ABSTRACT

The Rakti Khola (local name for river), a principal tributary of the mighty River Balasan; one of the leading river systems of the Darjeeling Himalayas, has owed its origin from the Kurseong range at an altitude of 2000 mt. (a.m.s.l.) & flown through the lofty hills & rolling plains of Darjeeling district, W.B. for a distance of 22.67 km. being associated with its two main tributaries Rohini & Rungsung Rivers. The entire catchment of this river having an area of 65 sq.km. within Lat. 26°44'11"N to 26°53'17"N & Long. 88°15'18"E to 88°21'18"E has been selected for the present study.

It has been observed that the increase in the density of population & their gradual encroachment of lands for tea gardening, settlements, agriculture, etc. by mass clearing of forested lands has thoroughly altered the natural eco-system of the Basin. As a result sudden gush of torrential rain falling over the deforested & abused hill slopes mostly come down as surface run-off carrying huze amount of eroded materials & finally cause the sudden flood & bank erosion as well as deposition of eroded detritus on the river courses giving rise a distinct braided channel system in the plains. Thus numerous problems starting from inundation of the villages & settlements by flood water adjacent to the river banks in the

plain areas to severe soil erosion & catastrophic landslides often take place & create havocks to the local inhabitants in a regular manner.

Therefore, at the present situation a thorough investigation of the problems & a well planned management is of utter requirement to sustain the ecological balance & to maintain the geo-environmental stability for this highly vulnerable region.

Geologically the Rakti Basin is made up of different rocks having varied compositions & characteristics. The upper northern hill portion is composed of metamorphites like gneiss, schists, phylites & slates of Dharwarian system. The lower portion of the hills encompassing the foot hill region is formed of sedimentary rocks like sand stones, shales & conglomerates of Damuda & Siwaliks with occasional Lower Gondowana coal seams in the shales. The rest half portion of the Basin is a wide open plain of alluvial deposits formed in Pleistocene and Sub-recent geological times. Soil of the Basin has a wide range of variation from place to place. In the plains it varies from poorly developed coarse soil to distinctly developed leached horizons of medium & fine textured soils depending on the nature of deposited alluviums. In the hills soil varies in texture, structure & depth depending on the amount of annual rainfall, slope, rock composition & hardness. Climate of this Basin is humid being principally characterised by south west monsoon. The plain areas of the Basin depicts Tropical Rainy type of climate. Hills have a great resemblance with Subtropical Rainy type.

The Geomorphology of the Basin depicts a natural development of the drainage net work of the Rakti River system irrespective of strong geological control since the laws of drainage composition have followed the general rules. The study of the landform configurations through various morphometric techniques

like the analysis of slope, relative relief, drainage density & frequency, hydrographic network, dissection & roughness indices & their correlations reveals that the Basin in its youn geomorphic cycle is consisted of three distinct geomorphic units of varied shapes & forms. The configurations of these geomorphic units, thus, ultimately impose various restrictions on their effective use. As such (i) the rugged middle hill topography at high altitudes having steep slopes, sufficiently infested by streams, rills & gullies is not so congenitally sound for indiscriminate human habitation. This region, therefore, should be utilized for settlements & agriculture with technically sound knowledge mostly avoiding the vulnerable & sensitive hill slopes. (ii) The dissected foot hill topography having series of ridges & vales, varing valley forms & litho -tectono structure with soft and friable rocks is more dangerous for human habitation unless sufficient care for human settlements & agriculture is taken. Therefore, very high engineering techniques for the construction of settlements & scientific terracing & tillage practices for agriculture should be provided for this region. (iii) Plain area having varied soil textures, susceptibility to flood and bank erosion is not a place of haphazard utilization as well. Sufficient intelligence & techniques should be implemented for the intensive utilization of the lands of this region.

The study of Natural Vegetation & its rate of depletion reveals that the Basin is consisted of very rich & valuable species of Tropical deciduous & subtropical montane types of forestes but sad to say that most of the forests have been depleted for tea gardening purpose, settlements, agriculture etc. Chronological study from 1931 clearly shows that the natural vegetation of the study area has declined to only 22.14% in 1991 (from 48.03%) which is far below the amount (33%) prescribed by the National Forest Policy for the restoration of the ecological & climatic balance. Study also reveals that unclassed

forest lands (i.e., forest on govt. owned waste lands beyond the areas of reserved forests) have been mainly deforested for tea gardening purpose, military installations & expansion of settlements. Moreover, density of forests has gradually been thinned by the illicit fellers & even by the practice of unscientific silviculture by forest deptt. itself. Therefore, a well thought conservation practice is to be taken to immediately stop such unwanted encroachment & exploitation of forests & to bring back the Basin to an optimum percentage of vegetation cover prescribed by the National Forest Policy. Keeping this idea in mind two types of conservation strategies are necessary for the Basin. (i) Present management strategies under which some strict rules like immediate inclusion of unclassed forest lands under reserved forests, steps against further encroachment of forest lands by different medias; immediate care of severely affected forest lands & slopes by mass afforestation & plantation of quickly growing shrubs, more strict protection measures against the collection of fire wood, felling of trees etc. should be implemented. (ii) Future management strategies under which social forestry & agroforestry programmes should be started to increase the vegetative growth. Further more the needs & demands for which the poor local inhabitants move towards forest exploitation should be taken care of by giving them facilities & incentives from govt. level.

The Rainfall Characteristics of the Basin prove that the middle part encompassing foot hills & northern portion of the rolling terai plain are under the average annual rainfall depths of 4750 and 5061.50 mm. which are the zones of highest precipation in the Basin. The variability in monsoonal rain (which contribute more than 80% of rain) is higher than that of the annual rainfall of the Basin. Except few stations the whole Basin depicts a distinct lack of rainfall trend & persistence with increasing wet years in the hills. Thus the characteristics of rainfall of the Basin clearly explain its erratic

nature along with the increasing wetness in the hill areas.

The study of the Channel Morphology & the Hydraulics of the Basin shows that with the passage of time the lateral expansion of the rivers on the plain area has taken place head-wardly untill the river channels have reached at the mountain front. It is also evident that after 1965 when the head-ward extention of laterally eroded channels has been almost stopped still then channels have expanded their widths by bank erosion. The flow dynamics of the Rakti River clearly proves that the Basin is associated with very high peak flood flows followed by heavy torrential rain & the general flow behaviour of the channel is highly inconsistent in nature. The study also proves that the peak flood flows are only responsible for broadening the channel widths in the plain area by bank erosion since peak floods, in most of the times, carrying less amount of suspended viscous sediment load increase the shearing stress of the moving fluid & provoke bank erosion. Moreover the scouring of the river beds in the peak flood periods remains very low which also helps the very high flood discharge to erode the Banks. Thus flood and bank erosion finally create a great problem to the settlers boardering river banks along with the gradual expansion of the lower channel areas of the rivers by destroying tea gardens & agricultural lands. Therefore, the implementation of the forest conservation measures (discussed above) to reduce the excess run-off & to prevent the climate from producing sudden high torrential rain should be implemented from this view point also as immediately as possible to control the erosional nature of the river channels especially on the plain areas to bring back the Basin for a healthy human habitation.

The quantitative Assessment of Soil Erosion by water shows that the western & central part of the hills is worst affected place where the actual soil loss has been estimated as $>1000\ t.h^{-1}y^{-1}$. The accelerated deforestation, improper

utilization of tea gardens for plantation coupled with the steep slope & inherent coarseness of texture & structure of the soil has ultimately resulted such severe soil loss. Therefore, this area should be treated with very high conservation measures starting from every possible aggronomic measures (especially mass aforestation) to adequate drainage & slope stabilization methods. High conservation measures are to be taken on the northern, north western portions as well as south of the central hill where the erosional loss of soil by water is from 500 to 1000 $t.h.^{-1}y.^{-1}$. Similarly moderate conservation measures are to be implemented on the foot hills, the north eastern hill & the extreme northern hill tracts where soil erosion by water has been estimated 100 to 500 $t.h.^{-1}y.^{-1}$. Both these areas of soil erosion should be treated with the measures starting from mulching, bench terraces, suitable water ways to organic matter application, cover - crops, application of geowire etc. so that they can not go beyond control. It should be noted that these are the areas of extensive tea cultivation. Low conservation measures are necessary to the largest portion of the southern alluvial plain where soil erosion is from 10 to 100 $t.h.^{-1}y.^{-1}$. Cover crops, crop rotations, contour bunds should be implemented to save the area from further deterioration in the long run. Only a small area on the south western portion of the Basin falling in plain can be kept beyond immediate conservation measures where the degree of soil erosion can be said negligible i.e., 10 $t.h.^{-1}y.^{-1}$ because such small amount of annual soil loss has a chance to tally the annual soil gain. Agronomic measures should be preferred for soil conservation in the Basin because they effectively reduce rain splash, increase infiltration, reduce run-off, resist wind & water velocities. Mechanical measures should be utilized for supplementing the agronomic measures & in time of sheer need only for a successful conservation of soil in the study area.

The Basin area depicts various type of slope failure like talus creep, sheet slide, soil slip & debris flow. The causes

of such landslides, so far have been detected, are structural complication of varied geological rocks, seismological tremor, heavy gush of rainfall, vibration produced by thundering and various anthropogenic factors like deforestation, removal of basal support of slopes, construction of settlements unscientifically over the head of the slopes etc. The assessment of Landslide susceptible zones shows that the entire middle part of the hill tract of the Basin is prone to very high degree of slope failure where as the northern top portion & southern part of the hills are less susceptible. Close study reveals that landslides of the Basin do not result out of only one reason, rather a number of reasons or factors are responsible for a particular landslide. Among the physical factors water plays the most deleterious role for slide occurrences. Nearly all the slides of the Basin get their ultimate shape by human induced causes & endanger the areas where they take place. For preventing such landslides & landslide susceptible zones the treatment of slope configurations, the maintenance of proper drainage facilities, prevention of excessive infiltration & ingress of water, improvement of soil properties, construction of retaining walls & similar structures, vegetative treatment etc. should be implemented as suitable conservation measures for the Basin. Besides, it is also necessary to make the local inhabitants conscious about their activities that are ultimately responsible for slope failure. This should be done by involving the student community to educate the local inhabitants. It is an acceptable truth that the ideas of observing landslides from regional point of view by the geographers & environmental scientists & the ideas to observe an individual landslide of a particular site by construction engineers are quite different and therefore, a compromise between these two ideas should also be done for a successful control of the landslide problems.

The above discussions clearly unveil the various degradational facets of the Basin that absolutely go against the human

habitation & therefore, they should be tackled with steady hands by implementing various management practices (already formulated) as immediately as possible. But in the mean time it is also necessary to estimate to what extent the lands of the Basin area are still efficient for production & what should be done for the restoration of such productivity of the lands to mitigate the needs of local inhabitants? Therefore, a well thought Land Evaluation of the Basin has been attempted to assess the present potential state of the lands & their suitable landuse which can give maximum sustained return to the local inhabitants. The study of land evaluation has been based on the determination of soil water potentiality for agriculture & various land capability classes of the Basin under study. The study reveals that the Basin is consisted of seven categories of land capability classes starting from II class land to class VIII land having four categories of water potentialities (low, moderate, moderately high & high) for plant's or crop's growth. The determination of the land capability classes of the Basin has been done on the basis of different physical & climatic characteristics of the terrain & their limitations for which a particular land is restricted for a specific landuse. Thus the texture, structure, chemical properties, stonniness, rootable depths etc. of soil. the gradient, liability to erosion & wetness of the terrain and the mean annual rainfall as well as temperature & altitude of different places by which climate is changed have been taken into consideration. Moreover the available plant's moisture or water by determining the water potentiality of the soil separately have been added to ascertain ultimately the best suitable landuse practice for a certain class of capable land. It is found in the Basin that the arable lands of different kinds (from class II to class IV) are mainly distributed over the southern rolling plain & a little porttion on the foot of the hills of Darjeeling Himalayas. These lands have suffered from various limitations like sandiness, wetness,

climatic aggressivity, stonniness, slope etc. The non-arable lands starting from class V to class VIII are all located over the hilly tracts of the Basin having various limitations like stonniness, slope, erosion, climate etc. Thus according to the limitations the arable lands should be utilized with various degrees of intensity for landuse practices & conservation measures starting from intense to restricted farming & low to very carefull conservation measures respectively for the maximum sustained productivity of the lands. Similarly non arable lands should also be utilized with the suitable landuse practices starting from intense grazing & woodland product to recreational & aesthetic use. Besides, the non-arable lands up to class VI should be considered for tea plantation keeping the view in mind that the change of existing landuse like tea gardening practice can hamper the present socio-economic set up of the Basin under study. Therefore, a compromise, between the existing unsuitable landuse practices for some lands & their recommended suitable landuse, has been made in such a manner that the optimum productivity of the lands is not hampered & the present landuse is maintained to its maximum extent to provide the lands their sustained ability to maintain the ecological harmony (what-ever) still left in the present set up of the Basin.