CHAPTER-I

Introduction

1.1 Introduction

The development of the North Bengal alluvial plains at the Himalayan margin has a long drawn historical perspective since the Pleistocene period. Subsequently with the passage of time due to climatic changes the physiographic configurations(Dorn R.I. 1994, Twidale, 2004)of the fan areas were reshaped and are also being modified by the post-periglacial processes i.e. the fluvial action by the major rivers and their tributaries. So, the alluvial fans are the result of the complex interaction of different processes which the present researcher seeks to be concerned with for understanding their detailed modes of action responsible for the evolution, development and modification of the coalescence of fans and fan segments as well as the interrelationship between the Pedo-Geomorphic character of the fans and land use of the study area.

1.2Area of study

The present researcher has selected this study area (Figure. 1.1) located at the foothills of the Darjeeling Himalayas, in the state of West Bengal, India widely known as the Terai which means moist undulating land with some complex research questions. The study area extends from 26º30’00” N to 26º55’00” N Latitudes and 88º05’00” E to 88º37’15” E Longitudes comprising the whole Terai plains. Tectonic characteristics, relief, climate etc. of this study area are very suitable for the development of alluvial fan. Major rivers flowing through the study area along with their tributaries are coming from the Himalayas and formed alluvial fan which is the main focus of this study. These alluvial fans conjoined and finally formed a piedmont zone. The area lies in between the right bank of river Tista and left bank of river Mechi. The major rivers of the study area are Tista, Mahananda, Balasan, Mechi, Rakti, Rohini etc. Rohini and Rakti are the tributaries to the Balasan which finally meets Mahananda at downstream. The total area of study is about 888.9 km^2.

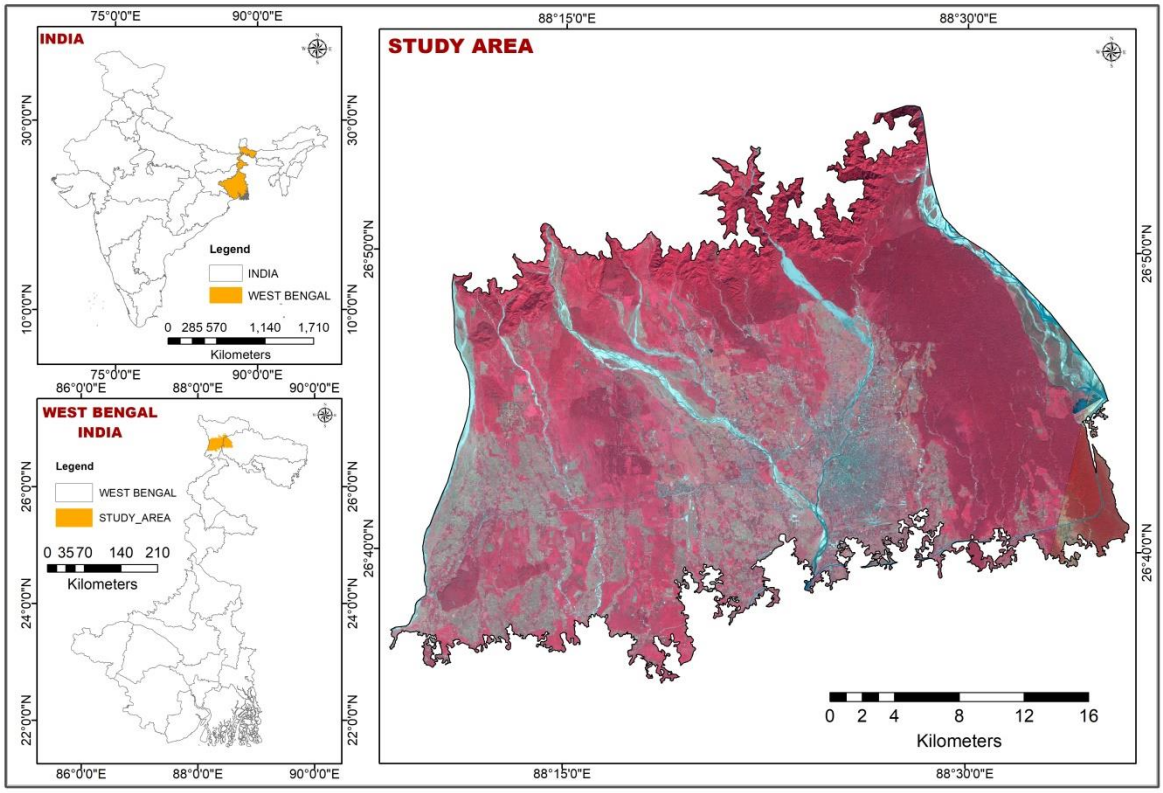

Figure 1.1: Location map of the study area

1.3 Scope of study

It has been observed that rivers from the different mountainous tract are carrying detritus characteristically diversified in nature and depositing accordingly over the different parts of the fans and thereby modifying fans characteristics after debouching on to the rolling plain.

The legacies from the past events in the form of scattered big boulder deposits on the upper part of the fans are getting further transported by severe flash floods and redistributed over the fan areas. Thus the shapes of the apex of the fans are changing which needs detailed investigation for accurate analysis.

In addition to it, defilement of environment in the form of mass deforestation, unscientific settlement construction on the vulnerable hill slopes, rapid growth of urbanization and associated phenomenon like, construction of roads, passing of heavy vehicle through these roads have become the triggering factors for severe soil creeping, sheet slides, slips and other types of slope failure, which results in the addition of extra sediment load in the river channels.

Due to above activities the soil surface in many places has been exposed and lost the compactness to a great extent since the pore spaces of the soils are filled up with water particles after direct contact with rain in the monsoon and has increased the shearing stress in the soil shattering the soil coherence. As a result severe soil erosion continuously take place on the hill tracts and huge quantity of eroded materials come down by the rivers to the lower course of the channels.

Moreover in absence of sufficient vegetative cover the surface runoff on the hilly tracts becomes higher and finally reaching the stream channels earlier than usual which results in sudden peak flood flow in the channel cross-section due to the reduction of Lag Time.

All these factors are ultimately resulting severe degradation of the hill areas and the materials are carried out by the mountain rivers down to the terai rolling plains, finally contributing unwanted detritus on the river beds which are getting incremented on the fan areas in an accelerating manner.

Thus human induced causes beside the natural causes play a very active role in the development and modification of the alluvial fans.

It is interesting to mention that the materials which are deposited on the alluvial fans have a very significant impact on the land use since the materials are transported by the rivers from the different parts of the hill areas which are consisted of the substances having different geologic, pedologic and geomorphic origin. Thus, the materials distributed onto the fan surface must have varied constitutional and nutritional values in different parts of the fans. As such the present researcher feels it essential to investigate the pedo-geomorphic significance of the fan region on landuse.

1.4. Objective of study

For a comprehensive study of the alluvial fans and their pedo-geomorphic significance on landuse some objectives have been taken into consideration. These are:

i. To investigate in detail the complex interaction of the fan forming processes and their mode of operation by which fans are being developed and the pedo-geomorphic characteristics are being resulted as an outcome.
ii. To correlate the pedo-geomorphic characteristics of this region with the landuse pattern existent in present scenario.
iii. To see how far the present landuse is suitable and adjusted in the existing pedo-geomorphic set up.
iv. To find out the contrasts between the present land use and their pedo-geomorphic environment and thereby formulate the more scientific land use method to achieve better result.

1.5. Hypothesis

i. The litho-tectonic and high rainfall induced fluvially erosive land characteristics of the Darjeeling Hills provide huge bed loads, wash loads and dissolved load to the stream network which are accelerated by various anthropogenic effects.
ii. The lower courses of the rivers get various types of debris in different regions supplied from the upstream tracts having certain geologic origin and the materials are reshuffled further by the action of the overflow of the braided streams to form the coalescence of fans.
iii. The alluvial fan segments as such may consist of various pedo-geomorphic characteristics in the different parts.
iv. These pedo-geomorphic diversities should have influence on the landuse of this area.

1.6. Review of literature

The present researcher is interested to work in the field of alluvial fans and the tentative topic is “Development of Alluvial Fans and Their Pedo-Geomorphic Significance on the Landuse in Terai Region, West Bengal, India”. So, the present researcher has consulted some books and articles regarding the different aspects related to the study of alluvial fans, its development, pedo-geomorphic characters and impact on landuse. During the library work the researcher

found that till date few rich and applicable works have been done in the field. In all climatic conditions alluvial fans may play an important buffering role in mountain geomorphic or sediment system (Harvey, 1996, 1997, 2002*b*). In mountainous terrain, alluvial fans are conspicuous locations for infrastructure and residential status development, and are excellent locations for growing trees, but these landforms can present significant risks because they are frequently the runout zones for landslides. David J. Wilford and Matthew E. Sakals in their paper 'Forest management for landslide risk reduction on alluvial fans' said that "A fan is a cone-shaped deposit of sediment formed where a stream channel leaves the confines of a mountain (Bull 1977). It is an expression of its watershed; the fan is created by and represents a summary of the hydrologic and geomorphic processes in the watershed. The watershed, or catchment, is the source area for water, sediment, and woody debris, the stream channels are the transport zone, and the fan is the deposition zone. Together, they constitute the fan-watershed system which is the basic unit for hazard and risk analyses". But while stream channels in the watersheds of fans transport material, it is common for stream channels on fans to be unconfined: when landslides or flood flows enter onto a fan there is usually a broadcasting of sediment and water. On fans with forests this leads to a characteristic "hydrogeomorphic riparian zone" with buried trees, log steps, scars on trees, and groups of trees of different ages (Wilford*et al.* 2005b). It is therefore important that resource development in watersheds above fans be planned and undertaken with an understanding of the fan-watershed system; the risk to downstream features must be critically considered (Jakob*etal.* 2000). The challenge facing on alluvial fan sedimentary sequences is to develop interpretive models that are compatible with the findings of research on contemporary processes and on extant Quaternary alluvial fans (Steel, 1974). In the research paper 'Differential effects of base-level, tectonic setting and climatic changes on Quaternary alluvial fans in the northern Great Basin, Nevada, USA" A.M. Harvey said that "The interaction between tectonics, climate, base level change have produced distinctive fan geometric relationships between younger and plder fan segments, also expressed in the morphometric properties of the fan". Alluvial fans develop at the base of drainages where feeder channels release their solid load (Blair and McPherson, 2009; Leeder et al., 1998; Harvey et al., 2005). A classic fan-shape forms where there is a well-defined topographic apex. Multiple feeder channels, however, often blur the fan-shape resulting in a merged bajada. Alluvial fans can be found in almost all terrestrial settings. These include alpine (Beaudoin and King, 1994), humid tropical (Iriondo, 1994; Thomas, 2003), humid mid-latitude (Bettis, 2003; Mills, 2005), Mediterranean (Robustelli et al., 2005; Thorndrycraft and Benito, 2006), periglacial (Lehmkuhl and Haselein, 2000), and different paraglacial settings (Ballantyne,

2002). If we talk about the sedimentation and its processes we can take the reference of the research paper 'Luminescence dating of alluvial fans in Intramontane basin of NW Argentina' written by R.A.J. Robinson, J.Q.J. Spencer, M.R. Strecker, A. Richter and R.N. Alonso; it is " Alluvial fans are sensitive recorders of both climatic change and tectonic activity. The ability to constrain the age of alluvial fan sequences, individual sedimentary events and the rates of sediment accumulation are key for constraining which mechanisms most control their formation". Actually "alluvial fans are ubiquitous along mountain fronts, and their evolution is tied to tectonic and climatic conditions" (Bull and Harvey, 1977). McSweenay et al (1994) provides a framework for soil landscape modeling particularly for soil properties prediction. Modeling process follow four consecutive stages: 1) physiographic domain characterization that involves integration of available data sets to define and characterize the physiographic area under study, to consolidate a priori knowledge about the area, and to identify other data that might be valuable for defining soil pattern; 2) geomorphometric characterization of the landscape by primary and secondary landscape attributes derived from a digital elevation model (DEM); 3) horizon stratigraphy characterization that includes development of a soil horizon legend that is used to determine the distribution and spatial relationship among soil horizons and other layers in the landscape; and 4) soil property characterization that involves laboratory and statistical analysis of soil horizon attributes collected during the third stage. However, the study of soil-landform relationship itself has begun since 1935, since catena concept was established (Milne, 1935). At the beginning of the 19th century all these fans of Terai region were well covered with tropical forests of densely growing Sal (*Shorearobusta*), Segun (*Tectonagrandis*) or Sturdy Sheesham (*Dalberghiasisso*),(S.R.Basu and S.Sarkar, 1990, pp328). In this field some attention being paid to floods and aggradation on alluvial fans in Duars, these damaging railway and road bridges and tea gardens. These were mainly focused in a valuable paper by Dutt (1966). The rivers which are fed partly by melt water form mega-fans with frequent avulsions (Sing, 1993). In the 1980s geomorphologists from North Bengal University studied landslides and alluvial fans in the catchments of two left-bank tributaries of the Tista, called the Lish and Gish (Basu, Ghatowar 1986, 1988, 1990; Basu, Ghosh, 1993). In the mean time the foothills-fed start in the marginal part of the Himalaya (mainly the Siwalik zone) where rainfall is higher, building a system of small fans and changing channels from braided to meandering within the wide inter-fan-zones (cf. Shukla, Bora, 2003). The detritus classification with relation to altitude has been done as, sands and gravels in the middle part (called the Terai-40 km wide) and further down stream of sandy loams and even clays (L.Starkel, S.Sarkar, R.Soja and P.Prokop, 2008). The overall changing pattern of landuse and

its distribution has been shown as the gradual establishment of tea gardens after 1866 on the undulating terrain having suitable soil and adequate drainage; more and more forests were cut. At present tea gardens cover about 40% of the total area under study. Moreover, tea gardens occupying about 5% of the region have been deserted by their owners as these were no longer economical (S.R.Basu&S.Sarkar, 1990, pp-328) or since boarder difficulties with the China in 1962, military installations have also been increased, occupying more & more of the forest land and uneconomical tea gardens (S.R.Basu&S.Sarkar, 1990, pp-328). The present researcher found it interesting that the materials which are deposited on the alluvial fans have a very significant impact on the land use since the materials are transported by the rivers from the different parts of the hill areas which are consisted of the substances having different geologic, pedologic and geomorphic origin. In the research paper 'Development of Alluvial Fans in the Foothills of The Darjeeling Himalayas and Their Geomorphological and Pedological Characteristics' S.R.Basu&S.Sarkar said that "in the area of study, the fan deposits are coarse-grained, poorly sorted and immature sediments. Usually gravel, cobbles, and boulders predominate with subordinate amount of sand, silt and some clay. The coarsest and the thickest deposits occur near the fan heads. Maximum grain size and thickness of sediments decrease rapidly toward the base of the alluvial fan deposits. The roundness of coarse grains also increases with increasing distance from the apex of the fan". Thus, the materials distributed onto the fan surface must have varied constitutional and nutritional values in different parts of the fans. The study of soil-landform-landuse relationship itself has begun since 1935, since catena concept was established (Milne, 1935). Soil-landscape model represents both relationships between soil and landform and the relationships between the pattern of soil-landform-landuse relationship and processes of pedo-geomorphic evolution. There are very complex relationships between soil and landform in the soil landscape system and the relationship between pattern and process of pedogeomorphic evolution (McSweenay*et al.*, 1994). But interestingly there is a firm research gap in the development, land use system and land evaluation of that alluvial fan as well as in their interrelationships. So, the alluvial fans at present are the result of the complex interaction of different processes which the present researcher seeks to be concerned with for understanding their detailed modes of action responsible for the evolution, development and modification of the coalescence of fans and fan segments as well as the interrelationship between the Pedo-Geomorphic character of the fans and land use of the study area.

1.7. Methodology

For the fulfilment of the objectives discussed above the present researcher has adopted a rationalistic and quantitative methodology which can be divided into different parts:

1.7.1Pre-field Methods

To study the physiography like Geomorphology, Geology, Landuse, Soil and Climatic conditions of the area basic data and associated maps have been collected and prepared with the help of the Survey of India topographical maps no. 78 B/1, B/5, B/6, A/4 and A/8 (1:50,000), NG 45-8 and 45-7 series U502 surveyed in between 1931 to 1944, published in 1959 and also published maps of NBSS&LUP, Govt. of West Bengal's Forests Department. Preparation of base maps of the study area from Topographical maps, NBSS&LUP maps and satellite imagery.

1.7.2 Field Method

1.7.2a Study of the fan geometry

i) Study of the fan forming materials by field survey.
ii) Measurements of the fan material size.
iii) Collection of soil samples for determining pedo-genesis of different fan segments.
iv) Determination of the coarseness of regolith.
v) Measurement of hydrologic properties.
vi) Identification of legacies from the past.
vii) Fan segmentation following break of slopes.

1.7.2b. Scheme for collection of primary data from the field

The collection of primary data has been done by a number of field studies. Such crude data have been collected through appropriate geomorphological, statistical and mathematical techniques for finding out the actual situation of the targeted aspects. GIS software have been used to draw different profiles and curves.

In addition, different samples of soil have been collected directly from the field for preparing soil zone map. Similarly the land use of the study area have been carefully observed and noted to chalk out the proper interrelationship with the present pedo-geomorphic set up of the fan area.

1.7.2c. Collection of secondary data

To get the exact view of rainfall, temperature and other elements of weather and climates, the different meteorological data of in and around the study area have been collected from the Regional Meteorological office, Silliguri, Bagdogra, Jalpaiguri, Alipurduar and Kolkata. For the agricultural data, the Department of Agriculture of Silliguri and Jalpaiguri, the Uttarbanga KrishiViswavidyalaya has been consulted carefully. For the land use, the satellite images of the study area have been studied cautiously.

1.7.3. Post-field Method

The detailed outline of the adopted methods is as follows-

A. *Graphical Methods*:

a) Profiles-

i) Cross profiles.

ii) Long profiles.

B. *Quantitative Methods*:

a) Slope analysis.

b) Relief analysis

c) Drainage density

d) Channel morphology and Hydraulics.

C. *Cartographic Methods*:

a) Morphometric mapping.

b) Soil mapping.

c) Landuse Mapping.

d) Land evaluation mapping.

D. *Statistical Methods***:**

a) Correlation Analysis.

b) Analytical Hierarchy Process (AHP) with Weighted Overlay.

c) Quantification techniques.

***E*. *Remote Sensing & GIS*:**

a) Analysis of satellite imagery & data extraction.

b) Data analysis with the help of DBMS software.

c) Map digitization & generation of relevant maps.

d) Drainage line density maps analysis.

e) Terrain modelling.

f) Land suitability classification model by AHP with weighted overlay method.

1.7.4 Library Work

For the compilation of the bibliography as well as the reference works the Libraries of North Bengal University, Library of Ananda Chandra College, The National Library, The Geological Survey of India, The Survey of India, Uttarbanga Krishi Biswavidyalaya, has been consulted thoroughly.

Finally, all the data collected from the field and various institutional sources have been analyzed, processed and computed in the laboratory to predict the exact nature of the problem and to provide a workable modus operandi for the corrective measures for overall development of the study area.