CHAPTER – 1

Introduction

1.1 Concept of the present study

The Jalpaiguri district has been formed in 1869. It is of comparatively recent creation. Earlier in March 1849, Hooker arrived at 'jeelpigoree'which is the past name of Jalpaiguri (undivided). It is a large straggling village near the banks of the Tista River. According to Hooker, 'we are detained for several days, waiting for elephants with which to proceed northwards.' (Kusari & Sengupta, 1981).

After the annexation of the Dooars in November 1864, Dooars is divided into eastern part which is known as Goalpara district (Assam) and western part known as Jalpaiguri district. Before the name of Jalpaiguri (undivided), western Dooars is divided into three parts (tahsil) viz. the Sadar lies between the Tista and Torsa rivers with Mainaguri block as head-quarters; the Buxa lies between the Torsa and the Sankosh river with Alipurduar as head-quarters; and the Dalingkot which cover the mountainous part of the annexed territory. In January 1867 during British period, Dalingkot has been transferred to the Darjeeling district and Titalya subdivision is under the Rangpur comprised Boda, Sanyasikata known as Rajganj and Fakirganj known as Jalpaiguri (undivided). After 1869, Titalya is separated from Rangpur and is made a unity with Western Dooars for new formation of Jalpaiguri district. After that, for the development of tea industry by British general, Jalpaiguri district is under the stresses of migrated people who came from Bangladesh, Bihar, Mayurbhanj of Orissa, and Bhutan. They settle down in foothill zone and both side of river (Grunning, 1911).

Jalpaiguri district in West Bengal situated not far from the Himalayan margin. It is crisscrossed by the Sub-Himalayan Rivers which have always been liable to flood. On other hand, Jalpaiguri district has been under increasing anthropogenic stresses due to large scale migration. The study area has been experiencing extensive heedless deforestation along with tea plantation, mining, quarrying, haphazard construction, illogical slope cultivation specially along the Himalayan margin since the past one hundred and fifty years. Such an unscientific and unplanned use of land has led to the establishment of vicious cycle of degradation. Thus, there is an urgent need to evaluate the nature and trend of land use changes and its impact on increasing flood hazards to develop management strategies.

1.2 Problem of the study

Land use pattern of Jalpaiguri district has changed dramatically since 1850s. Continuous deforestation in the catchment area of major rivers and the clearings of the steep slopes have been used for the extension of settlement, agriculture, plantation, communication caused disruption of hill slope hydrological balance. Records reveal that the flood of 1906, 1973, 1988, 1993, 1996, 1998, 2000, 2007 cause by the high intensity of rainfall in the Himalayan foothills. Heavy and incessant local rainfall is also caused large-scale inundation and flooding of Jalpaiguri district in 1952, 1972, 2000, 2002 and 2010.

Land use change induced flood is one of the major problems in Jalpaiguri district undivided). Available data augmented by remotely sensed data under GIS platform is directly use in visualization of the changing nature of different land use categories i.e., forest, tea plantation, grassland, wetland, settlement. This GIS platform which are very effective for identifying land, soil degradation and locate the increasing flood frequency of flood affected zone.

1.3 Literature Review

To better understand the present topic, review of books and articles provides better information. Specific region wise information has given in websites and reports. The consulted topic has been merged under various themes for better understanding.

To detect and analyze changes in riparian land cover and river channel morphology, remote sensing is one of the most important methodologies at present times (Bryant & Gilvear, 1999). “Land Use” is a very common term as a natural phenomenon which is similar to soil condition change and salinity of water (Forrag et al. 2016). The temporal changes show reduction in agriculture and natural vegetation with the settlement extensions in urban areas (Sundarkumar et al. 2012; Erasu, 2017). For better understanding of land use changes over the long period Landsat data is suitable (Nagarjun & Poongothai, 2011). Land use changes and water balance have a close relationship which has impact on ecological changes (Carlson & Arthur, 2000; Matheusen et al. 2000; Siriwardena et al. 2006). From visual interpretation of topographical maps and satellite images overlapping with logical rules in GIS are used for determination of stable and dynamic areas of land use changes of the Sikkimese - Bhutanese Himalyan Piedmont. Land use change analysis shows rapid replacement of forests through location of tea plantations, crop cultivation and development of settlements in the late 19th century (Prokop & Sarkar, 2012). Increasing or decreasing cover of dense mangroves in the reserve forests of Sundarbans have been observed

using unsupervised classification of all the three masked normalized difference vegetation index (NDVI) and a cumulative loss of original mangrove cover which was approximately 0.42% between 1975 and 2006 (Dutta & Deb, 2012). The four level of categorization of land use acquired from Landsat image of southern New England shows that the changes of forest, settlement, grassland, wetland have influence on the natural hazard. (Lindgren, 1985). Spatially explicit sensitivity analysis of land use and land cover change model generates sensitivity maps for identifying regions of factor influence a area where particular data input shows most to the clusters of residential development (Ligmann - Zielinska 2013). From the study it has been observed that in the coastal Land use patterns of Abu Dhabi, the rapid increase in the manmade plantation and managed vegetation from 1992 - 2000 due to dredging, tripping, anthropogenic activities. The land use changes data are acquired from the multi - temporal LANDSAT satellite data and the changes are analyzed using digital change detection techniques (Yagoub & Kolan, 2006). The supervised classification on three IRS (LISS III) satellite data for the study of seasonal spectral variation on land cover classification in the Solan district of Himachal Pradesh found that the overall classification accuracy of 76% in summer is better than spring and winter dataset with classification accuracy of 49% and 46% respectively (Sharma & Bren, 2005).

The dynamic nature of the braided pattern of river and failure of structural measures force bank erosion to occur in the Diana River (Dutta & Chakraborty, 2013). In Duars region, avulsion of one river into another neighbouring river have tendency to avulse by way of lateral erosion (Chakraborty & Dutta, 2013). The analysis is taken on the fluvial dynamics of confluence shift at the confluence zone of Jaldhaka - Diana rivers using the topographical sheet for three years. This area has undergone channel shifting, bifurcating and avulsion (Chakraborty & Dutta, 2013). During floods, 14 rivers are studied for changes between 1930 to 2001 and found that due to one major avulsion in the course of Torsa, the large rivers changed their braided pattern continuously (Bandopadhyay et al. 2014). The study on the relationship between flood and land use of West Bengal considered both the flood affected and water-logged areas together as both influenced agricultural operations adversely (Das, 1997). Critical examine of the impact of rainfall on soil erosion in the tropics and have stressed on the quantitative understanding of causative parameters in order to ensure conservation, land use planning and utilization. The observation on various river basin in India shows that after forced human migration due to river bank erosion, and due to

agricultural land loss and faced economic insecurities which increased unemployment (Das et al. 2014).

Floods are closely related with air masses, pressure system, short time heavy rainfall, low temperature above freezing point (Brooks & Thiessen, 1937). Floods are events caused by climatic change (Leopold,et al. 1964). The climatic factors are evapotranspiration, interception, nature of precipitation, duration of rainfall, intensity of rainfall, areal distribution of rainfall, with time which influence runoff (Raudkivi, 1979). In monsoon seasonal rainfall occurrence in North East India are shown the main cause of flood (Dhar & Nandargi, 1998; Goswami, 1998). The ploting of the mean annual runoff and coefficient of runoff by Choropleth method for Jamaican river basins are concluded that the region where the rainfall occured in different intensity have frequent flood whereas the rainfall is uniform have rare flood (Nkemdirim, 1979). The analysis between rainfall and flood on important rivers of India from 75 to 100 years are indicated the long-term fluctuations in annual peak discharge which is not random and showed the relation with long term variation in the monsoonal rainfall. The hydrograph analysis and correlation method is important analysis method of flood occurrence (Howe et al. 1967). The flood magnitude is determined by slope elevation, shape, area drainage network, vegetation, landuse of river basin area and climatic factor (Rodda, 1967). The hydrographs showed the water discharge of main and tributaries rivers and concluded that the peak discharge of a particular station is a local flood waves created by tributaries in the North Bihar plain (Sinha & Jain, 1998). From the measurement of the depth of sediment on the flood plain of Kickapoo in Wisconsin conclude the sediment load has increased over years with increasing flood (Happ, 1944). For the causes of flooding in Karad region the annual rainfall, drainage density, slope of basin, size of watershed and land use is mentioned (Warfhat et al. 2012). The flood prone areas of the Dooars region by nature surrounded by the intensive network of rivers and the Himalayan hills are affected by different land use pattern, deforestation, landslides, minning in the catchment area, in stream quarrying and human encroachment. (Chakraborty & Dutta, 2013). In the lower piedmont plains of Dooars region continuous and excessive rainfall for the several days in the catchment areas of river causes of melting snow accumulated on high mountain pick are responsible for high flood frequency (Chakraborty & Dutta, 2013). Regular flood and erosion by Ganga at Maldah district displaced huge people as out migration (Iqbal, 2010). It is discussed about the past evidence with the magnitude of flood occurrence of North Bengal (Sarkar, 2011). The fitting of hydrological data with proper mathematical model of

distribution the best way of fitting is frequency analysis. Frequency analysis examined the river and hydraulic behaviour (Boraand & Haque, 2008). The time series analysis of Indian rivers shows the discharge, increasing flood frequency and the peak discharge has increased significantly (Kale, 1998). Flood magnitude show the high discharge or high-water level that goes beyond certain arbitrary limits (Charlton, 2008). Flood magnitude is studied as probability function (Leopold et al. 1964).

The flood frequency and the magnitude have a relationship which shows the areas of the smaller flood events happen frequently which has large damage than the large flood occurrences (Chow et al. 1988; Davie, 2008). Log Pearson Type III analysis of the frequency distribution that has shown the recurrent interval of 2.1 years on the mean annual flood for Brahmaputra River (Goswami, 1998). For the analysis of pattern of floods, the lower Rapti-Surya Doab was demarcated as high, medium and low flood zone which covered the area in 30 to 60%. Based on flood frequency, high, medium and low intensity flood hazard zone is considered for the management of the lower Rapti - Surya Doab (Nag et al., 1997).

The flood frequency and magnitude have increased over the long period (Bora & Haque, 2008). The probability distribution is the best model to estimate the hydrological data (Roman et al. 2012). Flood zonation is very important in development and management of river basin. Flood zonation is a pictorial representation of the frequency and magnitude of different floods in a region. The flood hazard zones of North Bengal were prepared from survey of India toposheets of 1 50,000 scale and IRS LISS - II (Jana, 1997).

1.4 The Study Area

The Sub-Himalayan Jalpaiguri district lies between 26°15′ 22.5″ and 26°59′ 37.7″ North latitudes and between 88°23′ 13.5″ and 89° 53′ 4.5″ East longitudes. It comprises of an area of 6227sq. km. Jalpaiguri (undivided) is northeastern most district of West Bengal. It has long international borders with Bhutan to the north and with Bangladesh in the south and border with Assam to the east and Darjeeling district to the north-west (Table 1.1).

Jalpaiguri district has recently been bifurcated in two districts namely Alipurduar and Jalpaiguri in May 2012 however the proposed study will be carried out in un-divided Jalpaiguri district i.e., both Jalpaiguri and Alipurduar. The district has two subdivisions, namely, Sadar or Jalpaiguri and Alipurduar with their headquarters at Jalpaiguri and Alipurduar respectively. The sadar subdivision consists of the police stations of Jalpaiguri, Rajganj, Maynaguri, Nagrakata,

Dhupguri, Mal and Matiali, while the Alipurduar subdivision consists of the police stations of Madarihat, Falakata, Alipurduar 1 and Alipurduar 2, Kumargram, Kalchini.

The district has a more or less rectangular shape. The west part of the Tista River is covered by a slightly undulating expanse of paddy, bushy jungles, tea gardens, grasslands. (Master Plan for Flood Management and Erosion Control, 2003).

1.5 Objectives

The objectives of the present study are to examine the role of land use changes during the past 150 years in increasing frequency and magnitude of flood occurrences in Jalpaiguri district and to provide suitable strategies for flood management under the backdrop of changing land use pattern. The detail objectives shall include

1. To evaluate the spatio-temporal land use patterns (i) during the second half of nineteenth century based available records; (ii) during 1930s on SOI topographical maps; (iii) during 1960s on SOI topographic maps; (iv) during the year 2000 on IRS LISS-3 and (v) for the year 2014 based on IRS RS-2/Google.
2. To assess the nature and extent of land use changes between (i) 1850s and 1930s; (ii) 1930s and 1960s; (iii) 1960s and 2000 (iv) 2000 and 2014.
3. To analyse the role of such land use changes on the nature and degree of land and soil degradation.
4. To evaluate the Spatio-temporal variations of frequency and magnitude of flood occurrences with particular references to (i) the second half of nineteenth century; (ii) during 1930s; (iii) during 1960s; (iv) for the year 2000 and (v) for the year 2014.
5. To find out the relationships between the parametric values of land use changes with that of the flood occurrences during the identified periods in Jalpaiguri district.
6. Assess the nature of flood and its problem in the perspective of history of flood occurrences, causes and preventive process, socio-economic and environmental cost.
7. Finally, an attempt is made to suggest suitable strategies for flood hazard management under the backdrop of transformed land use pattern in Jalpaiguri.

1.6 Hypothesis

Changes in land use patterns since the past hundred and fifty years have aggravated the land and soil degradation vis-à-vis frequency and magnitude of flood occurrences in Jalpaiguri district. The processes are responsible for increasing the frequency and magnitude of flood hazards and erosion problems include:

1. Deforestation in the hills and piedmonts for setting up of tea gardens and extension of arable farming and settled areas. The hill slopes and piedmont surfaces thus became exposed to increased slope wash during the rainy season, followed by landslides and accelerated soil erosion induced massive aggradation along the river valley and flood plains.
2. Clearance of wastelands (listed as *gauchars* or current fallow land in Census of India Handbooks), wetlands/ depressions and dormant/ seasonal/ paleo-channels for extension of settlements and arable lands also responsible for increased magnitude of flood occurrences.
3. Construction and extension of transport lines, bridges, embankments across river channels and construction of small irrigation canal (locally known as *jampoi*) also have detrimental impact.
4. Unscientific mining activities along or near Indo-Bhutan border and quarrying of boulders from river bed also accelerate aggradations, bank failure and avulsion thereby intensifying the destructive impact of flood hazards.
5. High intensity rainfall has vital effects in transforming the geomorphology of the foothill zone, as indicated by the previous records of floods. Major and rapid changes in prevailing land-use patterns hasten the process of land degradation. Land degradation is resulting in transformation of the fluvial network. Floods and degradation, which are consequences of this transformation, have become annual problems and popular flood controlling techniques like construction and strengthening of embankments have proven futile. Catastrophic floods of 1968, 1993, 1998, 2000 and 2007 affecting different parts of the district demonstrate the seriousness of the prevailing situation. The vicious circle thus emerging has been affecting the socio-economic stability of the region.

1.7 Methodology

To fulfil the objectives, the methodology is to be adopted by the present investigator will be rationalistic one, comprising of an integration of hydrological, geomorphological, meteorological and anthropogenic investigations. The proposed methodological framework for the study is outlined as follows:

1.7.1 Reconnaissance

The investigator likes to obtain the basic data from different government organizations, from topographical sheets, Satellite imagery and from the work of individual researcher. These is used in preparing the detail programme of the present research work. Significant changes in land use pattern and flood hazard in the study area is followed by comparing the old documents with the newer one.

1.7.2 Data base

The tabular data is attached from excel for thematic map generation. The method of data base in Jalpaiguri district includes:

1. Preparation of database on changing land use pattern from Satellite Imagery (Landsat, LISS-3; RS-2) Survey of India topographic maps, US Army map service, database prepared at NRDMS Jalpaiguri centre, ISRO and researchers of North Bengal University.
2. Block register for flood hazards is scrutinized, verified, and crosschecked.
3. Collection of various data on agricultural, forest, soil, water, and meteorological form the concerned offices.

Data related with flood is obtained from the NBFCC, Irrigation & Water Department and Flood Meteorological Office, Jalpaiguri.

1.7.3 Data Analysis

Base map of Jalpaiguri district is prepared based on Survey of India topographic maps (163360) at ArcGIS platform (the gap area is covered by US Military topographic map). Different time series data is accessed under the same platform into mosaic files. Detail land use and land cover data is accessed and classified for change detection using post-classification comparison for identification of land use changes. The data related to flood hazards shall be accessed from both

the satellite image, field survey and from secondary sources. This analysis is done by using spatial analyst (Arc GIS) and Global Mapper software (Fig. 1.1).

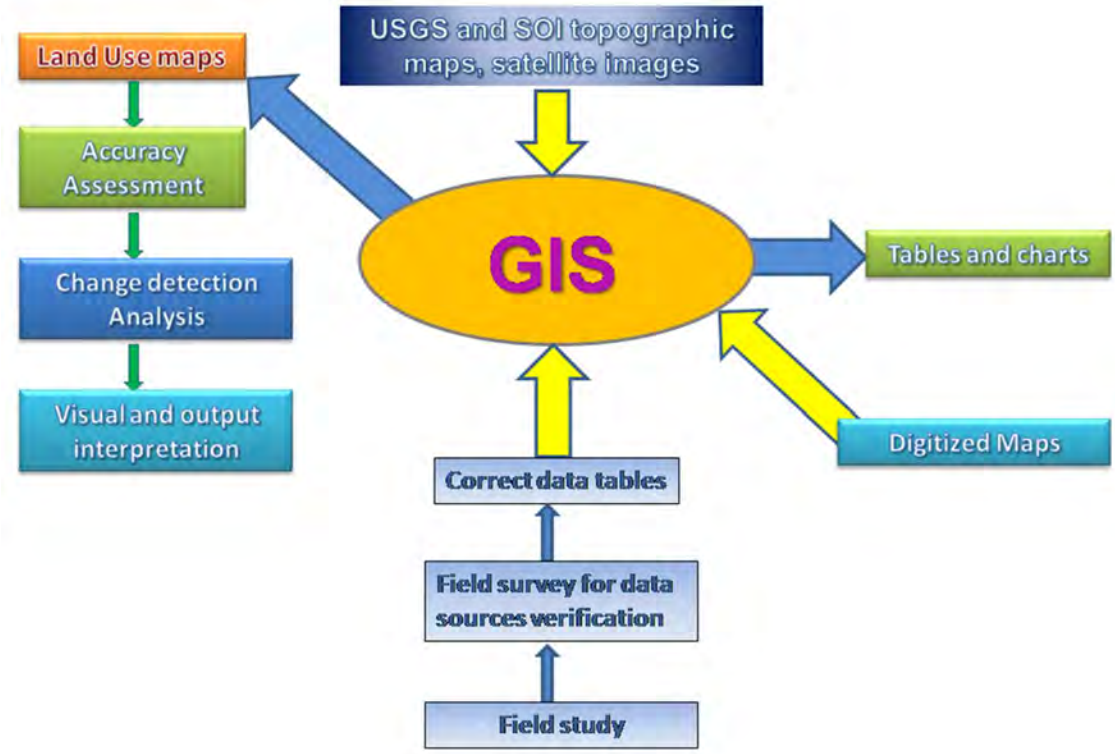

Fig. 1.1 Flow chart showing the different procedures used in the methodology section in the present work.

The reliability of the data collection from secondary sources is checked statistically. To evaluate the man-induced transformation -

- Each polygon represents a particular land use pattern and its distribution
- Calculation of total area in %, taken by certain land use pattern.
- Make a comparison of calculated values for each studies year and evaluate it.
- An attempt is made to calculate the quantity of total discharge of water through the past land use area and changing land use area.

1.7.4 Methods for identifying land use changes

- Thematic map generation on various land use pattern for different years between 1930 and 2014 based on Survey of India Topographical maps, US Army map service (1:253440 & 1:250000000), and Satellite Images (LISS-3 and RS-2)

- Supervised classification (maximum likelihood) on specific dates of satellite imagery and topographic maps is perform to study the changes of periodically seasonal spectral variation on land use classification.

1.7.5 Methods for assessing the impact of degradation on flood

An attempt is made to correlate the degradation data with that of the flood at different spatio-temporal levels to apprehend the relationships. The spatio-temporal relationships are analysed using river shifting of major rivers and landslide susceptibility analysis. The investigator has the opportunity to work under the NRDMS programme in Jalpaiguri district sponsored by the Department of Science & Technology, in 2010-11 and some relevant data may also be accessed for the present research with due permission of the concerned authority.

1.8 Significance of the study

The present study emphasizes on the longtime changes of land use as well as its impact on flood of entire Jalpaiguri district in response to the major rivers like Tista, Jaldhaka, Torsa, Raidak II which have not been studied previously. This study will help us to envisage the relation between flood incidences and the land use changes.

1.9 Organization of work

The present work has been organized into eight chapters.

The first chapter gives an introduction of the entire work, addressed the problem of the study and incudes objectives, hypothesis with its scope, literature review and methodology. This chapter also includes the significance of the study.

The second chapter includes the detail study of geographical set up of Jalpaiguri district.

The third chapter gives detail study of chronological changes of land use in Jalpaiguri district. This chapter focuses on the changes of selected land use type from past to present, causes and impact.

The fourth chapter includes land use change induced land degradation with detail study of land, soil degradation, landslide, bank erosion and avulsion.

The fifth chapter deals with the process and impact of flood hazard. This chapter includes the detail study of implication of flood on physical landscape, past occurences of flood, causative

factors of flood and analysis of flood prone zone, correlation between discharge and high-water level.

The sixth chapter deals with the frequency and magnitude of flood in major rivers and assess the best method.

The seven chapter includes the management of flood.

The eight and last chapter gives conclusion of this work. This chapter has been discussed to open for further study.

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