CHAPTER 3. STUDY AREA AND EQUIPMENT USED

3.1 Study Area

2/3rd of the Indian population depends on agriculture for their living, and therefore land degradation is progressively turning into a noteworthy concern for India. Various arrangements and projects have been started over the last two to three decades to address this problem; however, the outcomes are small. Analysis of the causes of land degradation and their extents are fundamental to design suitable policies to overcome the degradation problem.

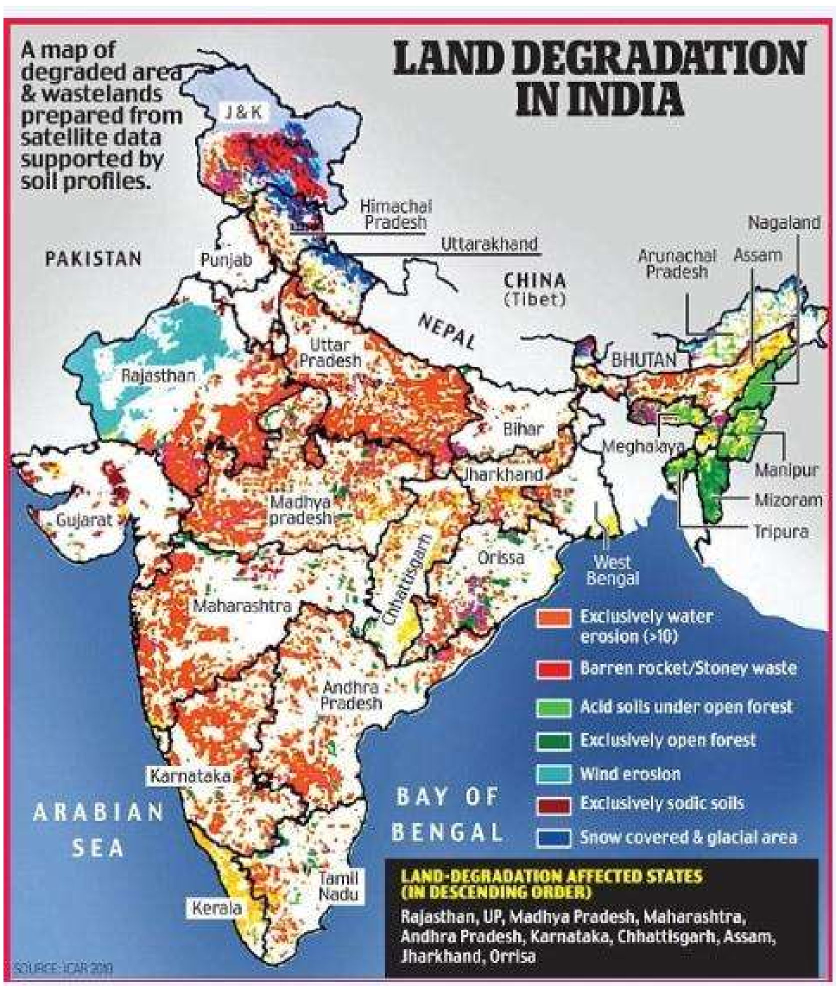

Figure 3.1 Land Degradation Hotspots of India (Mythili and Goedecke, 2016)

It is officially estimated that 44 % of Indian land is degraded. From Figure 3.1 which shows the land degradation hotspots of India. It is clear that the land of Uttar Pradesh, Bihar, MP, West Bengal, and Orissa are getting degraded. So in this research, the part of one of the most land degraded the state of India that is South Eastern part of U.P. is taken as a study area.

River Ganga is one of the largest rivers in Asia. Its basin lies in many countries with an area of more than ten lakh square kilometers. In India, the basin covers ten major states including UP, Uttarakhand, and Bihar with an area of about eight lakh square kilometer. The extent of the Ganga basin lies between 73°2’ to 89°5’ E and 21°6’ to 31°21’N.

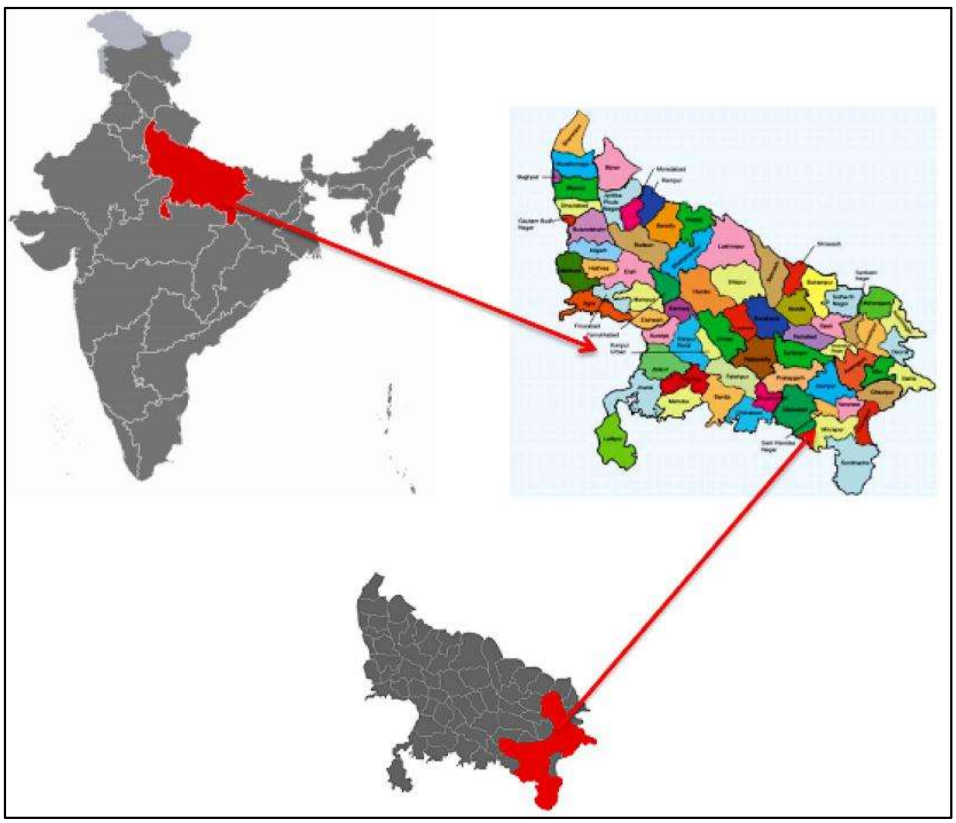

Figure 3.2 Location of The Study Area.

This study, have covered the part of Ganga basin which is from Allahabad to Ballia of Uttar Pradesh. The extent of the study area lies between 80°3' E to 84°49' E and 24°3'N to 26°56' N. The total area is about 22000 km sq. Figure 3.2 shows the location of the study area. The watershed is divided into 17 sub-watersheds (Shown in Figure 3.3) and then the soil erosion-prone areas were determined, and prioritization is done (explained in chapter 4 & 5).

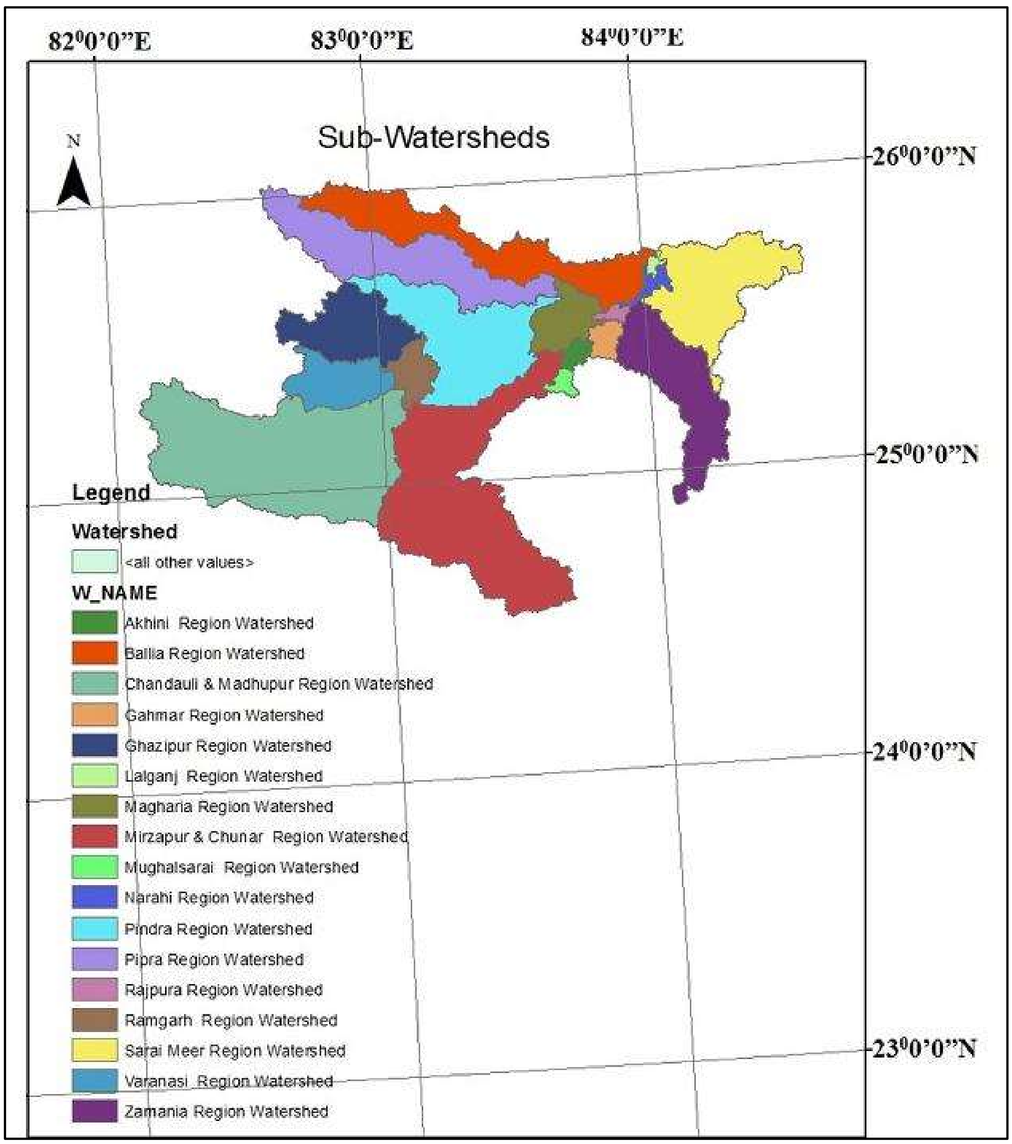

Figure 3.3 Subwatersheds for study area (for chapter 4 and 5)

After prioritization, the study area was focused on soil erosion-prone areas for further modeling and analysis. Hence the study area for modeling and analysis (chapter 6 to chapter 9) is a part of Ganga basin situated in the south-east of Uttar Pradesh state as shown in Figure 3.4, and it covers five significant districts Varanasi, Mirzapur, Balia, Babatpur, and Ghazipur.

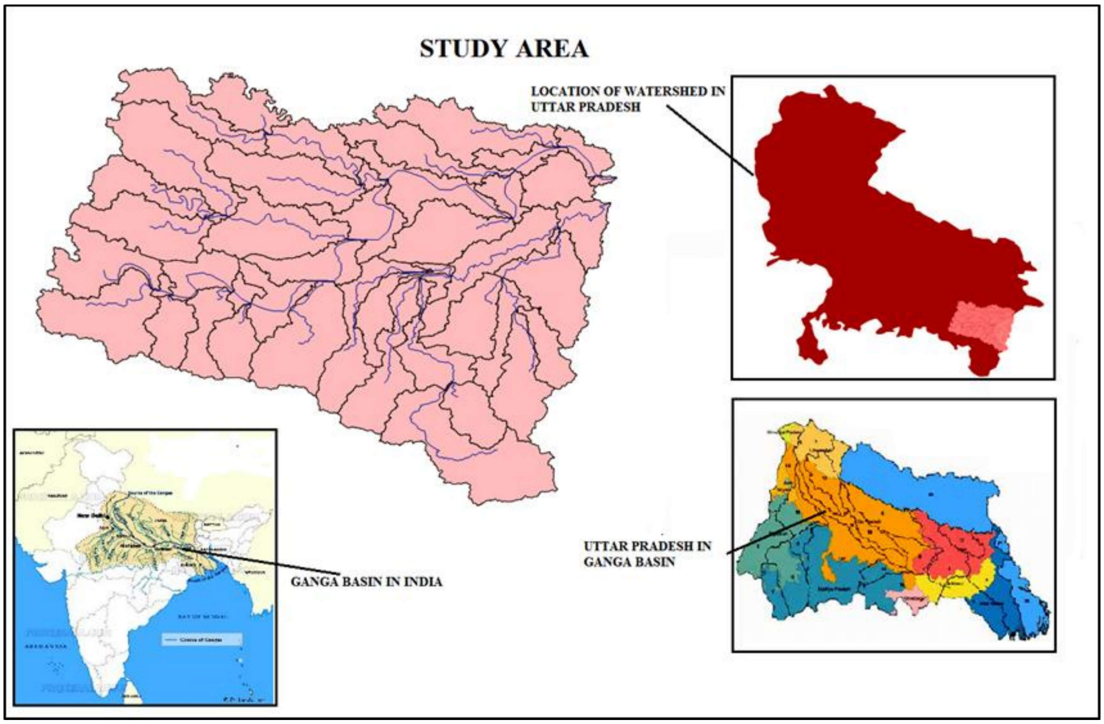

Figure 3.4 Study Area (for chapter 6 to 9).

The latitude and longitude of the study area lie between 82°22'7.511"E, 25°51'47.728"N and 83°38'3.508"E, 24°33'16.402"N. the total area of the watershed is 15621.612 km2. After watershed delineation of this study area, the watershed was divided into 46 sub-watersheds as shown in Figure 3.5.

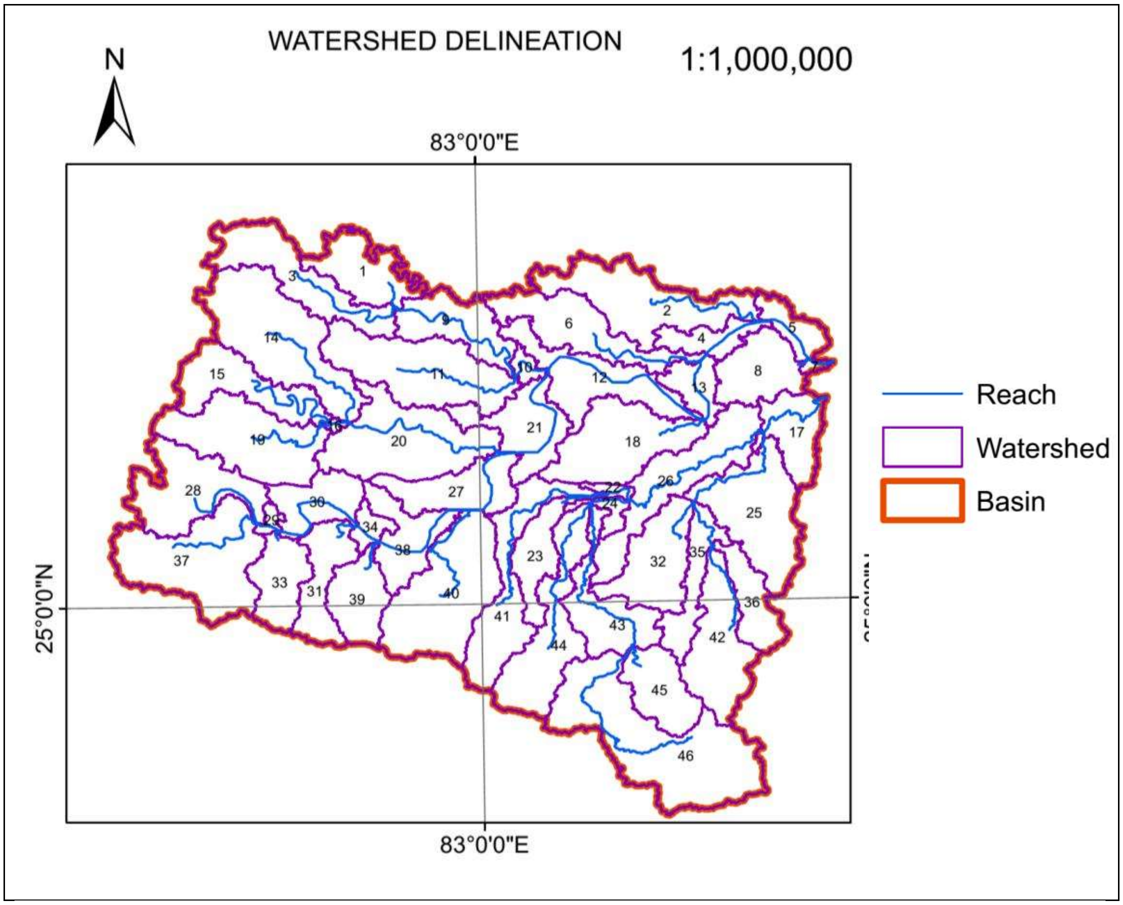

Figure 3.5 46 Sub-watersheds of the study area for chapter 6 to 9

3.2 Data Used

There are two types of data required in the present study for modeling Spatial data (DEM, LULC map, Soil map) and Temporal data (Hydrological and climate data) . For temporal data, 20 years of daily climatic data were procured from Indian metrological department (IMD) from the year 1996 to 2015. The data consist of daily rainfall data solar, radiation data, minimum and maximum temperature data, relative humidity data and wind speed data. Table 3.1 shows the details of the raw data used in the research.

Table 3.1. Details of raw data used for modeling

Data	**Location**	**Period of Record**	**Organization**	**Primary Use**
Rainfall and Temperature Data	Varanasi Mirzapur Ballia Babatpur Gazipur	1961 to 2015	IMD Pune	Model Input
Satellite Imagery Landsat 5 and 8	82°1'52.439"E 26°2'7.842"N to 83°55'10.63"E 24°22'53.034"N	June 2004 and November 2015	USGS	For creating LULC map required Model Input
DEM	82°1'52.439"E 26°2'7.842"N to 83°55'10.63"E 24°22'53.034"N	Unknown	USGS	Watershed Delineation
Soil Data	Uttar Pradesh	Unknown	NBSSLUP	For creating Soil map required Model Input
Observed sediment yield data	Varanasi	19960-2015	CWC Varanasi	For calibration and validation

Note: IMD is Indian Meteorological Department, USGS is United States Geological Survey, and NBSS is National Bureau of Soil Survey and Land Use Planning, CWC is Central Water Commission

3.3 Data Preprocessing

3.3.1 Spatial Data

Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (DEM) data of 30 m resolution was downloaded from the USGS earth explorer website. For covering the whole area, two DEM files were required covering the Latitude Longitude from 82°1'52.439"E 26°2'7.842"N to 83°55'10.63"E 24°22'53.034"N. For using these DEM files in research first the DEM files were checked for having null values. If the null values are present in the DEM, we need to process these null values using the Fill function of ArcGIS 10.1 software. After correcting the null values both the DEM files are needed to be mosaicked to be used as a single input. So these Dem files were mosaicked using image processing tool Erdas Imagine.

Satellite images were required for preparing LULC maps. For this Landsat 8 images of row -path 141-42, 141-43, 142-42,141-43, 143-42, and 143-43 were procured from USGS website. These image files were then stacked first using an image processing tool Erdas imagine. Then the image classification was done as explained in section 3.3.3 and 3.3.4.

The soil data was procured from NBSS. The data was then validated using sieve analysis and lab testing. For this, the soil samples were taken from different parts of the study area as shown in Figure 3.6.

Figure 3.6 Soil data validation

3.3.2 Temporal Data

Daily weather data from 1996-2015 was procured from IMD, Pune. The data were collected for five stations namely Varanasi, Mirzapur, Babatpur, Balia, and Ghazipur. The Consistency of the data was checked using a double mass curve method.

3.4 Technologies Used.

3.4.1 Remote Sensing

Remote sensing is the way of detecting and monitoring the physical attributes of an area by estimating its reflected and emitted radiations at a distance from the targeted area. Unique cameras gather remotely sensed images of the earth which enables analysts to sense things about the Earth; a few precedents are: - Cameras on satellite and planes take pictures of vast territories on the Earth's surface enabling us to see substantially more than we can by standing on the ground. Sonar systems on the ships can be utilized to take pictures of the sea depths without needing to travel to the bottom of the ocean. This makes it potential to gather surface information inaccessible or unsafe area where it would be too hazardous to bring in a team and equipment to collect data. Since the sensors are high above the earth, they are beneficial for gathering data in a vast area. Applications of remote sensing include monitoring the extent of deforestation, also to analyze the impact of a natural disaster like a tsunami, earthquakes and volcanoes. Remote sensing can be of two types:

1) Active remote sensing and

2) Passive remote sensing.

Passive remote sensing means that the sensors are only collecting data for that are already available such as reflected light and radiations when taking various kinds of images like standard photos and infrared and thermal images. Active remote sensing means that the sensors or another part of the overall system initiates its own form of signal to be projected to the surface and then collect the reflection such as firing a laser and then calculating the time it takes to reflect back to the sensor in order to get the distance from the surface to the satellites. This allows resources to get an accurate reading about the death of information such as a mountain or even buildings.

3.4.2 Geographical Information System (GIS)

GIS is a Framework intended to capture, store, control, analyze, manage and present a wide range of spatial information. The word geographical implies some bit of the information is spatial or the data is referencing to the location on the earth. Combined with the information is usually tabular data also known as attribute data. This tabular data can be generally defined as additional information about each of the spatial features. An example of this is a college the attribute data of the college is the college name, courses, placement, number of students, etc. and the location of the college is the spatial data.

It is the association of these two data sets that empowers GIS to be such a successful and useful problem-solving tool through spatial analysis. GIS is more than just software. People and method are combined with geospatial software and tools to enable spatial analysis, manage large data sets and display information in a map or graphical format.

GIS can be utilized as instruments in both critical thinking and decision making processes and additionally for the perception of information in a spatial situation.

Geospatial information can be analyzed to decide:

1. The location of the features and relationship to other features.
2. Where the most and least of some feature exist.
3. The density of the features in a given space.
4. What is happening inside an area of interest?
5. What is happening nearby some feature or phenomena?
6. How a specific area has changed over time.

3.4.3 Image Classification

An image can be understood as the matrix of pixels where each cell has different Digital Numbers (DNs), which are representative of each pixels intensity value. Image classification is the procedure of automatically classifying each pixel in a raster environment based on their distinct spectral reflectance. There are two ways to deal with this classification procedure: supervised and unsupervised.

The unsupervised image classification consequently bunches cells into groups automatically dependent on the measurements of their digital numbers (DNs), (Lillesand et al., 2004). This procedure involves negligible user effort; the user only has to choose the number of classes he wants to classify the image in, the unsupervised classification technique is entirely automatic.

In supervised classification, the operator manually controls the inputs, agreeing the operator's knowledge to impact the results. In this process, the operator creates the signature classes by its own and gives it as the input to the software by which the tool classifies the image.

A supervised classification method was selected for this study. The image classification process was carried out using Erdas Imagine 9.0 image classification tool. Although the clumping of pixels is performed automatically by the software, the procedure followed in this study required manual input. The quality of these inputs is instrumental in generating an accurate classified image. These inputs existed in the form of training sites, which were polygons digitized within the boundary of several different feature classes. The placement of these polygons was based primarily on the spectral reflectance of pixels in different wavelength band combinations. Some useful combinations of the red, green, and blue bands (R,G,B) used during the training stage were 4, 3, 2 false-color combinations (FCC) for the purposes of visualization and better object determination.

3.5 Software and Equipment Used

For image processing and image analysis software, ArcGIS 10.1, ArcSWAT and Erdas Imagine 9.0 were used. The instrument Garmin Global Positioning System (GPS) with Paper Maps was used for field observation of latitude, longitude, and elevation. A0 scanner was used for scanning of toposheet maps. A sonic meter is used for measuring the water surface depth in the open wells.