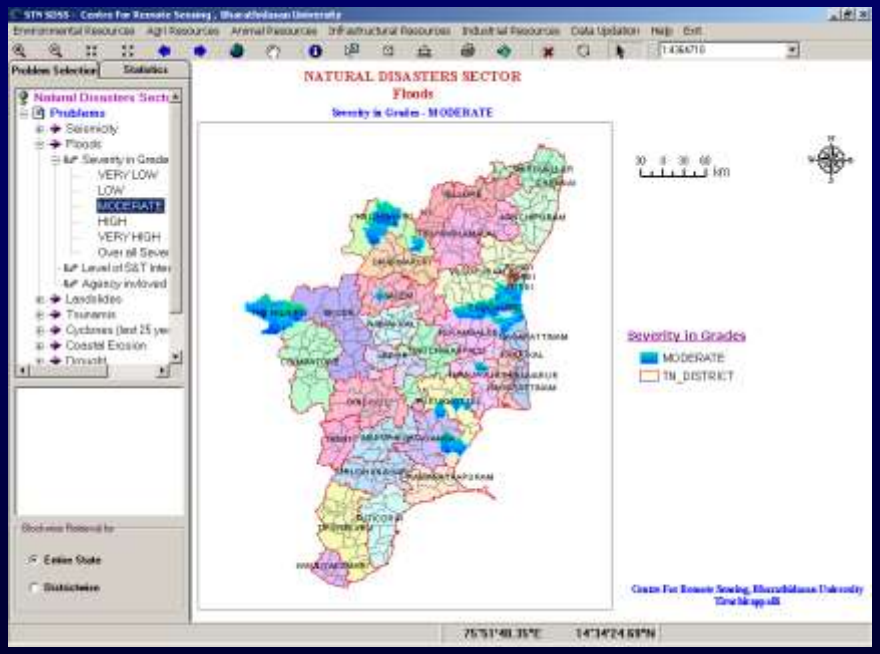
- Delineation of drainages and watersheds – from elevation raster data,
- Generation of Rainfall map – from rain gauge stations through websites
- Generation of Hydrological soil group map – from pre-existing data
- Generation of Landuse / Land cover map – from satellite data
- preparation of watershed wise calculation of all above parameters, and finally Runoff Estimation by applying the values into the formula, automatically.

GIS can provide Spatial Decision Support System (SDSS) for various developmental planning

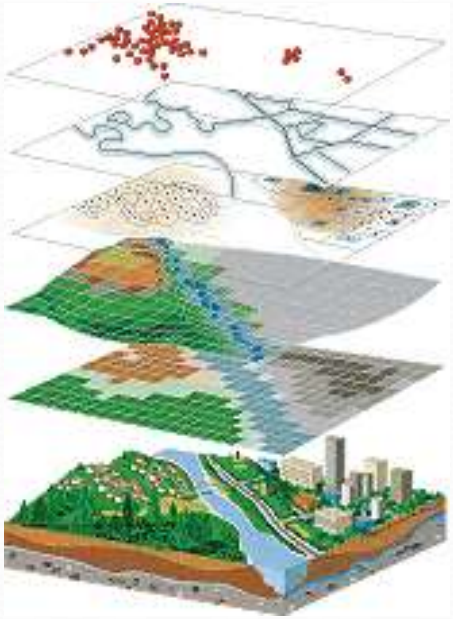
- ➔ User defined, query based, spatial data retrieval / map display
- ➔ Display of non spatial data by linking spatial data
- ➔ Data listing, map wrapping
- ➔ Programming for automated mapping, spatial database generation, spatial / tabular analysis, spatial modeling and suggestion of remedial measures / providing action plan map, etc.

NRDMS SDSS





Capability based definition of GIS



GIS is a computerised/digital system for

- capturing,
- editing,
- manipulating,
- systematically storing,
- analyzing,
- integrating,
- modeling,
- visualizing,
- sharing,
- retrieving, and
- representing/displaying

huge quantity of both ***spatial*** and associated ***attribute data*** with customization and automation capabilities.

How GIS differs from Related Systems

- **DBMS**—typical data base contains implicit but not explicit locational information
  - city, county, zip code, etc. but no geographical coordinates
  - is 100 N. High around the corner or across town from 200 E Main?
- **Automated Mapping (AM)** --primarily two-dimensional display devices
  - thematic mapping (choropleth, etc., such as SAS/GRAPH, DIDS, business mapping software) unable to relate different geographical layers (e.g zip codes and counties)
  - automated cartography--graphical design oriented; limited database ability
- **Facility Management (FM) systems**--
  - lack spatial analysis tools
- **CAD/CAM** (computer aided design/drafting)--primarily 3-D graphic creation (engineering design) & display systems
  - don't reference via geographic location
    - CAD sees the world as a 3-D cube, GIS as a 3-D sphere
  - limited (if any) database ability (especially for non-spatial data)
- **Scientific Visualization Systems**--sophisticated multi-dimensional graphics, but:
  - lack database support
  - lack two-dimensional spatial analysis tools

IMAGINE THE FOLLOWING SITUATIONS:

- My village has got very good fertile soil, man power, facilities, etc.,
  - but, there is less rain.
- Undulating hilly terrain covered with dense vegetation looks like a green carpet–a scenic beauty - is my area,
  - now-a-days affected frequently by forest fire, soil erosion, landslides and flash floods.
- In my very calm and wealthy village,
  - due to continuous burglary / robbery problem in many nights of a month and also during day time recently, most people are decided to shift their families.

Some… more …requirements.

- A Highway Patrol officer likes to know a feasible route to take the ambulance to the nearest hospital having a particular Life-saving-treatment Facility.
- A Forest Officer immediately wants to preserve the forest from a fast spreading tree disease.
- A Fireman has to reach the target within short time and to know about the water/other relevant facility therein nearby.
- A district level Planner (the Collector), plans to utilize the fund for development on priority basis.
- Election Commissioner, wants to identify/install possible booths based on the population, reacheability, etc.

Can GIS help in dealing the above important tasks?

- Resource Management
- Resource Conservation
- Resource Exploitation
- Resource Planning – Integrated and Sustainable manner
- Resource Estimation
- Resource Prospecting / Exploration

- Disaster Management
- Disaster Mitigation
- Disaster Prevention
- Disaster Inducing Parameter (s) Identification
- Disaster Vulnerability assessment
- Disaster Relief fund distribution / Rehabilitation
- Disaster Damage Assessment

All the tasks can be dealt together?

If yes, How? Using GIS.

TEN Important challenges in solving issues

In every case, we need to

- Collect relevant data
- Data preprocessing
- Prepare a genuine database
- Data Regrouping / Reclassification
- Analyze through comparison, integration, classification, prioritization, buffering, etc.
- Derive the fact / information
- Identify / understand the reasons – qualitative / quantitative – to develop model
- Prepare plans for implementation,
- Identify the ways & means for precise, efficient & economic implementation
- Implement properly in correct location
- Follow-up / monitor its functionality
- Update / Manage the mechanism to work properly.

All the above tasks can be easily done in GIS environment…

1.2 ADVANTAGES OF GIS

- 1. ALL DATA CAN BE STORED IN DIGITAL FORMATS IN COMPUTER
- 2. IT OCCUPIES LESS SPACE IN CONTRAST TO VERY LARGER MAPS AND DATA SHEETS
- 3. DATA / MAPS DOESN'T SHRINK OR DAMAGED
- 4. DOES NOT REQUIRE LARGE STORAGE CABINS
- 5. DATA SEARCHING AND RETRIEVAL IS EASY

6. PREFERENTIAL FILTERING OF SELECTIVE DATA

➔ FROM DIGITISED ROADS

* NATIONAL HIGHWAYS ALONE

* STATE HIGHWAYS ALONE

* DISTRICT ROADS ALONE

* VILLAGE ROADS ALONE, ETC.

7. MANIPULATION OF DATA

- NUMERICAL DATA CAN BE DISPLAYED IN CONTOURS (WATER LEVEL, WATER TABLE, WATER CHEMISTRY CONTOURS)
- IT CAN SHOW THE SINGLE THEME CONTINUOUS DATA IN DENSITY SLICED MODE
- IT CAN SHOW 3D DEM (Elevation) or DTM (Terrain)
- DATA CONVERTION (FORMATS)OF MULTI THEME DATA

8. SOME USES OF 3D MODELS

- GEOLOGIC MAPPING
- CREATING FLY-THROUGH VIEW
- CUT AND FILL CALCULATIONS-VOLUME
- COST ESTIMATION
- MAN POWER REQUIREMENT CALCULATION
- SLOPE MAP PREPARATION
- DRAINAGE & WATERSHED DELINEATION
- DRAINAGE ORDER & FLOW DIRECTION
- FLOW ACCUMULATION, ETC.

9. OVERLAYING OF MULTI THEMES

- LITHOLOGY
- SLOPE
- LINEAMENT
- LANDUSE / LAND COVER
- DRAINAGE …

OF THE SAME AREA CAN BE OVERLAID ONE OVER THE OTHER TO HAVE A SINGLE INTEGRATED DATA – TO DELINEATE LSVZ, SEVZ, ETC.

10. TREND SURFACE ANALYSIS

- 1ST ORDER TREND SURFACE
- 2ND ORDER
- 3RD ORDER , ETC.

For e.g.,

General slope of entire Tamil nadu is W to E -1st order

Northern TN - NE, southern TN – SE – 2nd order

Etc.,

11. TIME SERIES ANALYSIS

- CHANGE DETECTION
- PATTERN OF CHANGE
- MODELLING
- SIMULATION

TO UNDERSTAND THE FORTH COMING EVENT OR SCENARIO AND DETERMINE THE SAME TO HANDLE THE SITUATION EASILY

12. CUSTOMIZATION

- Generation of own interface – Based on the nature of our project work – self designed
- Series of multiple tasks can be done easily as a simple task through a single mouse–click event
- Continuous and repeated processing till it attains a good result

13. Decision Support Systems

- DSS with multiple models
- Quick and easy access of multiple datasets as maps
- Complex querying and data retrieval
- Spatial display of vast non-spatial data quickly
- User defined options
- Easy access by non-GIS users too

14. Process Automation

- Lineament extraction
- Drainage extraction
- Lineament / drainage classification
- Automated digitization, etc.

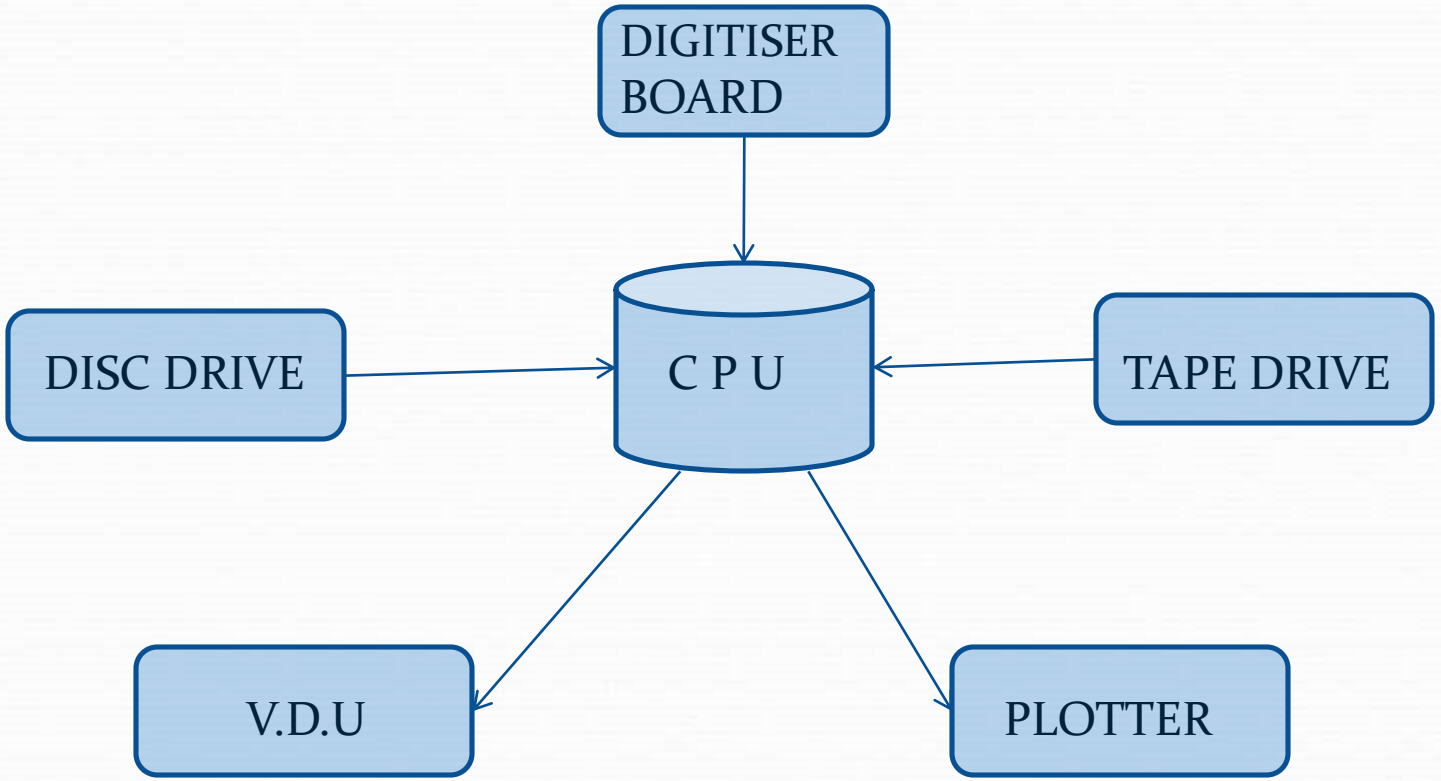
15. Internet / web GIS

- Open source GIS
- Non-Commercialisation
- Increase data usability
- Decrease work duplication
- Easy access by GIS community
- Quick and easy planning during crisis

1.3 COMPONENTS OF GIS

- 1.3.1 COMPUTER HARDWARE
- 1.3.2 APPLICATION SOFTWARE
- 1.3.3 PROPER ORGANISATAIONAL CONTEXT

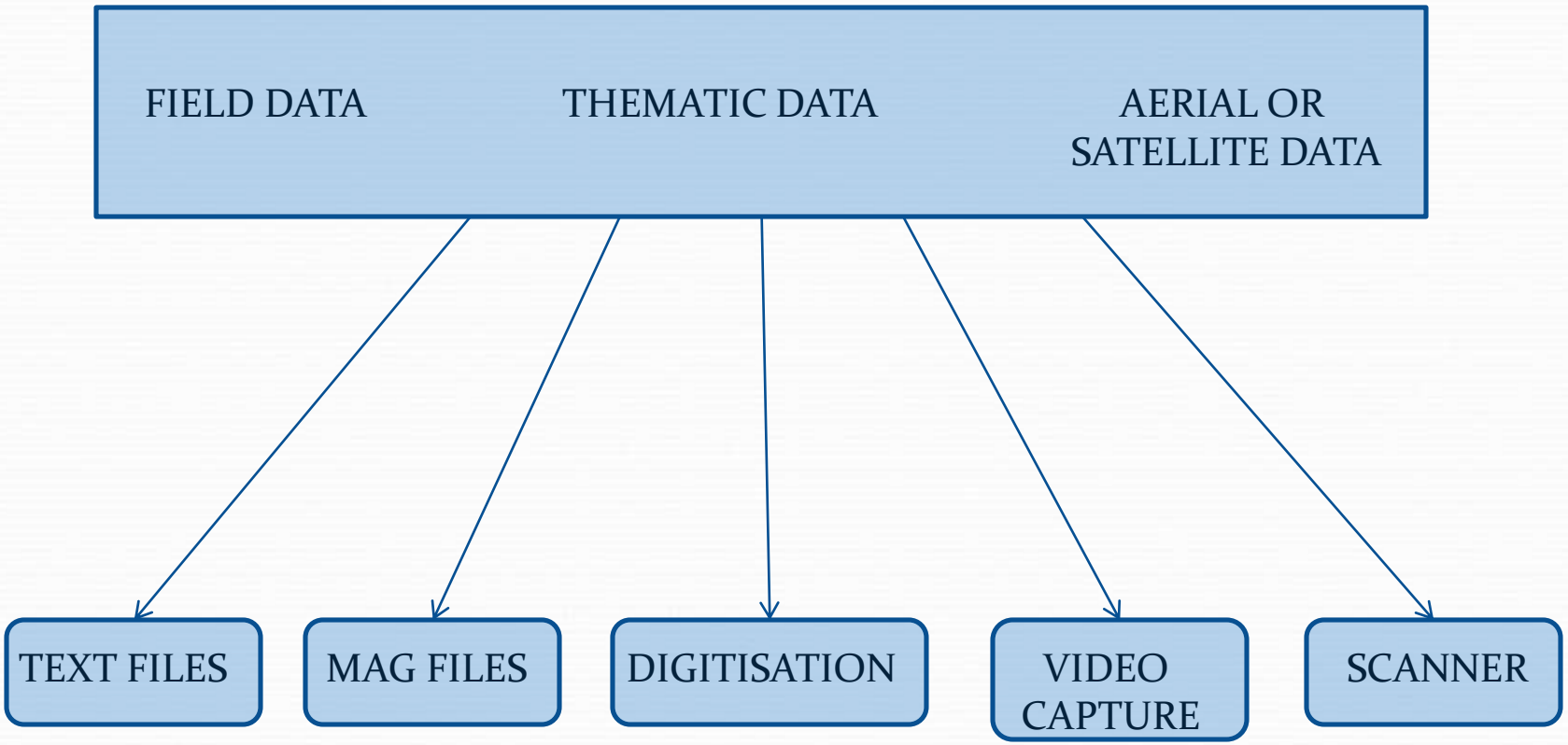
1.3.1 COMPUTER HARDWARE



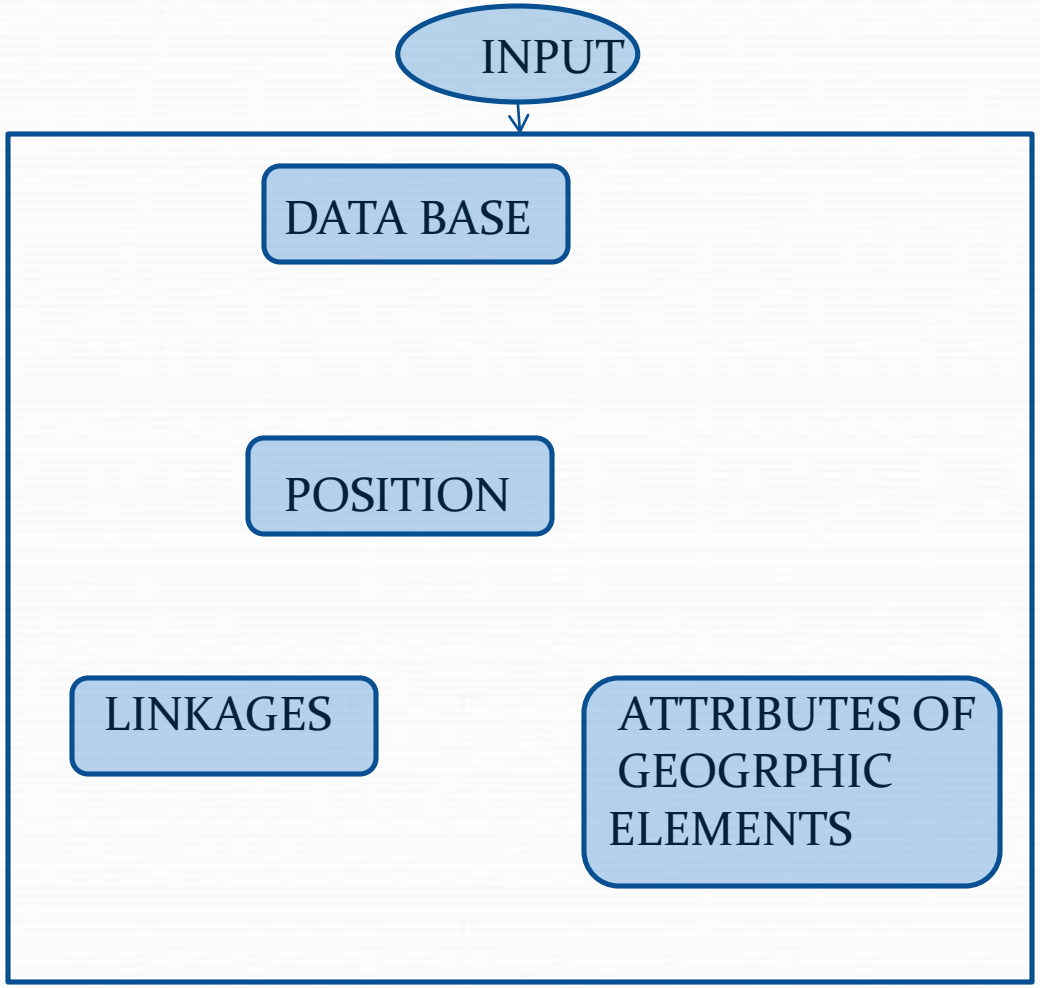
1.3.2 APPLICATION SOFTWARE

1. DATA INPUT AND VERIFICATION
2. DATA STORAGE AND DATABASE MANAGEMENT
3. DATA OUTPUT AND PRESENTATION
4. DATA TRANSFORMATION
5. INERACTION WITH USER

1.3.2.1 DATA INPUT



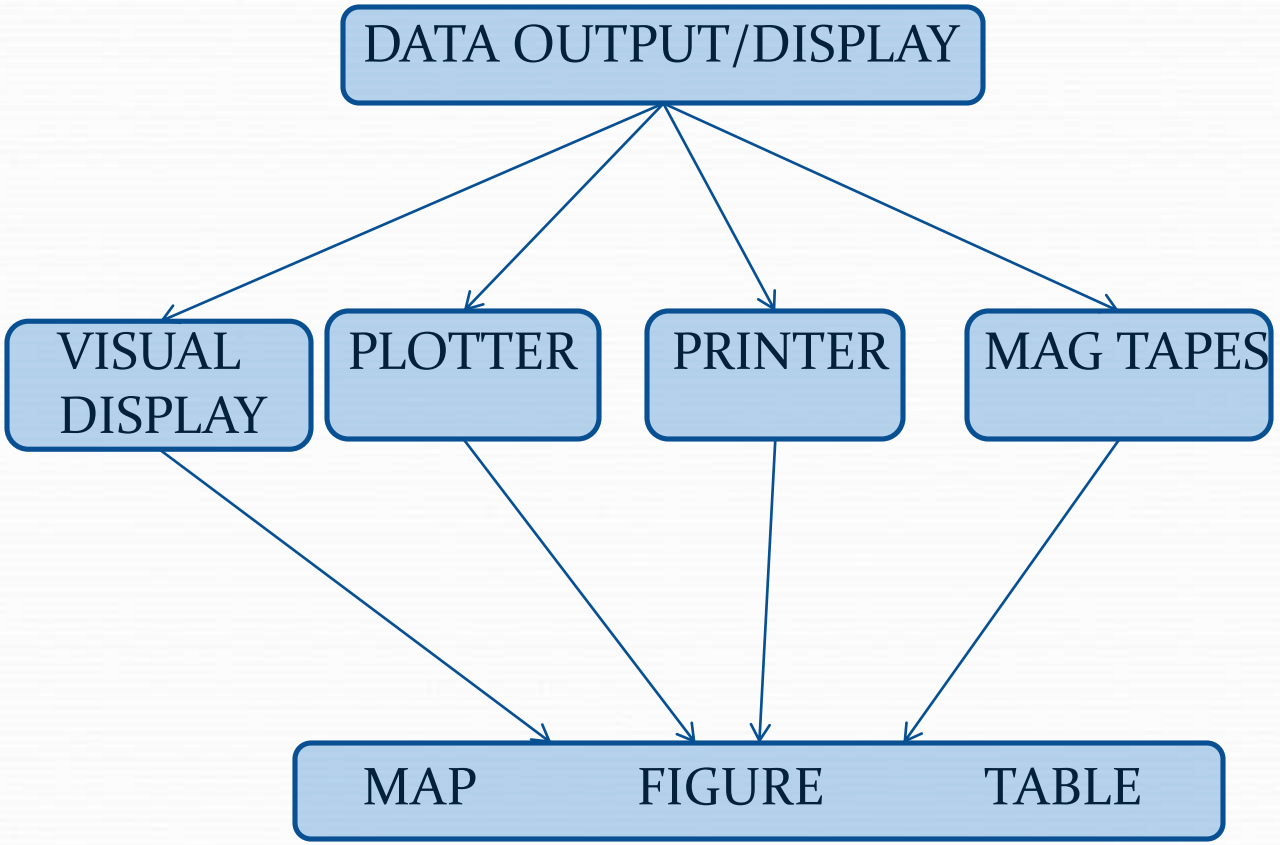
1.3.2.2 DATA STORAGE AND MANAGEMENT



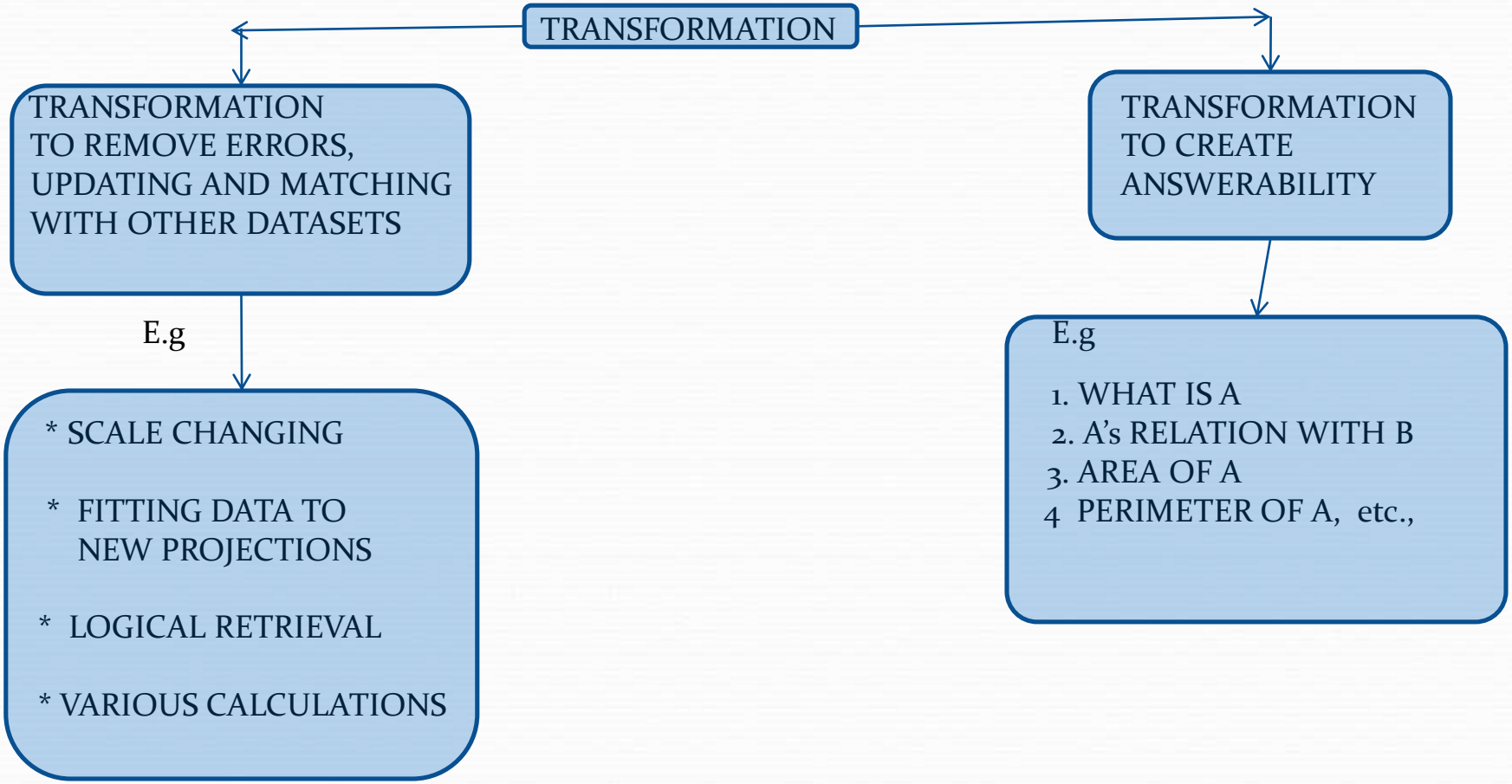
CALLED

D B M S

1.3.2.3 DATA OUTPUT AND DISPLAY MODULE



1.3.2.4 DATA TRANSFORMATION



1.3.2.4 DATA TRANSFORMATION … CONTD…

1. **UPDATION OF GROUND CONTROL POINTS**

   - **RAW DIGITAL DATA ARE EITHER IN DIGITIZER BOARD UNIT OR DISPLAY SCREEN UNIT**
   - **UPDATE THEIR COORDINATE VALUES WITH DECIMAL DEGREES**
     - **DD = (DEGREE + (MINUTE / 60) + (SECONDS / 3600))**

2. **PROJECT THEM TO THE REQUIRED PROJECTION SYSTEM**

DETAILS REQUIRED:

INPUT DATA DETAILS

- **PROJECTION TYPE – GEOGRAPHIC**
- **UNITS – DD**

OUTPUT DATA DETAILS REQUIRED (AFTER PROJECTION)

- **PROJECTION TYPE (EXPECTED) – POLYCONIC …**
- **UNITS – METERS**
- **CENTRAL MERIDIAN IN DMS (MAX – MIN LONGITUDE/2)**
- **LATTITUDE OF PROJECTIONS ORIGIN IN DMS**

1.3.2.4 DATA TRANSFORMATION … CONTD…

3. **TRANSFORMATION OF ALL DIGITAL SPATIAL DATA (using** IMPORT SPATIAL REFERENCES **option)**

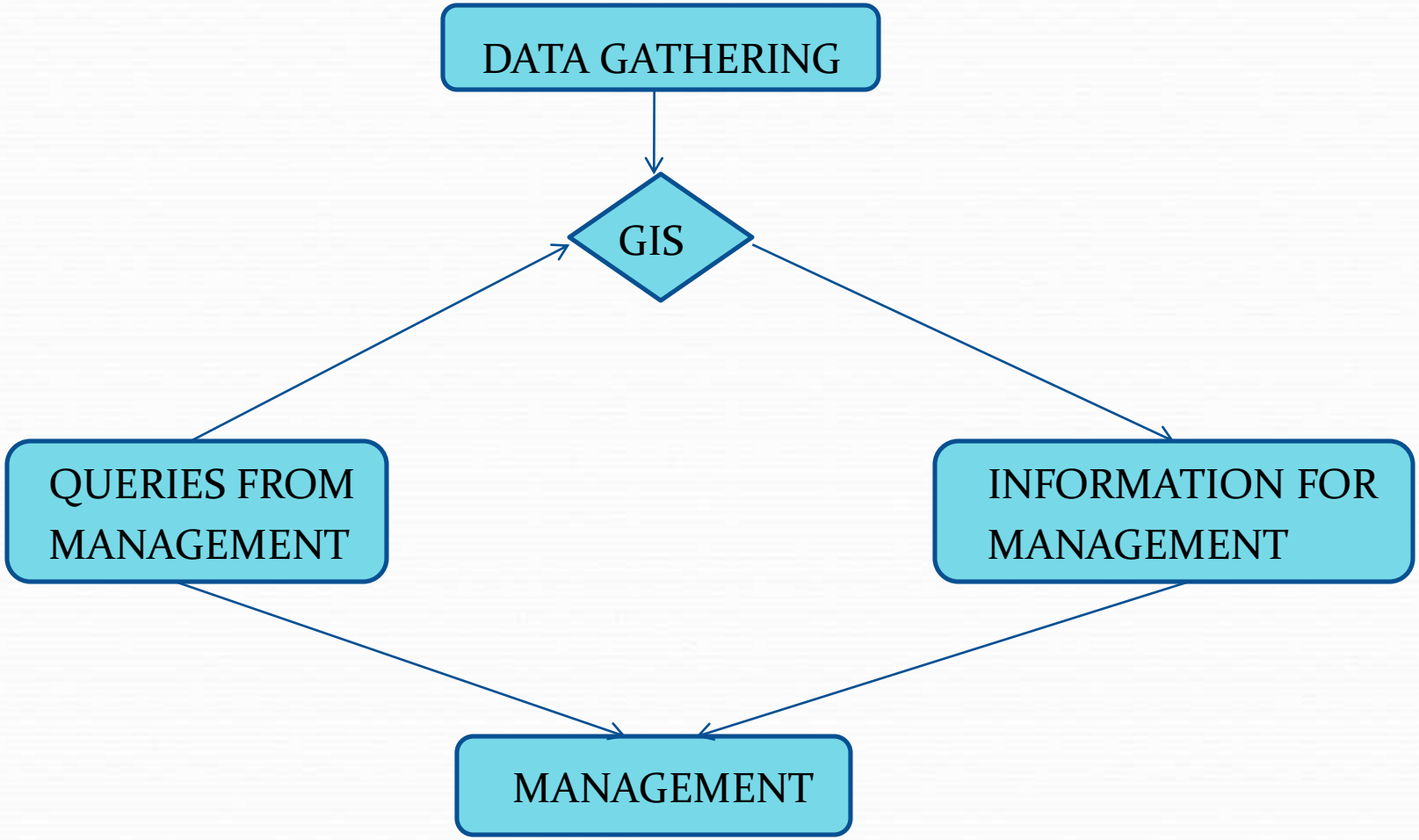
- **MAKING A COPY OF PROJECTED COORDINATES PERTAINING TO THE SAME STUDY AREA**

- **TRANSFORMATION OF ALL THEMES TO THE PROJECTED REAL WORLD COORDINATES USING "TRANSFORM" OPTION**

1.3.2.5 INTERACTION WITH USER

- GENERAL INTERACTION
- QUERY INPUT
- COMMANDS
- MENU DRIVEN SYSTEMS.

1.3.3 ORGANISATIONAL ASPECTS OF GIS



ORGANISATIONAL ASPECTS OF GIS ...contd...

1. **PROPER INTEGRATION OF DATA WITH GIS INVOLVES, THE PROPER DATA ORGANIZATION,**

For SPATIAL DATA SETS

- **RASTER - CONVERSION POSSIBLE**
- **VECTOR - -DO-**
  - Points
  - Lines
  - Polygons – For e.g. Continuous data - Surface & Subsuface ...
    Discontinuous data

ORGANISATIONAL ASPECTS OF GIS ...contd...

- **CONTINUOUS DATA**
  - Surface
    - **SLOPE**
      - **DEGREE / RADIANCE / PERCENT**
      - **LENGTH**
      - **ASPECT / DIRECTION**
        - **CONSEQUENT**
        - **SUBSEQUENT**
        - **OBSEQUENT**
      - **GEOMETRY**
        - **PLAIN**
        - **CONVEX**
        - **CONCAVE**
      - **SURFACE COVER**
        - **ACTIVE**
        - **PASSIVE**
  - Subsuface
    - **WATER LEVEL**
    - **SSG**
      - **TTS**
      - **TWZ**
      - **TFZ**
      - **DBR**
    - **AQ.CHARC**
      - **T**
      - **K**
      - **S**
      - **SY**

- **DISCONTINUOUS / CHOROPLETH DATA**
  - **LITHOLOGY**
    - **IGNEOUS**
    - **METAMORPHIC**
    - **SEDIMENTARY**
  - **GEOMORPHOLOGY, ETC.**

COVER PARTS OF SURFACE

For NON-SPATIAL DATA SETS

ORGANISE ATTRIBUTES FOR PROPER LINKAGE WITH SPATIAL DATA

- **FOR SPATIAL DISPLAY OF NON-SPATIAL DATA**
  - **Provide unique identifier**

ORGANISATIONAL ASPECTS OF GIS ...contd...

2. DATA ENTRY – STRUCTURE TYPE
3. DERIVATION OF INFORMATION
4. DATA RETRIVAL - QUERY BUILDING
5. MANAGEMENT – DATA UPDATION