CHAPTER IX

CONCLUSION AND RECOMMENDATION FOR MANAGEMENT OF THE BASIN

9.0 Conclusion

This mountain river Basin Rayeng is characterized by cliffs, rocky slopes, spurs, ridges, sharp break in slope, narrow and steep sided deep river valleys. There are two distinct physiographic zones within the basin viz. hilly tract of the northwestern and southwestern part and lower valley tract. The former one is characterized by ridges and valleys and the latter one is characterized by river deposits such as boulders, pebbles and sands. Topographic features of the basin are the latest phase of the tectonic uplift. The basin is influenced by subaerial denudation.

The basin displays complex geologic structure. Geologically the rocks of the basin are belonging to different geologic formations such as Darjeeling gneiss, Kanchenjungha Augen gneiss, Damuda formation, Paro sub-group, lingtse granite gneiss, feldspathic greywacke marble, Reyang formation and Gorubathan formation. Different structural aspects are found within this basin area such as foliation and schistocity, mega fold and warp and faults. Due to various geological formations the morphological features in the basin area vary in magnitude and dimensions. Bare rocky steep scraps, rugged topography, deep rives valleys have been produced by the stream of this basin on account of Stratigraphic variation. The basin has been affected by Himalayan orogeny.

Geological structure, one of the determining factors for the development of the soil of the Rayeng Basin. Soils of the basin have been developed through fluvial action and lithological disintegration. Due to existence of phyllite and schist in the source region of the Rayeng and Rambi River, occasional dark soils are found. Soil of the lower reaches of the basin is composed of alluvium. Sandy loam soil is common in this portion. There are also considerable tracts of sandy and gravelly soils. While in the hilly tract the soils are white, red and black. At greater portion of the basin soils are reddish loam due to excessive leaching. Interfluvial area of the basin is mainly composed of mixed sandy loam soil.

In the Rayeng Basin plant species variety is influenced both by climatic condition and relief. The study area is experienced with long hot and humid summer and short dry and cool winter season. High rainfall and high temperature of the study area is favorable for luxuriant growth of tropical semi evergreen vegetation, the type of natural vegetation of the Rayeng Basin varies at the different altitudinal zones of the relief. Three major forest

types according to altitudinal variation found in the Rayeng basin, viz, tropical moist deciduous forest below (1000m), temperate evergreen lower mountain vegetation (1000m – 2000m) and temperate evergreen upper mountain vegetation (above 2000m).

From the study about the linear aspects of the basin different hypothesis have proved, viz. length of the streams decreases with increasing gully order, positive relationship is found between stream length and basin order. Number of the streams is increased with increase in basin order. Length of the streams increases with increasing the basin area. Bifurcation ratio of the basin indicates that these are not distorted by geological structures, but lithology has significant role.

Sinuosity indices of Rayeng and Rambi rivers designate important characteristics of channel pattern and basin development. Standard sinuosity indices of both rivers are >1, specify that these rivers are flowing sinuous channels. The lesser percentage of HSI indicates that the development of Rayeng Basin is passing through the youth stage. The higher Percentage of TSI indicates the dominance of topographic control on the development of Rayeng Basin.

From the study of areal aspects different characteristics of the basin have been exposed. Value of 'F' is 0.65 (Form factor of the basin) specify that shape of the basin is almost circular or pear shaped. Value of 'E' (Elipticity Index) is of the Rayeng Basin is 5.59. Thus the shape of the basin is almost circular. The value of 'C' (Circulatory index) of the Rayeng Basin is 0.76 signify that the shape of the basin is almost circular. In case of Rayeng Basin 'K' (circularity index according to Lemniscates Method) value is less. Thus the shape of the basin is almost circular. Law of basin perimeter of the Rayeng Basin denoting that basin area of Rayeng River has been increased due to vigorous head ward erosion of the first order segment of the basin. Basin perimeter has been increased due to back wearing of divides simultaneously. Line of regression of positive power function denotes the mean length of the streams has been increased with increasing the gully basin area. Correlation coefficient between these two variables is 0.941. It is significant at the 0.01 level. Thus the law of allometric growth is valid. The accelerated erosion by the streams of the Rayeng Basin proved that there is a successive increase in orders with the advancement of fluvial cycle. The study of drainage frequency proves that on an average the basin has high drainage frequency. Irregular slope and different lithology of the basin is responsible for the high drainage frequency. High drainage density indicating that major portion of the basin area is composed of coarse gained hard rock.

Study of relief aspects of the Rayeng Basin has revealed different characteristics of the relief. The hypsometric integral of the basin is more signify that the basin is belonging to

the juvenile stage. From the study of clinographic curve of Rayeng Basin prepared on the basis of Finster Walder's technique (1980). In this basin area it reveals that the break in slope and sudden changes in relief. The hypsoclinographic curve indicates the similar view of hypsometric curve and more over small changes in relief also indicated by the curve. From the study of mean slope curve, prepared based on the Strahler's method (1952), changes of slope in Rayeng Basin is found prominent. From the overall study of the clinographic curves it can be concluded that the Rayeng Basin is belonging juvenile stage. From analysis of the overall slope scenario it is found that distribution of slope in terms of total area is not equal. Vast area of the basin (69.24%) is under steep to very steep slope and rest part (30.76%) is under moderately steep slope. The area has been uplifted orogenetically in the recent past. The steep slope has enhanced the intensity of vertical erosion of the streams. Consequently the basin surface configuration is displaying the evidence of stream erosion. Major portion of the area has moderately high to high relative relief. It indicates that the basin is belonging at the youthful stage. The study of dissection index of the Rayeng Basin it is found that on an average the basin has high dissection index. The highlands with scraps of the basin are well dissected and eroded by their drainage lines. In many areas narrow elongated ridges are formed by the streams through cut back their valleys. The average slope ratio of Rayeng River is 0.51. But it ranges from 0.20 to 0.82 on the other hand average slope ratio of Rambi river is also 0.51. But it ranges from 0.21 - 0.61. These unusual changes in slope ratio (RS) cannot be explained by climatic variation. The differential erosion mainly caused on account of various rock structure of the basin. Analysis of the longitudinal profiles of the Rayeng and Rambi rivers denoting multi cycle of erosion are faced by the both rivers. It can be said that the Rayeng Basin has long epeirogenic history.

Study of correlations and regressions of different morphometric attributes reveals that some attributes are highly correlated. It proves that morphometric variables are interrelated. It is also evident from the regressions analysis that the stream numbers, stream lengths, basin widths, basin perimeter and basin length are closely related to the magnitude of the basin areas in which they occur, where stream gradients and basin relief in many cases show only general agreement with the basin area. Since all such characteristics do change in value exponentially with basin area, it is likely that they will also change in response to change in each other by power function. Regression between stream length and basin perimeter, basin width and basin perimeter, stream numbers and total lengths of streams are displaying strong relationship between them.

The study regarding the soil erosion of Rayeng Basin revealed that the mean annual rate of soil loss from the Rayeng Basin is about 8.34 hectors. It means 0.734 mm thick soil cover is eroded every year from catchments area of about 145.50 sq km of the Rayeng River. High rainfall, clearance of natural vegetation, practice of agriculture and plantation on steep slope, constructional works on the weak geologic structure responsible for severe soil erosion.

Notable portion of basin area is suffered from the critical problem of landslides. Not only the physical but also the anthropogenic activities are also responsible for landslide in the basin. Landslide is the most important factor for the degradation of Rayeng Basin. Vulnerability of landslide in this area is highly related geology and climatic condition.

From the study of effect of environmental degradation it observed that natural flow of the channel has been altered. Vegetal communities have been reduced. Intensity of soil erosion and landslides has increased. Aquatic lives are also in danger. Ecological balance has been disturbed. Land capability assessment of the basin designates that the basin has no class-I and class-II category of land.

Different textural types of soil are found in the Rayeng Basin. Thus field capacity of soils is variable. Sandy soil has comparatively low water holding capacity than the other types of the soils of the basin. Soil texture is one of the striking determinants of field capacity. Soil porosity as well as permeability is also determined by the soil texture. Rate of infiltration influences the field capacity. There is a positive relation between field capacity and soil porosity. Soil moisture is varied seasonally. In the basin moisture content of soils declines in dry season and increases in wet seasons on account of variation in amount of rain fall. Slope of the terrain highly influence the rate of runoff and infiltration. Thus moisture content of the soils is also determined by the slope also. Depending on the total available water (TAW) various vegetal community have been flourished in basin although there others factors like altitude, climate influences the growth and distribution of vegetation.

This basin is important for the supply of water for drinking, energy. Freshwater from this basin also supports unique ecosystems and biodiversity of this basin area. But the basin is under pressure of deforestation, agriculture and tourism and other heavy construction. For the security of the local people water resource of this basin must be restored.

9.1 Recommendation for the management of the basin

From the general study of geomorphic and environmental scenario of the Rayeng Basin it has been observed that the basin is being faced different problems. The identified problems are environmental hazards, deterioration of ecological balance, hydrological

disturbances and land use problem. Following recommendations may be suggested for the on the whole management of the basin:

1) Recommendation for the management of environmental hazards

The basin is being faced the problems of landslides and soil erosion. To minimize the problems of the aforesaid phenomenon following steps to be taken:

Steps for landslides management

Landslides are one of the recurring problems in the Rayeng Basin. To minimize the problems of landslides the traditional ways of mitigation may be followed:

A) Restriction of constructional works on the weak geologic structure.

B) Good outlet system for rain water in the form of catch water drains to be constructed.

C) Cracks on the rocks to be sealed.

D) To protect the toe erosion rock bolting by wire net with boulders extending down to the bed of river is to be adopted for the selective areas.

E) Landslide prone areas are is identified properly.

Steps for soil erosion management

The basin is also being faced the soil erosion problems. To minimize the problems of soil erosion different ways of mitigation may be followed:

A) Ploughing to be practice at right angles to the hill slope, following the natural contour of the hill, the ridges and furrows break the flow of water down the hill. Such method may prevent severe soil loss.

B) A series of terrace may be cut on the steep slope to reduce the sheet erosion due to surface runoff.

C) Plantation and agriculture to be restricted on the steep slope.

D) Clearance of natural vegetation must be prevented,

E) Check damps are constructed in slope with an objective of ponding the water and depositing upstream sediments to reduce the slope with time.

Steps for river bed siltation management

At the downstream area of the Rayeng River excessive siltation has been observed. Owing to siltation, the water holding capacity and transport capacity of Rayeng at the lower segment has been reduced. This is mainly due to supply of huge loads for soil erosion and landslides and obstruction in natural flow by the manmade construction. To reduce excessive siltation following steps to be taken:

A) Excessive soil erosion and landslides to be checked.

B) Manmade construction, hindering the natural flow of the river, should not be allowed.

C) Deforestation must be stopped.

2) Recommendation for water management of the basin

Water of the river Rayeng may be used for different purposes if the basin is managed scientifically.

Drinking water

If the water of this river is purified, it can be used as drinking water by people of the basin area. The people of locality endure from the paucity of drinking water. Thus the water of this river may supply to the locality after proper purification.

Enhancement of hydroelectric power development

Huge amount of water is supplied by this River in the River Tista. Near the confluence Point of Rayeng River with Tista, a hydel project is being constructed. For the maintenance of this project the huge supply of water by the Rayeng is necessary as a tributary of Tista. Thus through proper management of this basin the amount of discharge of this river must not be disturbed by man-made construction or dumping of garbage in this river.

3) Recommendation for the maintenance ecological balance

The ecological balance of this basin has been disturbed due clearance of forests. For the encroachment of settlement, agriculture and plantation and construction of road huge amount of forests have been cleared. Thus not only ecological quality of the basin but also the biodiversity of the basin have been hampered. Constructional works within the river bed disturbed the hydro geomorphic characteristics of the basin. To maintains the ecological balance of this basin area following steps to be taken:

A) Development of settlement, practice of agricultural and plantation not be permitted by clearing the forests at any cost.

B) No constructional works would be allowed in the river basin which may hinder the natural behaviors of the river.

C) Water of the tea garden and agricultural field containing chemical fertilizers and insecticides are not to be allowed to mingle with the river water as it may destroy the aquatic lives.

4) Land use management

This basin has attractive scenic beauty. The major portion of the basin is covered the flora of different species. But recently the land use pattern of this basin has been changed due human interference. Construction of roads, establish of tea garden and cinchona plantation

has altered the land use pattern. The unplanned land use of this basin is responsible for the deterioration of the basin. Thus to restore the natural characteristics of the basin the land used must be operate with proper planning strategy.

5) On the whole resource management of the basin

A) In this basin cinchona are cultivated. Cinchona is one the valuable medicinal plants. If cinchona is cultivated with proper scientific management it would be beneficial for local economy. But it should not be practiced on vulnerable soil erosion and landslide zones.

B) This basin has valuable forest resources. These resources should utilized and restore by implementing proper management.

C) Tea is also a valuable resource of the basin. The tea garden should be established on areas having minimum or no risk of landslides and soil erosion. It must be scientifically managed. Tea plantation through proper scientific way may enhance the economy of the basin area.

D) Ecotourism may be introduced for development of economic status of the people of the basin area. Natural scenic beauty may attract large number of tourists. Thus ecofriendly tourism may be encouraged.

Last of all it can be concluded that basin must be maintained and restore to protect the environmental condition. This is a zone with rich biodiversity and important watershed. Thus this basin must be studied more for the betterment of ecological balance.