Chapter 2

Objectives, Database and Methodology

2.1 Objectives

The following objectives have been set for the proposed research to be carried out

- To study the pattern of landuse/landcover change in the study area
- To study the pattern of soil erosion in the study area
- To examine the impact of the Dhansiri river flood and erosion in the watershed and its adjoining areas including the Kaziranga National Park
- To formulate a sustainable management plan for the natural resources of the basin including its forests
- To develop an integrated watershed management strategy for the Dhansiri watershed (South)

2.2 Database used in the Study

To fulfill the objectives the database has been derived from both primary and secondary sources.

Primary Data Sources: The primary data sources include the data collected by the researcher in the field and those generated based on geoinformatics techniques

***Secondary Data Sources*:** The secondary sources include satellite imageries, published maps and reports of Government departments and other published literatures.

The database thus derived has been categorized as

- Remotely sensed (spatial) data
- Collateral data (spatial and non-spatial)

A brief description of the entire database used at different stage of the research is given below:

2.2.1 *Remotely sensed (spatial) data*

a) LANDSAT-ETM:

LANDSAT-ETM (Multispectral) imagery of 30m spatial resolution of 1999 data was used for visual interpretation of the landuse/landcover of the study area. The American series of LANDSAT satellites has provided high quality multispectral data since 1972. Over the years, millions of scenes have been acquired to form a worldwide archive of earth observation data. LANDSAT 7 was launched successfully on 15th April 1999 and has enhanced features, including a 15 metre panchromatic band. It is an ideal, multipurpose, cost effective tool for a huge range of applications. LANDSAT 1-3 carried MSS (multi spectral scanner) sensor and a RBV (return beam vidicon). LANDSAT 4 and 5 launched in 1982 and 1984 respectively have a MSS and TM (thematic mapper) sensor on board. LANDSAT 6 unfortunately suffered an early demise. The satellite orbits at an altitude of 705 km. A full size LANDSAT MSS or TM scene covers an area of approximately 185 km by 175 km. The swath of the sensor restricts the maximum width and the continuous orbit data is then divided into normal scenes. Digital products include raw and system corrected data. The ETM+ sensor on LANDSAT 7 has a number of enhanced features, including a new panchromatic band with 15m spatial resolution, co-registered with the multispectral bands and thermal infrared band 6 has increased resolution from 120m to 60m and now has two gain settings and world-wide data in which the solid state tape recorder can collect 100 images per day from anywhere in the world. A summary of the band information is contained in the table below:

Table 2.1: LANDSAT data provision

Band number	Band width	Spatial resolution
Band1	0.45-0.52m (blue)	30m
Band2	0.52-0.60m (green)	30m
Band3	0.63-0.69m(red)	30m
Band4	0.75-0.90m (near infra-red)	30m
Band5	1.55-1.75m(infra-red)	30m
Band6	10.4-12.50m(thermal infrared)	60m
Band7	2.08-2.35m(near infrared)	30m
Band8	0.52-0.90m (green-near infrared)	15m

b) RESOURCESAT-I LISS III:

RESOURCESAT-I LISS III (also known as IRS-P6) (http://en.wikipedia.org/wiki/Resourcesat-1) is an advanced remote sensing satellite built by Indian Space Research Organization. The tenth satellite of ISRO in IRS series, RESOURCESAT-1 is intended to not only continue the remote sensing data services provided by IRS-1C and IRS-1D, both of which have far outlived their designed mission lives, but also vastly enhance the data quality. It was launched into an 817 km high polar sun synchronous orbit by the eighth flight of India's Polar Satellite Launch Vehicle (PSLV-C5). RESOURCESAT-1 carries three cameras similar to those of IRS-1C and IRS-1D but with vastly improved spatial resolutions - a high resolution Linear Imaging and Self Scanning system (LISS-4) operating in three spectral bands in the Visible and Near Infrared Region (VNIR) with 5.8 metre spatial resolution and steerable up to 26 degrees across track to obtain

stereoscopic imagery and achieve five day revisit capability; a medium resolution LISS-3 operating in three spectral bands in VNIR and one in Short Wave Infrared (SWIR) band with 23.5 metre spatial resolution; and an Advanced Wide Field Sensor (AWiFS) operating in three spectral bands in VNIR and one band in SWIR with 56 metre spatial resolution.

Table 2.2: LISS 3 data provision

Spectral Band	Wavelength	Resolution
Band 1	0.52 - 0.59 µm	24 m
Band 2	0.62 - 0.68 µm	24 m
Band 3	0.77 - 0.86 µm	24 m
Band 4	1.55 - 1.70 µm	24 m

c) ASTER DEM:

ASTER DEM (Multispectral) imagery of 15m spatial resolution of 2003 is used in the study. ASTER is the Advanced Space borne Thermal Emission and Reflection Radiometer, a multi-spectral sensor on board one of NASA's Earth Observation System satellites, Terra, which was launched in 1999. ASTER obtains high resolution (15 to 90 sq. m per pixel) images of the Earth in 14 different wavelengths of the electromagnetic spectrum. There are three groups of channels: three recording visible and near infrared radiation (VNIR), at a spatial resolution of 15m; six recording portions of shortwave infrared radiation (SWIR) at a spatial resolution of 30 m and five recording thermal infrared radiation (TIR) at a resolution of 90 m.

ASTER swath width is 60km (each scene is 60X60km) which makes it useful for regional mapping.

Table 2.3: ASTER DEM data provision

Band Number	Band Width	Spatial Resolution
Band1	0.52-0.60(green)	15m
Band2	0.63-0.69(red)	15m
Band3	0.76-0.86(near IR)	15m
Band4	1.60-1.70(SWIR)	30m
Band 5	2.145-2.185(SWIR)	30m
Band6	2.185-2.225(SWIR)	30m
Band7	2.235-2.285(SWIR)	30m
Band8	2.295-2.365(SWIR)	30m
Band9	2.36-2.43(SWIR)	30m
Band10	8.125-8.475(TIR)	90m
Band11	8.475-8.825(TIR)	90m
Band12	8.925-9.275(TIR)	90m
Band13	10.25-10.95(TIR)	90m
Band14	10.95-11.65(TIR)	90m

2.2.2 Collateral (Spatial and Non Spatial) Data:

1. Survey of India Topographic Sheets: 83 (F/6, F/7, F/10, F/11, F/12, F/13, F/14, F/15, F /16); 83 (G/9, G/13); 83(J/1, J/2, J/3, J/4); 83 (K/1, K/5) of 1:50,000 Scale are consulted for baseline information of the study area. These maps were reprinted in 1970.

2. Ten years monthly rainfall data for the period 2001 to 2010 are collected from the Regional Meteorological Centre, Guwahati
3. Soil type have been collected from NBSSLUP, Regional Centre, Jorhat
4. Geology map of Assam prepared by Geological Survey of India is downloaded from internet
5. Isohyetal Map from Dept. of Environmental Science, Gauhati University
6. Revenue Village Boundary map of Golaghat District collected from ASTEC
7. Flood Inundation maps downloaded from the website of Dartmount Flood Observatory and Bhuvan
8. Daily Discharge Data of the Dhansiri (S) River for the years 1998, 1999 and 2000 and High Flood Level at Numaligarh site for the period 1982-2005 are collected from Water Resource Department, Govt. of Assam and Brahmaputra Board, Assam
9. Published literatures, reports, research theses, Gauhati University are consulted for other collateral data
10. Population information is collected from Brahmaputra Board, Assam and Statistical Handbook of Assam, 2013

2.3 Methodology

An appropriate methodology has been formulated after conducting a thorough literature survey to fulfill the above mentioned objectives using the database. Both spatial technology and conventional technique has been used in the methodology to carry out the research on the chosen theme.

The research theme has been designed through stages so as to reach the objectives. The stages designed for carrying out the research include:

- Preparatory activities
- Data collection and field survey
- Interpretation and Analysis

2.3.1 Preparatory Activities

In the first stage study objectives have been formulated and some literature related to subject has been studied . The aim of this preparatory study was to formulate a set of study objectives.

2.3.2 Data Collection and Field Survey

In this stage remotely sensed data and other collateral data comprising satellite imageries, SOI topographical sheets and other thematic data on the drainage, geology, soil etc. of the study area has been collected from different state government agencies and internet. . A reconnaissance field survey to the study area was also conducted. Soil samples have also been collected during field survey of the study area.

2.3.3 Interpretation and Analysis

This is a very crucial stage of research. The primary data set as well as secondary data set has to be analyzed separately and then integrated them to arrive at suggestions and solutions for the set objectives. Finally the interpreted data can be applied to decision making process. The data generated during the period of work through field survey as well as secondary sources has been analyzed using spatial techniques that includes remote sensing , GIS and GPS in the mapping of different themes and their analysis and integration .

Remote Sensing : Remote sensing in the simplest words means obtaining information about an object without being in touch with the object . It 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.

It has three essential components:

- The signal (from an object or phenomenon)
- The sensor (from a platform)
- The processing (acquiring information about the object or the phenomenon after analysis of the signal received by the sensor with the help of computer based software)

It has the following advantages:

- Synoptic view
- Time efficiency
- Cost effectiveness
- Multispectral nature of data
- Repetitive coverage
- Digital data set
- Spatial resolution
- Spectral resolution
- Data from inaccessible areas

Geographical Information System (GIS) : GIS is a tool for handling geographic (spatial and descriptive) data . It is an organized collection of computer hardware , software , geographic data and the personnel designed to efficiently capture , store , retrieve , update , manipulate , analyze and display all forms of geographically referenced information according to the user defined specifications . We can visualize the real world as consisting of many facets such as topography ,

landuse, landcover , soils , crops , forests , water bodies , infrastructure , administrative units and so on .

Data on different aspects of these facets are stored in the GIS files on different data layers. Spatial data used in GIS deal with location , shape and relationship among different features , whereas descriptive data deal with the characteristics of the features. A GIS links spatial data with descriptive information about a particular feature on a map . The information are stored as attributes of the geographically represented features. A GIS can also use the stored attributes to compute new information about the map features. Hence GIS is looked upon as a tool to assist in decision making and management of attributes that need to be analyzed separately.

Global Positioning System (GPS) : GPS is a global monitoring tool for two basic purposes

- To locate a position
- To help in navigation
- It also aids in ground truthing

For proper interpretation and analysis of the database specific methodologies has been designed to complete the works mentioned below:

- Assessment of landuse/ landcover change in the study area for two time periods
- Nature of channel change and bank erosion
- Evaluation of geotechnical properties of soil samples
- Soil Erosion Risk Zone Mapping
- Problem of Flood and Inundation Mapping

The database thus collected for the study is brought under GIS platform for their evaluation and interpretation and the soil samples are investigated in laboratory. These have been achieved through the following steps:

Preprocessing and Extraction of Spatial Information of the Database:

Preprocessing of datasets involves scanning of the all the Survey of India Topographic sheets and other thematic maps of the study area and its geometric correction using Geographic Co-ordinate System. These geo-referenced toposheets and maps are then extracted and mosaiced to get a single image. These images are then reprojected using Universal Transverse Mercator (UTM) with World Geodetic System (WGS) 1984 datum and 46 North Zone. The geo-referencing and reprojection of the toposheets and maps are done in ERDAS Imagine 9.1 software. The different layers of satellite imageries downloaded from website with appropriate projection parameters are stacked in ERDAS Imagine 9.1 and then extracted and mosaiced to get a single image.

After geometric correction of all the collected toposheets, satellite imageries and other thematic maps are done, spatial information from them are extracted and stored as attributes in GIS. This is done in ArcGIS 9.2 software.

Spatial information from the satellite imageries are extracted to prepare the landuse/landcover maps of 1999 and 2008 of the study area using visual interpretation technique. The information on different landuse/landcover types is stored as attributes in GIS platform. The main river channel is also digitized from the satellite imageries of 1999 and 2008 in GIS. After digitization of the main drainage channel the Sinuosity Index of the Dhansiri River Channel for years 1999 and 2008 are evaluated. It has been done by taking continuous points all along the drainage channel and using the formulae

CL/VL where CL represents channel length and VL represents valley length. Bank erosion has been evaluated by overlaying the river layer of 2008 on 1999.

NDVI maps of years 2008 and 1999 are also generated after proper radiometric correction of the satellite imageries. Similarly drainage channels are digitized from the topographic sheets to prepare a drainage network map.

A Digital Elevation Model (DEM) of the Dhansiri watershed has been clipped from the Aster DEM to prepare the slope map of the study area.

Likewise all the other maps collected in relation to the research theme are digitized and spatial information are stored as attribute in GIS. The basic thematic layers of the study area that are generated in Arc GIS 9.2 software include the following:

- Landuse/Landcover map of 1999
- Landuse/Landcover map 2008
- NDVI map
- Drainage Network map
- Slope map
- Isohyetal map
- Geology map
- Soil type map
- Rainfall map
- Soil Erosion map
- Flood Inundation map
- Village Boundary map of Golaghat District that fall within the study area

Soil sampling and Laboratory analysis:

Soil Samples are collected from the study area during field survey to determine the Grain Size Distribution, Unit weight and certain geotechnical properties which include Atterberg's limit namely- Liquid Limit, Plastic Limit and Plasticity Index of the samples and their classification in order to correlate them with the erosion susceptibility. Chemical test of the soil samples include estimation of organic matter and pH value. Fifteen numbers of soil samples were collected from different locations at Golaghat and Karbi Anglong districts of Assam. The methodology of soil sample analysis is described below:

- *Determination of Grain size distribution*- Grain size distribution analysis was done as per methods prescribed by IS: 2720 (Part 4) – 1985. About 200gm of oven dried soil samples were taken for sieve analysis. The percentage of soil retained on each sieve was calculated on the basis of total mass of sample taken and from these results the percentage passing through each of the sieves was calculated. Sedimentation method was used for the soil portion passing through 75 micron sieves.
- *Determination of Liquid Limit and Plastic Limit*: Liquid limit, plastic limit determined as per methods prescribed by IS: 2720 (Part 5) – 1985 by Cone Penetration method.
  - *Liquid Limit*- About 150gm of soil sample was taken and worked well into a paste with addition of distilled water. The wet soil paste was then transferred to the cylindrical cup of cone penetrometer apparatus. The vertical clamped was then released allowing the cone to penetrate into the soil paste under its own weight. The penetration in the range of 14 to 28mm of the cone after 5

seconds was noted. A graph representing water content and cone penetration is prepared. The best fitting straight line was then drawn. The moisture content corresponding to 20mm was taken as the liquid limit of the soil and expressed to the nearest first decimal place.

- ❖ *Plastic Limit*- The soil sample was mixed thoroughly with distilled water in an evaporating dish and a ball was formed with about 8 gm of soil and rolled between the fingers and a glass plate. The rolling was done till the threads were of 3 mm diameter with crack formation and then the samples were kept in oven for determination of moisture content. This moisture content is the plastic limit of the soil sample and expressed in percentage in a whole number.

- ➢ *Natural moisture content of soil*: It was determined as per IS: 2720 (Part II) – 1973. In-situ density and dry-density were also determined. In-situ water content of soil sample was determined by oven dried method. This method covers the determination of water content of soils and expressed as a percentage of the oven dry weight. About 25g of soil sample was taken for this test.
- ➢ *Determination of organic material in soil by wet combustion method done as per IS: 2720 (Part 22) – 1972:* 10gm of sample (<2mm size) was dried at 105 degree centigrade for approximately 18 h and weighted (A). The crucible containing the sample was placed in a muffle furnace and temperature was increased slowly (2 degree centigrade/min) to 430 degree centigrade and kept for overnight. The crucible was removed and cooled in a desiccator and reweighted (B).

  Calculation: % loss on ignition (430 degree centigrade) = A-B/A*100

The organic matter content influences many soil properties like capacity of soil to supply N,P,S and trace elements; infiltration and retention of water, degree of aggregation and overall soil structure; cation exchange capacity; soil color.

Preparation of Soil Erosion Risk Zoning Map:

A Soil Erosion Hazard map is prepared following Analytical Hierarchical Process (AHP) developed by Satty (1980). The AHP is a psychophysical theory of measurement which means that judgments about subjective feelings and understanding are essentially not very different and depend on judgments about the physical world in which we acquire our experience and understanding. It uses Multi-criteria evaluation (MCE) techniques that are numerical algorithms. These define the suitability of a particular solution with some mathematical or logical means of determining trade-offs when conflict arise on the basis of the input criteria and weights together (Heydon et. al., 2003). In this technique, the data layers are assigned 'weight' to reflect their relative importance in soil erosion. The process is illustrated in detail in Chapter 5 while discussing the results obtained on preparation of the Soil Erosion Risk Zone Map.

To prepare the map, six thematic layers prepared in GIS have been used with different weights assigned to the layers. The six thematic layers that are used for preparing the Soil Erosion Risk Zoning Map include:

a. Slope Map
b. Geology Map
c. NDVI Map
d. Soil Type Map
e. Landuse/Landcover Map
f. Rainfall Map

The Soil Erosion Risk Zone map is then overlaid on the village boundary layer of Golaghat District and villages falling under different soil erosion hazard zones are identified.

Problem of Flood and Preparation of Flood Inundation Map:

The Flood Inundation Map has been prepared from MODIS Data available in the Dartmount Flood Observatory website and inundation maps of different years downloaded from Bhuvan website. This map has been overlaid on the village boundary map of Golaghat district and the villages falling under different inundation zones has been identified for effective management strategies. The area under different inundation risk zones is calculated and is presented graphically.

High Flood Level (HFL) data from 1982 to 2005 collected from Brahmaputra Board has been used for Flood Frequency analysis using Log-Pearson Type III method Data on annual damage to cropped area and total area affected by flood inundation for some years from 1954-1993 and 1977-2000 respectively for which the data is available are collected from Brahmaputra Board, Assam and graphs of the same are prepared. Data on flood damage caused due to flooding in the Golaghat district collected from the revenue circle office for the period from 2004-2012 is presented in tabular form.