

CHAPTER V

PROBLEMS RELATED TO SOIL EROSION AND THEIR EFFECTS

INTRODUCTION :

This chapter deals with various land usages which are erosive in nature . They aid and abate the fundamental erosional mechanisms and processes bringing about the effect of overall deterioration of , both , the climate and the productivity of any area . The problematic practices discussed in details are , faulty cultivation practices , unauthorised quarrying , unscientific water disposal , construction of new roads , extension of existing roads , construction of dams bridges , etc . , over settlement , deforestation , overgrazing , and forest fires . The effects discussed in details are deterioration of climate , shortage of fuel and fodder , increase in flash floods , reduced water supply , damage to reservoir and irrigation channel , damage to communication routes . To get an insight into the effects of soil erosion the problems need be discussed first .

5.1 PROBLEMS :

Among the problems related with soil erosion , faulty cultivation and land management practices are of paramount importance .

5.1.1 FAULTY CULTIVATION PRACTICES :

Major land use in the study area is tea cultivation . There are some pockets of agriculture in sprawling tea gardens . Several faulty cultivation practices have been noticed in the study area .

The study area by virtue of having a very high rainfall , generates large amount of run off from the fields . Cultivation of contour terraces is absolutely necessary . The contour terraces act as a series of miniature reservoirs to hold excess run off and provide increased time opportunity to soil to absorb as much water as possible (Singh et al , 1991) .

It is seen that several tea gardens have raised tea crops without proper terracing of land. In other cases , even if terraces are made , they are very poorly maintained as in Singel tea garden (Plate 7) and do not provide any protection to soil against run off . Invariably in such tracts the tea bushes are extremely sickly and have very low yields . In some others (Ambootia tea garden) , it is seen that extensive soil working has been done to raise a new plantation without any terracing (Plate 8) . Though the slope is not steep and area is protected from



PLATE 7: POORLY MAINTAINED TERRACES IN TEA GARDEN
(SINGLE TEA ESTATE)



PLATE 8: SOIL WORKING ON SLOPING LAND IN TEA GARDENS
(AMBOOTIA TEA GARDEN)

straw mulch during rains , the soil and nutrient losses are formidable . In agriculture lands , terracing is quite common . But except a few patches on the stretch between Sonada and Ghoom - Jorbunglow , most of terraces are ill maintained and outwardly sloping ones . Since construction and maintenance of terraces is quite costly , it is only the wealthier farmers who are able to afford them . Outward sloping terraces have been seen in and around Gorabari , Dilaram , Tung , Sepoydhura , and Pachim . Among the tea gardens , Cedar , Mandakoti , and Talkat tea gardens are seen having outwardly sloping terraces . Large number of abandoned fields are seen around Gorabari and Pachim , probably , because of low fertility and exposure of rock outcrops due to excessive soil washing . Outward sloping terraces , especially in case of agriculture where intensive soil working is necessary , are instrumental in causing lots of damage by washing down top soil , soil nutrients and soil organic matter . Wherever impounding of water is done for cultivation as for paddy , land slides often result (Plate 6) . This is also seen that no proper arrangement are made for disposal of excess water from terraced fields . Terrace risers get broken here and there and once impounded water is let loose , it goes down breaking a series of them . This results in gullying . Soon landslides over take , devours part of field and renders rest the least fertile and most degraded . Such fields are abandoned as maintaining of terrace risers becomes uneconomical once the top soil is washed .

Among the agronomic practices , cultivation of potato and maize are quite extensive in the study

area .Both of them need intensive soil working during rainy season . Cultivation of maize without any soil conservation measure causes heavy erosion on the sloping land (Khybri , 1991) . Both , maize and potato along with vegetables are considered as soil depleting crops as they leave little or no residue on or in the soil (Michael et al , 1981) . Besides , it has been seen that potato is planted along the slope (up down the slope) in the study area leading to enhanced erosion . No crop rotation is seen as most of agriculture is single cropped and rain fed . This leads to degradation of soil over a period of time . The fact that simply by adopting appropriate cultivation procedures , it is possible , without any great increase in cost to reduce soil erosion by up to 80 percent is realised little by cultivators (Zachar , 1984) .

5.1.2 UNAUTHORISED QUARRYING FOR BOULDERS :

Large size boulders are common on the jhora beds in humid regions . These boulders protect the soil underneath which would otherwise be washed down by the gushing torrential waters . Besides this , the boulders work as natural barriers , and reduce velocity of flow considerably . Roughness of beds , too , increases . On account of this , effective gradient of jhora and the height of water fall are reduced . Due to zig zag movement of flowing waters caused by presence of boulders in the jhora bed , the length of slope of running water is increased , thereby reducing the gradient of running water further . All these

factors tend to reduce the energy gradient of running water as much as possible providing stability to jhora banks and beds .

Once the boulders are removed during dry season , the soil underneath gets exposed . The running waters rushing down the jhora during the following rainy season , carries the exposed soil along exposing still deeper layers . The process continues . The jhora goes on deepening and banks go on slumping till a fresh layers of boulders has lined the bed again either by exposer from deeper layers of soil or by deposition from the bed load carried from upstream side . During the next dry season these boulders , too , get removed by unauthorised quarrying . The process continues with consequence of widening and deepening of jhora ultimately leading to mass failure of the nature of land slide or debris flow .

The unauthorised quarrying was unknown a few years back . During political disturbances in Darjeeling hills between 1986 and 1988 slackened control resulted in ominous start of unauthorised quarrying . As per Forest (Conservation) Act , 1980 , boulders in hills are permitted to be brought only from a few river beds in plains , the collection by unauthorised quarrying of boulders increased by leaps and bounds . Being cheaper than that brought from plains , these boulders got ready market .

Tea gardens , too , are contributing to unauthorised quarrying . All the constructions in tea gardens , especially roads , culverts , bridges and buildings , use large quantities of boulders collected locally . Very little of boulders

are imported by tea gardens from the stable river beds in plains . The boulders are usually dug out from the degraded areas within the tea garden leading to further degradation of site .

Specific localities where unauthorised quarrying is seen in the study area are large in number . The jhora near Phazi catchpit , meeting river Rinchintong on its left bank , (200 mt down stream from Dilaram factory) is subjected to quarrying . The stretch of Hill Cart road between Gorabari to Rinchintong has several sites of unauthorised quarrying . At the time of survey during November 1993 , about 200 cub. mt. of boulders were seen stacked along the Hill Cart road in this stretch . A site , 100 mt down the road from Dilaram bazaar , is subjected to intensive quarrying . A jhora crossing Hill Cart road , 200 mt north of Tung railway station , too , is subjected to intensive quarrying . So is the case of Chaitapani jhora draining the stretch between Goethal's memorial school and St. Mary's Hill (Plate 9) . On a site 100 mt down the Hill Cart road from Sonada bazaar , a precipitous uphill slope along the road is being quarried dangerously . The Sonā Hollow Block Industry , located on the left bank of Rinchintong jhora on Hill Cart road has been quarrying sand over several decades without any apparent check adding enhanced sediment load in the stream . Near Cedar basti and Pachang bazaar , a few sites of unauthorised quarrying are seen . The list is the least exhaustive . Because of paucity of time and resources , detailed survey could not be undertaken . However , it is believed that unauthorised quarrying has taken very serious dimensions in the study area . There are innumerable spots where



HILL CART ROAD

PLATE 9 : UNAUTHORISED QUARRYING ALONG
HILL CART ROAD
STACKS OF BOULDERS SEEN

men and women could be seen breaking boulders into chips and metals for selling . What is even more serious is that , after the loose boulders are exhausted , rock outcrops jutting either in the bed or in the bank are attacked with hammer and chisels . These rock outcrops are the anchors and help transfer the weight of the land mass lying upslope to the deeper strata of earth . When they give way , mass failures occur .

5.1.3 UNSCIENTIFIC WATER DISPOSAL :

The disposal of water in any tract should be done through natural drainage systems. Nature has designed each jhora , however small or large , to carry a certain quantity of water from its catchment . If this quantity is altered , the jhora redesigns itself . If flow is augmented , velocity of flowing water , hydraulic radius of flow , and gradient of surface of flow , increase . This shall be a high energy situation and hence unstable . The flowing water shall tend to attain a low energy situation by reducing the velocity . As per fundamental principles of flow of liquids in open channel (Manning's formula being one based on that) , the reduction in velocity can be brought about by reducing , either hydraulic radius or surface gradient or both , of the flow . The result is widening of flow channel or meandering of flow . The former reduces the hydraulic radius , and the latter , the surface gradient , of flow . In nature , usually , a combination of these two occur and a river , when it widens , invariably meanders , too . The results are disastrous from the point of view of soil conservation . Any

considerable slumping of otherwise stable stream banks is sure indication that the flow in the channel might have been augmented.

The black top hill roads traversing across the slope and having elaborate drainage systems, are the biggest factors in changing fluvial pattern on hill slopes. The drains along the hills run for a considerable distance collecting flowing water from smaller jhora finally debauching the same in bigger ones where bed is considered "stable". Little is realised that as per the fundamental principles of flow of liquids in open channels, slumping of banks shall take place. More often than not, such accumulated flows result either in landslide, or in subsidence. It is far better if each small drainage line is given its way; its flow characteristics and natural catchment is altered as little as possible. It is not done, probably, on cost consideration as each jhora shall have to be provided with a safe passage across the road. The present practice may be economical for the time being, but the overall loss in long run is colossal.

The dirt road in the study area provide another instance of unscientific water disposal. These roads are often not provided with proper side drains. During a rain storm, it is a common sight that water is flowing on the surface of such dirt roads. Agricultural fields, even if terraced, do not have proper system of disposal of excess water by grassed water ways. In some instances, water from jhora is directed through irrigation channels for flood irrigation and excess water is not properly disposed off. This leads to soil degradation down slope.

Due to unscientific disposal of water several instances of soil erosion are seen in the study area . Dirt road in Maharani tea garden is damaged due to this about 2 km above Dilaram tea factory . In Margarate's Hope tea garden , faulty water disposal along the roads has led to rill and gully erosion . In Chhota Ringtong and Bara Ringtong tea gardens , several dirt roads (some of them abandoned) , are seen without proper drainage . They are contributing a lot to the sediment load of Pachim river . Many foot tracks are degenerating into gullies . In Rongmuk , Oaks and Mandakoti tea gardens , too , roads are not provided with proper drains and water flows on the road surface causing severe soil erosion . In Talkat and Milling tea gardens few foot tracks are seen degenerating into gullies .

5.1.4 EXTENSION OF ROADS :

Extension and construction of roads is yet another activity causing lots of erosion . This involves cutting of earth for making road bench . In the steep hilly terrain , spoils are never transported from the site or are used otherwise . Invariably they get dumped on the down hill slope . With coming of rains, most of it gets washed down the slope . It buries productive fields rendering them waste . Progressively , it is washed down the stream making entire expenditure on soil conservation any where in the catchment infructuous . The process of washing down of spoils , continues over several years rendering the stream muddier that long .

In addition to soil erosion problems related with the dug up earth , the road bench cuts across many a streams changing hydrological characteristics of drainage lines . This often leads to flow of water on the surface of road dislodging freshly exposed soil particles . This adds to the spoils ready to be washed down the slope . Because of obstructing road bench , water starts flowing chaotically some times leading to failure of road bench and , if sufficient water flow is available , to mass movement of soil .

Study area has a well developed road network. Many are black topped with reasonably good side drains . On account of this , there is no great need for construction or extension of roads . Two specific instances that need be mentioned are the new road being constructed from Pubong Phatak (located near Lepchahagat) to Dudhia and an air strip under construction on a site about 2 km south west of Rongbul . The Pubong Phatak - Dudhia road is a very ambitious project taken up by Darjeeling Gorkha Hill Council . This has been only partly constructed and has brought about very severe soil erosion in Upper Balason Catchment . As the cutting of road bench proceeds further in future , it is likely to contribute increasingly higher amounts of sediment load to the rivers . The air strip is being constructed on top of a spur emanating from Rongbull . Here , too , flattening of ground involves huge amount of earth cutting . The dug up earth is getting washed down to , both , Upper Balason and Rongmuk rivers . Minor extension of some roads has been seen in Rongmuk tea garden . In Oaks tea garden , too , construction of one new dirt road is

causing a lot of soil erosion . Similarly one dirt road , leading from Cedar tea garden to Rongmuk factory is also showing lots of soil erosion . One new foot track being constructed about 300 mt below Sonada bazaar is also showing erosion .

5.1.5 OVER SETTLEMENTS :

Over settlements , as such , do not affect very largely soil erosion status of any particular tract . The effect is more indirect than otherwise . Heavy concentration of population is often accompanied by increased concentration of cattle population , too . This necessitates increased supply of fodder and brings about increased pressure on pasture lands leading to their degradation . Grass becomes scarce during winter and summer when trees are badly lopped for fodder . This results in reduced canopy density causing greater splash and sheet washing during next rain. Heavy concentration of human population requires larger quantity of fuel wood . This tells very badly on the sustainable use of woody vegetation , especially forests . Heavy concentration of population is almost always associated with large destruction of forests . This leads to all possible forms of soil degradation including leaching down of soil nutrients and organic matter impoverishing the soil further .

In the study area , the highest population density is met in the Kurseong town , the density being 3566 persons per km² in 1981 (Appendix IX) . This value has gone up to 5430 in 1991 (Govt. of India, 1991). The lowest population density of 66 persons per km² is met in the Ghoom forest

. The Hill Cart road village and the ST. Mary's Khas mahal have high density of 2068 and 2039 persons per km². Among the tea gardens, Maharani is the most and Ambootia the least, populous. Maharani tea garden is located very close to the Mahldram forest, causing spectacular degradation of forests around Sepoydhura, Tung and Dilaram (Plate 10). It is seen that in 1981 the population density for the entire study area is 465 whereas the over all density for the Darjeeling district was 325 (over 143 percent above the average).

5.1.6 DEFORESTATION :

Another important factor leading to soil erosion is deforestation. To understand the menacing effects of deforestation, one has to consider, first of all, the influence of forests.

Deforestation, as is obvious, brings about a number of pedological, hydrological and environmental degradation. Removal or thinning out of canopy, exposes the soil beneath to the full erosivity of rain storms. This sets in various soil eroding processes and mechanisms active. So long top soil contains some organic matter, soil particles are not easily splashed by the impact of rain drops. The organic matter, however, does not last long. Organic molecules with low molecular weight are first to depart. Others follow soon. Soluble salts and soil nutrients are leached down far quickly than the organic matter. In situations of splash erosion, fine soil particles block the pore spaces making soil impervious. Even there



PLATE 10: EXTENSIVE DEFORESTATION ABOVE
SEPOYDHURA

be elaborate root channels beneath , water is not allowed to percolate down . Thus , volume of run off is increased with consequent effect on soil erosion .

In various phases of forest's progressive succession towards the climax , the corresponding plant associations modify the site and prepare the way for plant associations typical of following phases until the climax is reached . Wherever the progressive succession of forest vegetation is allowed to evolve without outside interference , above all by man , the forest supplies the most complete and most efficient defence of soils (Pavari , 1978) . There is a marked contrast between the influence of forests and influence of other plant covers , especially grass cover . Grass , when it is dense and unbroken , provides an effective defence against surface erosion ; but it affects soil porosity only along a comparatively thin layer , while the forests probe to a far greater depth . The grass cover (more so because it easily gets saturated) facilitates surface run off , while the forest , when there has been no interference , tends to encourage infiltration and absorption of water and to increase under ground supplies . In forest stand , water can move rapidly , both , parallel to the slope and downwards . Where underlying soil horizons are dense , root channels may be the principal path ways for water movement (Hoover , 1978) . More than 10,000 vertical channels per ha in a hard wood forests growing on silt loam soils has been reported (Gaiser , 1952) . These channels are formed by decay of roots . They may be nearly hollow or may be filled with soils resembling A1 or A2 horizon .

Many lateral channels radiate outwards from the central core and they also contain very permeable materials . In the course of one forest generation, several thousands of vertical channels are formed . The fact that the decayed root system are interlocking in a horizontal and vertical network , increases their efficiency in distributing water through the deeper soils . In addition to forming passage ways for rapid water movement , the large pore space provides an opportunity for temporary water storage . This water is only temporarily held , but this form of storage is exceedingly important because it prolongs the period during which water can percolate into underlying strata . This also provides emergency storage of water which is otherwise forced to move off over the soil surface . Forests use water in large quantities and a watershed bare of vegetation is capable of yielding a larger quantity of water than that when it is fully under the cover of forest . Denser and more luxuriant the forest vegetation , greater the loss of water to the watershed . Forest cover tends to equalise the run off over a longer period of time. It increases storage capacity of watershed (especially where soil are thin and heavy and impervious) and reduces soil erosion . In general, if primary object of land management is flood regulation and soil stabilisation , the aim should to maintain densest possible cover of vegetation . If , on the other hand , object is to obtain maximum water yield compatible with soil stability and flood regulation , minimum of vegetation above the critical level of deterioration need be maintained (Hoover , 1978) .

As is seen from Appendix X , a total of 4777 ha of forest is there in the study area . Out of this , tea gardens have 845 ha and Govt. forests account for 3780 ha and the rest 152 ha are located in private ownership . The condition of privately owned forests , which are in small patches in homestead lands , is good . Tea garden forests are mostly degraded . So are those owned by the Government , especially on south - western aspect . The localities where extensive damage to forests have been done are Mahaldram and Senchal forests . These areas are flanked by heavy density of population and have degraded mostly on account of illicit collection of fuel wood .

5.1.7 OVERGRAZING :

Yet another practice leading to soil erosion , is overgrazing . This is a menace and generally does much more serious damage to vegetal cover than is usually believed . The entire country has the problem of overgrazing . In 52 percent of India's forests , there is no regeneration owing to the combined effect of biotic pressures , the chief among which is overgrazing . While the policies advocate a strict grazing practice , cattle entry into reserve forests continue to be free and unregulated (Sunder , 1992) . Constant grazing even in alpine pastures has caused the diminution of phosphoric acid in the soil (Chatterjee , 1980) . Usually in alpine pastures , too , the numbers grazed is beyond the grazing capacity and , hence , impoverishment of pasture is the result . Sheep and goat are arch enemies of vegetation . Sheep graze on grass only whereas goat is a voracious

browser which devours leaves , twigs , small branches , and leading shoots of the plants , either killing them or mauling them very badly . Overgrazed slopes show erosion and characteristic heavy trails of cattle criss crossing one another . Sheep and goat trails are spectacular and extend on even very steep slopes . Overgrazed grass lands degrade into bush land and dry thickets . The removal of protective vegetation combined with the trampling of the soil surface by animal hooves , leads to a rapid loss of soil , a lowering of infiltration rate and flash flooding (Edward et al , 1990) . In regions of high rainfall erosivity and high soil erodibility , this cycle is self propagating and may lead to the wide spread removal of soil by sheet and gully erosion . Moderate grazing produces only negligible soil erosion , whereas heavy grazing brings about great loss of soil . In forest ecosystem , under Deodar stands , overgrazed plots produce seven times more soil loss , several times more nutrient loss and less than one third litter fall in comparison to the control plot (Singh et al , 1995) . Though variable with species to species , in general , moderate grazing leaves approximately 10 cm of stubble height , whereas that height after a period of overgrazing is 5 cm or even less (Dunford et al 1969) .

Secondary succession on grazed timber lands can be encouraged by limiting animal use , which decreases damage by , both , grazing and trampling . Stepping on trees or grass and soil compaction can be even more damaging than grazing . Soil compaction is specially serious when the soil is too wet to

bear an animal's weight without making deep foot prints (Harris et al , 1984) .

In Darjeeling Forest Division , which contributes north and north - western parts of the forests in the study area (Ghoom Simana forest) , open grazing was earlier allowed only in areas north of Little Rangit river . Elsewhere , it was restricted and allowed only on the strength of permits . The deleterious effect of overgrazing on soil and regeneration are noticeable in these parts of upper hill forests where undergrowth has been reduced to those species which are non - palatable to cattle . Natural regeneration of tree species have become practically non - existent as a result of continued browsing and trampling . There are a number of departmental bathans where cattle are stall fed . The owners are allowed to collect fodder from the adjoining forests and there are fenced areas around the stalls where cattle can exercise . This system was introduced to discourage open grazing which often degenerates into overgrazing . But in practice , bathan stall feeding has been found to be of limited utility due to indifferent attitude of cattle owners (Govt. of West Bengal , 1970) . Though Darjeeling Grazing Rules were made way back in 1895 , and were meant to regulate grazing in the reserve forests of Darjeeling Forest Division , they could not save the forests from being overgrazed . In case of Kurseong Forest Division , which contributes forests located on the eastern part of the study area all along , forests were always closed for grazing . Nevertheless unauthorised grazing took place along the boundaries . In younger plantations adjoining the localities ,

damage to seedlings is caused , particularly by goats (Govt. of West Bengal , 1959) . It is reported in subsequent Working Plan , too , that unauthorised grazing damages younger plantations near human habitations . Even forest villages , established with sole purpose of propagation of forests , have started contributing their share of cattle involved in such overgrazing (Govt. of West Bengal , 1976) .

5.1.8 FOREST FIRES :

Forest fires do a lot of damage from view point of soil conservation . They alter the physicochemical and biological property of soils by heating , altering and removing substances and exposing the surface . The nature and degree of alterations depend on soil properties , fire intensity , and duration , topography and climate . The processes involved are complex ; effects can not be predicted accurately and some times appear contradictory . During a forest fire heat moves into soil by conduction and within the soil by conduction , convection and diffusion (Barney et al , 1984) . Quantity of availability to plants of N , P , K , Ca and Mg tend to increase temporarily in the upper mineral soil when overlying organic matter burns . Soil pH increases in direct proportion to the amount of material burnt . Virtually all species of mesofauna (mites , collembolids etc.) and macrofauna (large insects , spiders , earthworms , snails) experience an immediate , sharp population drop following a forest fire . Some require years to recover . Some are persistently kept at low levels by repeated burning . Earthworms tend to decline

more than other species because of drier surface soils . Ants increase disproportionately because of more xeric habitat .

The effect of fire is so great on total runoff that control of fire is considered as one of the most effective tools of flood control (Heard et al , 1969). Potential harmful emissions from forest fires include carbon dioxide , carbon monoxide , hydrocarbons , nitrogen and sulphur oxides , and particulate tarry droplets , ash , shoot etc. The effects of burning are extremely detrimental when heavy rain follows immediately after (Dunford et al , 1969). Fire on grass land does much more damage than is generally recognised. The time one watershed needs for complete recovery from severe fire would be hard to determine . It may be measured in decades for grass lands and brushwood and in centuries for forests (Friedrich , 1969).

In Darjeeling district , fire is a great source of danger in upper hill forests . In these forests fire breaks out easily due to strong winds and presence of dense bamboo undergrowth. The study area , where upper hill forests are non - existent , does not suffer from any serious forest fire . Crown forest fire is unknown in the study area . In excessively dry weather , younger plantations do suffer from ground fires . Protection of younger plantations from grazing produce profuse regeneration of grasses . These dry during summer and present fuel for occasion fire , sweeping through plantations . Forest fires are completely unknown in the north - western parts of the study area which has easterly aspect . Another reason for absence of forest fires in the study area could be extensive monoculture by conifers

which produce little leaf litter and do not encourage multi-tier forests .

5.2 EFFECTS OF SOIL EROSION :

Soil erosion has a multitude of effects on quality of life of any nation . One of the most important injurious effects of soil erosion is the deterioration of climate which is discussed next .

5.2.1 DETERIORATION OF CLIMATE :

Continued washing of soil progressively degrades the top soil and reduces the fertility leading to progressive deterioration and finally disappearance of vegetation . These leads to extremes of climatic conditions . In regard to temperature , maximum and minimum reach a new peak . Humidity is lowered because of absence of transpiring foliage . While the evaporation of moisture from the soil is increased , the incidence of convection rain are reduced because of disappearance of forest cover . Thus , erosion results in extremes of temperature , lower humidity , increased evaporation and decreased local precipitation .

In the study area , in general , soil erosion has brought about reduced density of forest vegetation . The effect is very pronounced if areas are grazed heavily . In tea gardens patches with sickly tea bushes are met in plenty . Though

study area is too small to get any meaningful inference about impact of deterioration of vegetal cover on various environmental parameters, it is a general experience that flood peaks, incidence of landslides and extremes of temperatures have increased.

5.2.2 DETERIORATION OF CULTIVATED FIELDS :

The surface soil lost with run off consists of rich productive soil and fresh or active organic matter. The eroded material which is ultimately carried into ocean, and thus lost, consists of colloidal matter, clay, silt, and finest grade of sand. Only a small fraction of the eroded material is generally deposited in river beds or plains when the velocity of water reduces with the reduction of slope of river bed. The soil deposited in a river bed or reservoir is not only unavailable for cultivation but is definitely harmful.

Shallow stony soils consequent to sheet erosion and badly cut up and gullied area consequent to gullying have never been liked by cultivators. Such areas are often abandoned as agriculture there becomes uneconomical. Damage of cultivated fields also takes place due to deposition of erosion debris. Velocity of flow comes down appreciably as rivers enter the plains. Most of the debris are deposited in the bed forcing the streams either to change their course or overflow its banks. In former eventuality, rivers destroy large tracts of productive fields and in later deposit sand, gravel and boulders on the fertile fields turning them into barren waste. In dry and arid

areas moving sand dune often cover the fertile fields rendering them a waste land .

In the study area , deterioration of cultivated fields is mainly on account of sheet washing , gullying and land slips . In the upper zones of almost all the five river basins large number of abandoned agricultural fields have been noticed . The soil depths are definitely shallower in the upper reaches and a slight negligence by the farmer erodes the shallow top soil beyond the stage of recovery . Such fields are soon abandoned . Many of such abandoned fields are also severely overgrazed , subsequently , causing reversal of natural restoration processes , if any . In tea gardens , too , wherever tea bushes do not provide complete cover to the soils , they have deteriorated resulting in rickety tea bushes struggling for survival . Most severe degradation is seen on the steeper slopes which are overgrazed , burnt and subjected to quarrying of boulders .

5.2.3 SHORTAGE OF FUEL AND FODDER :

As forest degrades , a very important source of fodder disappears . This affects badly the health of pasture lands as they as excessive burden of grazing is forced on them . The over all shortage of fodder affects the health of livestock in general . Consequently the cattle population slowly degenerates into scrub . Deteriorating forest do not produce optimum timber and fuelwood aggravating their scarcity further . In the study area , shortage of fodder is quite acute . It is a

common sight to come across scrub cattle moving around inside reserve forests in huge numbers . Similarly , large number of illicit firewood collectors could be seen entering the forests and removing whatever wood they could lay their hands on .

5.2.4 INCREASE IN INCIDENCE OF FLOODS :

Because of complete absence or only a scanty presence of vegetation and greatly reduced infiltration capacity , the run off from river catchments is greatly increased . This results in more frequent floods than usual . Besides this persistent deposition of sediment load in flatter gradient of river beds , progressively reduces the capacity of river channel leading to more frequent floods even with smaller rate of discharge in the channel . In valleys , along the river banks , some paddy and maize fields are occasionally affected by floods for short duration of time .

5.2.5 REDUCED WATER SUPPLY :

Since eroding soils get their infiltration capacity greatly impeded , rain water flows down the slope quickly and is not able to replenish the underground reservoir which feeds the streams round the year . Consequently , streams become seasonal and are practically dry after rains . The dry season discharge of rivers , which is very crucial for supply of potable water and that for hydroelectric projects , comes down quite appreciably . Municipal catchments of Darjeeling and Kurseong towns fall in the study area . The forest cover in both

of these catchments are very severely degraded . This , probably , is the reason of severe scarcity of water in these towns during dry season . In absence of monitoring of rivers during dry season over a longer period of time , it is not possible to draw any quantitative inference regarding the reduced supplies in the study area .

5.2.6 DAMAGE TO RESERVOIR , IRRIGATION CHANNEL , WATERWAYS AND HARBOURS :

Accumulating sediments silt up the reservoirs, clogg the irrigation channels, and fill up the navigational channels. Clogging of channels results in overflow and flooding of down stream areas which damages the crops and is disastrous to the man made structures . Some irrigation channels are seen to have been blocked because of deposition of silt .

5.2.7 DAMAGE TO COMMUNICATION ROUTES :

Damage to communication routes is probably the most visible effect of soil erosion . The instances of highway and railway embankments being washed away by cutting of uncontrolled water , land slips , landslides and debris avalanche during rains is a common feature . In dry and desert areas , they get buried under shifting sand dunes . It has been estimated that more than fifty percent of annual cost of maintenance of communication routes are due to erosion damages .

In the study area , disruption of communication routes is a major problem . This is mainly because

of landslides . The landslides in Darjeeling district have been widely studied by several workers . The Hill Cart road which runs about 40 kms inside the study area , has been a subject of many a investigations . In 1950 , 1968 , 1980 , and 1984 , communication links were badly damaged in the study area (Chattopadhyay , 1987). In 1968 , Hill Cart road between Kurseong and Darjeeling was blocked at 18 different points (Gerrard , 1991) . In 1984 a 150 mt long stretch of the same road was washed out . During 1950 and 1980 , too , serious disruption of communication routes took place.

CONCLUSION :

Thus it is seen that various problems relating to soil erosion include faulty cultivation practices in agricultural lands and tea lands . Faulty agronomic practices , too , are a cause of concern . Unauthorised quarrying also adds to the sediment load and is instrumental in triggering slump of banks and even landslides . Unscientific water disposal along elaborate road networks also adds to soil degradation processes . Extension of roads and construction of new roads involving cutting of earth in highly fragile slopes also contributes to sediment loads of the streams of study area . Over settlements on account of presence of large number of tea gardens brings about consequences related to that . Heavy population density flanking the forest has taken a very heavy toll . Related with the high population density is the problem of deforestation due to illicit removal of firewood and

excessive grazing in the forest . This has degraded soil greatly . Overgrazing is rampant in forest as well as on steep scrub lands attached with tea gardens . Connected with the cattle population is the heavy lopping of the trees of broad leaved species reducing crown cover and exposing soil underneath to eroding forces of rain drops . Forest fires are great menace in upper hill forests. A few occasional and limited burning of younger plantations have taken place. Among the effects of soil erosion many of them , such as deterioration of climate , increased floods , reduced water supply and damage to reservoirs occur on a much larger tract and such effects are visible in the study area . Deterioration of cultivated fields , shortage of fuel and fodder is quite visible. What is most visible is the disruption of communication routes by landslides , landslips and debris avalanches .It is probably the severity of disruption of communication which has helped most in making people realise the importance of sound soil management practices .

For studying various soil characteristics , morphometric factors , soil eroding processes and other parameters relating to soil erosion , a number of methodologies have been utilised to analyze their effects on soil erosion . These methodologies have been discussed in subsequent chapter.