ABSTRACT

The Kurseong Sub-Division lies in the South -Western part of Darjeeling Himalaya and is situated between the meridians of 88^0 7′ and 88^0 27′ East Longitude, and between the parallels 26^0 47′ and 26^0 58′ North Latitude. It covers an area of 432.49 square kilometer. Environmental degradation and associated problems are the most pervasive of natural problems that undermine the economic and cultural development of the Kurseong Sub-Division. Ever since the British occupation, extensive heedless deforestation, tea plantation, unscientific slope cultivation, haphazard construction work and inadequate drainage have disturbed the physico-cultural set-up of the area. The unscientific and unplanned usage of land has led to the establishment of vicious cycle of degradation.

Among the various degradational processes, landslide, soil erosion and destruction of biodiversity in the northern hilly tract, and the rising riverbed, flood and destruction of biodiversity along the southern foothills are more important. The situation has deteriorated further in recent years; the last two decades having witnessed the worst lansdslips on the hill slopes and heaviest flood in the North Bengal Plains.

Geologically, the area under study is composed of several types of rock formations of varying characteristics. The northern part is composed of highly metamorphosed rocks like gneiss, schists, phylites, slates and quartzites. The southern hilly tract is composed of sandstones, siltstone, shale, etc. while the extreme southern part is composed of recent to sub-recent alluvium and fan materials.

Topographical study of the area indicates that it may be sub-divided into two broad zones, the northern hilly section and the southern piedmont i.e. the Terai. Geologically, the area is vulnerable to soil erosion as the hilly portions are predominated by intensely metamorphosed rocks like phyllites, schists, slates and gneiss which are highly weathered, fractured, jointed with a tendency to produce slope instability during intense rainstorm.

Deforestation and high precipitation (>3000 millimeters) in the area make it even more susceptible to soil erosion and landslides leading to loss of soil nutrients and endangering the lives and property of the people. The foothill or piedmont zone is the zone of maximum aggredation and exhibits convex slope and fan formation. The area maintains a fair amount of natural vegetation but their distribution and density are not uniform. The piedmont slopes are highly vulnerable to choking caused by the translocation of the eroded debris from the hilly areas.

Geomorphological analysis of the study area reveals that the erosional form of northern hilly part is further sub-divided into ridge, upper hills and lower hills while the accumulative form of southern piedmont zone sub-divided into alluvial fan and deluvial plain. The study reveals that the region is young and active with convex ridges having gentler slopes in upper areas, and steeper at the foot where active down cutting is still evident. Geomorphic processes like the fluvial process, which is the most important, together with denudation, slope wash, and mass movement have been found responsible for the final shaping of lower Darjeeling Himalaya. Major geomorphic forms have been identified in the study area like the denudate outlier, dome like summit, broad ridge, landslide scars, landslide tongue, deluvial and solifluxion plains, erosional cuttings, trough like valleys, gorge, river accumulation, alluvial fan, river terrace. The quantitative analysis of the various morphometric properties of 67 third order basins also reveal some striking results regarding their multiple process-response relationships. It has also been revealed that the various function of the drainage network is still under operation, which might be demonstrated by the re-organisation of the morphometric parameters of the drainage. The streams are still extending their length, the consequent increase in relief ratio, drainage density, elongation ratio and stream gradient to adjust themselves with the existing terrain typified by variations in lithology, structure, relief and vegetation. The region is thus, trying its level best to remove the vagaries of inequilibrium and to put one step forward to enter the stage of late to early maturity in near future.

The study of land-use changes since the day the British started developmental activities in

the region reveals how the dense virgin forests were gradually cleared and depleted to give way to the development of tea, settlements, cultivation, roads and communication and other developmental activities to promote tourism and thereby increasing the environmental hazards that we are now exposed to. Incidences of environmental breakdown like the first recorded landslides of 1899, which took the toll of many lives and loss of a lot of property in the area following unprecedented rainfall, have been found related not only to the natural phenomena of the heavy amount of rainfall but also to defective drainage of sites, excessive lead of drains, imperfect or badly constructed revetments, neglect to reduce or protect steep slopes, defective supervision of building sites and quarrying in unsafe localities. It indicates how man's activities in the area has escalated the pressures of an increasing population on the ecologically fragile environment leading to widespread deforestation, soil erosion and landslides, and floods in the plains.

The assessment of soil loss by water erosion has been attempted through the study of its processes and mechanisms and apprehending a number of diagnostic criteria. A formula for proposed conservation plan has also been presented to protect the extremely vulnerable soil against erosion. The study reveals that the forest-clad mountains of Kurseong Sub-Division of Darjeeling Himalaya, with high precipitation, have been subjected to man's heedless activities that have accelerated the average soil erosion. The worst affected north-western and north-central parts (upper Balason and upper Mahananda basin respectively) have been found to be mostly deforested along with skeletal soil and very steep slope ($>30^0$), and therefore, need immediate conservation measures like large scale afforestation with suitable terracing and drainage facilities to check massive soil loss. The study points to the special attention that should be given to the roads, railways, tea gardens, agricultural terraces and in and around the existing settlements. The southern and south-eastern parts have been found to have very low to negligible amount of soil loss (below 5 tons/h^{-1}/y^{-1}). This amount is most probably below the upper limit of the permissible soil erosion and thereby, no immediate conservation measures are required. The study also reveals that high to very high level of conservation measures are required in many areas of northern and central parts of the study area, where, extensive tea plantation and terrace cultivation exist, and where the amount of

soil loss has been estimated to be in between 250 to 2500 tons/h^{-1}/y^{-1}. For the areas located along the ridges and the southern margins of the study area, moderate level of conservation has been proposed, while, low level of conservation measures has been recommended for the southern piedmont slopes and the northern ridges. Among the various conservation measures, the agronomic measures should be given preference because they are less expensive and deal effectively in reducing the impact of raindrops, increasing infiltration, reducing run-off, volume and decreasing water velocities. It is also easy to fit them into the existing land-use system.

The study area is the show place for various types of slope failures, of which, slumps, soil slips, debris slides, mud rock flows and debris flows are important. Assessment of landslide prone areas show that the settled areas, areas along the roads and railways, tea gardens and the valley side slopes are highly susceptible to large scale slope failure phenomena.

The analysis of the landslides has revealed the characteristic peculiarities of each of the landslides under study indicating water as having the most deleterious effect. While some of the slides have been caused by toe erosion of the drainage elements, some of the slope failures have been found to be the result of unscientific and unplanned human interference disrupting the delicate hill eco-system. The study highlights the fact that the choice of remedial measures to prevent landslide and similar slope movement should be made after careful analysis of the causative factors and that the design of the preventive structures should depend on the geomorphological and geological framework of the region and strength of the materials involved in the landslide. Treatment of slope configuration, improvement of drainage facilities and retaining walls, afforestation and restriction to human settlements are identified as the most important corrective and preventive measures to be adopted in the study area.

The study water resources reveals that the Kurseong Sub-Division of Darjeeling Himalaya is unable to hold back water due to extensive deforestation and commercialisation of hill slopes, as a result of which most of the precipitated water goes down the slope, giving rise to

severe soil erosion and landslides. The debris, which is translocated and deposited in the riverbeds, restrict the free passage to an excessive amount of run-off, which follows heavy and concentrated rainfall and thereby causes flood. On the contrary, during the non-monsoon months the shortage of water hinders the local people from deriving any benefit out of soil, in conjunction with the river itself. The study assesses that out of the total surface water resource of 1035.514 million m^3 (based on long term empirical model) or 1347.15 million m^3 (based on discharge run-off model), nothing substantial has been utilised commercially. The sub-surface water reserve has also found to be commercially untapped. It has therefore, been found absolutely necessary to devise suitable ways and means to conserve such huge unutilised water resource. Suggestions like the construction of a number of check dams across the river at suitable sites to preserve the monsoonal supply for re-distribution during the non-monsoon months, construction of mini-hydel projects and tapping the mountain torrents at suitable sites to provide with the vital energy base for domestic and industrial activities in the Sub-Himalayan West Bengal have been made. The study brings out the fact that in the absence of suitable water harvesting facilities, the vast quantity of monsoon supplies goes waste. Thus, the problem of proper scientific management of water redistribution during drought needs an immediate and closer investigation.

The Impact assessment of selected developmental activities on the environment through studies involving impact identification and case studies consisting of phytosociological analysis of man made forest and study of man induced landslide has been conducted.. Quantitative assessment of environmental impact of developmental activities has been attempted based on Leopold's matrix. The vegetational studies reveals that the number of species represented in the *Cryptomeria japonica* plantation is less than that of the natural forest. The natural forest area possesses a multilayered structure with trees, shrubs and herbs of different sizes comprising the upper canopy, middle storey and the under growth. In comparison to this, the Dhupi plantation is found to be devoid of the multilayer structure and almost lacking in undergrowth. The ground remains covered with a thick mantle of undecomposed dhupi needles. The study therefore reveals that changes in regime with the

introduction and growing of exotic species as a monocrop are detrimental to the species diversity of the area and induce increased surface run-off leading to more soil erosion in the absence of undergrowth.

The study of man induced landslide reveals how unscientific and irrational activities of man can cause irrevocable damage to the environment. It illustrates how the activities of man in a geologically unstable area have aggravated the conditions to extreme limits, like the common practice of disposing the talus materials, resulting from the excavation of hill slopes and hill tops for various purposes, downhill and in many cases into jhoras and kholas in the hilly region. The case study exemplifies how such an action has initiated landslides that have affected the road communication, agricultural fields and threatened the normal life of the local people residing in the vicinity The cutting of the hilltop and throwing the excavated material downhill into the source of Marma khola has initiated landslide in the area and the entire tract along the khola. The studies on impact assessment therefore reveal that developmental activity can cause problems serious environment degradation particularly in the case of such an activity being inconsiderate to the law of nature or unmindful of the fragile nature of the Himalayan ecosystem.

Thus, it is apparent that the fragile ecosystem of Kurseong Sub-Division has been disturbed seriously through unscientific and unplanned uses of land, heedless deforestation, over grazing and so called short sighted development activities, thereby endangering the life and property of the local inhabitants. Under existing conditions of environment degradation manifested by the occurrence of increased soil erosion, frequent landslides, disturbance in the delicate hydrological balance and biodiversity, deforestation and floods in the study area, it has become imperative to review and analyse the impact of the developmental activities in the area so that a comprehensive plan can be projected to offer every possible remedial measure for every type of adverse effect and to advise also the precautions that are pertinent and need to be followed before taking any developmental activity in the area. Immediate steps have, therefore been recommended for suitable afforestation of vulnerable areas,

restriction of agriculture and settlements to stable geological formations and propagation of scientific knowledge to the people for an effective solution to the problem of degradation. The overall restorative measures in the area under study should also be directed towards providing positive alternative sources of energy to the local inhabitants, so that they are not forced by circumstances to seek out the only existing natural source of energy, the timber. Tapping of perennial mountain streams through mini-hydel projects may provide a source of cheap, sustainable and environment friendly resource for energy to the local inhabitants to run their daily needs. Once, such projects become economically viable, the local people will automatically shun the laborious habit of cutting trees for fuel. As a result, the vegetal cover will ensure consumption of a good part of the total rainfall thereby lessening total run-off as well as fury of soil erosion, landslides, and minimizing the danger posed by the rivers as a result of sedimentation. A good deal of water which is being lost to the plains lower down would be conserved, enhancing year round stream flow, soil moisture as well as fertility and thereby multiplying the blessing of nature.