Abstract

North Bengal alluvial plains at the Himalayan margin has a long drawn historical perspective since the Pleistocene period. Subsequently with the passage of time 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. Hence 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.

The present researcher analysis the correlation of the existing landuse with the pedo-geomorphic character of the study area. This correlation study is based on some different perspectives and interrelationships. Finally on the basis of these correlations the lands of the study area have been assessed with a precise objective to recommend the agro climatic resilient land utilization.

The study of geological and tectonic characteristics of the study area is always vital for the study of alluvial fans because the tectonic characteristics confirm the proportion of streams vertical erosion and deposition of new sediments. Lithology of the study area determines the character of the sediments and therefore influencing the form of the fan and its pedogenesis. The tectonic influence on the development of alluvial fans can be considered in terms of fan intrenchment, fan segmentation and also the sedimentology, shape and thickness of each new and old depositions of the alluvial fans.

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. 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, Balason, 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.

The present study area is having diverse physical & climatic characteristics which have been classified into different land segments based on the capability classes to investigate the numerous notch of the competence of the lands for agriculture with other type of applications

in the primary stage and distinguish the arable lands from that of non-arable lands in the secondary stage. Based on the findings, the best fit landuse types and management methods, which will be essential for the preservation lands for future, will be recommended in the next chapter for the sustainable utilization of lands as well as to minimize additional risks of damage of this unique study area.

The shapes of the apex of the fans are changing with modifying fans characteristics after debouching on to the rolling plain. Mass deforestation, unscientific settlement construction on the vulnerable hill slopes, rapid growth of urbanization and associated phenomenon like, construction of roads which results in the addition of extra sediment load in the river channels. Consequently, 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. 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. The result of the analysis speaks about the mechanical &chemical properties of soil with the degree of pedogenesis of the whole study area.

Objective

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.

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.

This study is based on primary and secondary data. Relevant primary data were collected from field survey through conventional survey techniques. Hence, different methodologies were adopted for different objectives. These are:

Analyse the development of alluvial fans in this region referencing of previously published data, research works has been done. Digital Elevation Modeling has been created with the help of GIS platform to visualize the relief of the study area. Analyses of hydrological characteristics have been done on the basis of field observations and drainage maps. Climatic data from different tea gardens were collected and analyzed with statistical tools.

Different morphometric analysis have been carried out such as cross and longitudinal profiles were drawn with the help of GIS tools, average slope, relative relief, drainage density, area-slope distribution study, slope map generation etc. During field survey soil samples were collected from different pits and measurements of fan materials have also been done in logical techniques. Testing of soil samples has been done in well-equipped laboratory. On the basis of the outcomes of these techniques alluvial fan segmentation map was generated.

To identify the existing landuse and land cover of the study area vectorisation of the different topographical maps of Survey of India and open source USGA topographical sheets in support of Govt. of West Bengal's Forests Department etc. have been done with the help of Arc-GIS 10.5 platform and statistical analysis of data was also performed.

To understand the importance of Soil Water Potentiality the Battelle formula of SWP has been relevantly cited. To establish the correlation between Rainfall and runoff the Rational method has been used with other statistical techniques.

Analytical Hierarchy Process (AHP) implemented by weighted overlay technique has been practiced to determine a classified structure of landuse and its suitability as specified by FAO.

Satisfactory standard procedures were maintained during the field survey for the land capability classifications. Determination of capability classes had been done as per the main principles of the land classifications of FAO with required adjustments. Distinctive physical & climatic characteristics of the study area are given highest importance during the identification of capability classes & their sub classes as this area under study is consisted of diversified soil types. The outcomes of different land classes were based on the general rule of observation of the land restrictions of the present study area.

The study revealed that the Development of alluvial fans and their morphometry are strongly controlled by several factors which are segmented as Geo-tectonic factors, relief, climate, lithology, and hydrology since the Pleistocene period. So, on the basis of these dynamic factors of fan development and the morphological characteristics of the fans, it can be said that fan formation process of the study area is still in action.

The pedogenic process here is more in the nature of Podsolization than Laterization. These soils may be taken as typical soils formed by weathering as the presence of iron oxide, alumina and clay indicates considerable amount of weathering. The Red bank soil is generally highly acidic due to the removal of lime and other bases by weathering and leaching action. This soils, however, is very rich in essential plant foods. This is why most of the land under these segments to some extent is occupied by tea gardens and natural vegetation. Upper part has immature soil cover due to soil slips and high surface runoff due to massive deforestation the arable land are not so fertile for crops. The area is however blessed with large nos. of perennial rivers, khals, beels and water bodies. Approximately 141.05 sq.km area which is about 15.87% of the whole study area is under agricultural landuse.

Maximum settlement cover found in the lower fan segment where about 148.51 sq.km. area which is approx. 25.16% of this segment area is under settlement. In many cases the socio-economic parameters and population pressure also drove the configuration of land use parameters by artificial management. In lower fan segment potential crop fields has been converted into small tea gardens supported by artificial drainage system which is also accelerated by legacies of large tea gardens dominated economy. This unprecedented phenomenon adversely affect the physical characteristics like water holding capacity, bulk density, porosity, nutrients stratus etc. of soil in the study area.

The study also depicted that the land use is vastly controlled by the pedo-geomorphic characteristics mainly in the upper fan segment where the slope, altitude, runoff, climate, soil are relevantly synergistic with the land use and vice-versa. In case of soil sand % and altitude are positively correlated where the silt % is having negative correlation with altitude. The water holding capacity somehow manipulated mainly in the lower fan segment with land conversion and artificial drainage. Hence, the harmony becomes questionable in case of middle and lower fan segment where the land use land covers to some extent is not adjustable with the pedo-geomorphic scenario of the study area.

It is also found that the lower fan segment is dominated by silted soil characteristics, more water holding capacity in comparison with the upper and middle fan segment, high rainfall with uneven yearly distribution, stagnation of water in patches, prolong low average temperature etc. based on which some sustainable land use may also be adopted in the lower fan segment.

It can be concluded on the basis of information gathered from the field and from the analysis of morphometric maps, that, the alluvial fans over the study area are divided into three separate segments having different characteristics and pedogenesis. Steep to gently steep gradient, semi-deep trenches and enormous sub angular boulders widely spreading over moderately developed soil are the major features of the upper fan segment.

Hence, the current study illustrates that the agricultural and horticultural land use will be more sustainable land use than small tea gardens in this part of the lower fan segment supported by prolong winter season and compatible pedo-geomorphic characters. Being situated in the highly susceptible to erosion zone, if, any adverse changes stuck down the monopoly tea based economy, this substitute sustainable high value agricultural and

horticultural landuse may control the situation in a positive approach with the support of agriculturally favorable pedo-geomorphic conditions of this segment.

Though agriculture and construction sites are may be targeted away from the fragile zone of the stream bank area with proper planning as this region is formed by diversified alluvial detritus carried by different streams from mountainous tracts.

Over all the following recommendations have been proposed for the study area:

i. Cultivation of high value crops like Gherkin, Baby corn etc. can be practiced on the basis of soil suitability and water potentiality.
ii. In the lower fan segment agricultural activities can be carried out based on soil characteristics and fertility available as suitable soil cover is changeable as new alluvium covers the surfaces by the river bank side almost every year due to seasonal floods and flash floods.
iii. Leguminous crops which develop nitrogen capital and soil compactness resisting soil loss like Arhar (*Cajanuscajan. L)*and pulses (*Vignaradieta, Vignamungo* etc.) can make a sustainable approach towards the development of the area.
iv. Photo and thermo insensitive crop variety can be adopted.
v. Submergence tolerant crop variety may be applicable in the patches of water stagnation.
vi. Deep rooted crops should be avoided.
vii. Intermittent drought tolerance crops can be cultivated with temporal variations.

About 61% of the land surfaces of the study area is occupied by tea gardens and forests. Greater portion of cultivated land is located on the lower fan. Mainly in the upper part of the lower fan segment and lower part of the middle fan segment destruction of forest to meet the demand of land for cultivation and settlement is a regular feature here which initiates soil erosion, landslides, flooding and hinders process of soil found in the upper fan region.