CHAPTER 7

RESULTS AND DISCUSSION

7.1 INTRODUCTION

In the preceding chapters, degradation studies for the Nilgiris district, action plan generation for selected watersheds and prioritization of the watersheds for conservation measures by morphometric analysis were presented. This chapter presents an integrated analysis and synthesis of the results of each study carried out, to understand better the status of degradation using remote sensing and GIS.

7.2 LAND DEGRADATION IN THE NILGIRIS

This section discusses the results of the land degradation studies carried out for the Nilgiris district for two years. The study has been done in a GIS environment using weighted overlay analysis for 1973 and 1993. The thematic layers such as landuse, slope, drainage density, geomorphology and lineament density which have influence on the degradation are prepared. The Nilgiris has been divided into four zones as highly degraded, moderately degraded, less degraded and not degraded. During 1973, the highly degraded area is 13% of the total area. The moderately and less degraded areas are 25% and 30% respectively. The areas not affected by the degradation are about 32%. During 1993, the highly degraded area is 33% of the total area. The moderately and less degraded areas are 13% and 37%. The areas not affected by the degradation are about 17%.

From the above results, it is seen that the area under highly degraded category has increased by 20%. More area has been affected by degradation over the study period (1973-93). There is a decrease of 16% in the areas not affected by degradation. Thus, there is a general decline in the quality of the lands in the Nilgiris. A similar study was undertaken by Institute of Remote Sensing, Anna University in 1986 and it has been estimated that highly degraded area occupied 27.16% of the total area in the year 1983. It is observed that compared to 1983, highly degraded area in 1993 has increased to 33%. There is continuous decrease in the status of the condition of land in the Nilgiris. The study of landuse pattern in 1973 and 1993 reveals that there is a decrease in the dense forest cover by 12% and increase in the area of tea plantations. These facts compare well with the results of the degradation study. The Agricultural Engineering Departments has divided the Nilgiris district into 75 subwatersheds and prioritized 10 subwatersheds as highly degraded that need immediate attention in the form of soil conservation measures. Majority of these subwatersheds fall under highly degraded category of our degradation status map for 1993. Thus results of this study compares well with the field condition also.

The major cause for the degradation is that the present landuse practice is not in tune with the slope category. In majority of the watersheds, tea plantations are the major landuse category seen in all categories of slopes. Annual crop and forest plantations are also seen along inappropriate slopes. Vegetables like cabbages, carrots, and potato are grown in all slope categories near Nanjanad, Emerald, Muttari, Palada, Thuneri, Kalhatti, and Sholur Kokkal, which results in severe soil loss.

Tea plantations above 33% slope results in faster rate of land degradation. Kundahpalam, Neeralipallam, Saranganihalla, Katteri are some of the watersheds where tea is grown in all slopes and which needs to be changed, so that the land degradation is reduced.

Another factor leading to the degradation is conversion of natural forest into commercial plantations. From landuse study for the years 1973 and 1993, it is seen that there is a decrease in the dense forest cover by about 12%. The landuse statistics collected for the district by Giriappa (1983) has reported that tea area has increased from 19,191 Ha in 1966 – 1967 to 25,438 Ha in 1976 – 1977. During 1993 – 1994 area under tea increased to 46,542 Ha. Most of this is due to conversion of forestland. Though tea plantation will be a protective cover after a period of 5 – 6 years, the possibility of erosion is more in the initial stages due to surface being exposed to impact of rainfall and temperatures.

The inherent soil characteristics such as shallow depth, moderate permeability, excessive drainage, poor organic matter content, in combination with undulating topography with steep slopes, inadequate vegetal cover and improper cultivation practices contribute to the accelerated erosion and consequent degradation. The villages of Sholur, Hulhatti, Kadanad, Tuneri, Tummanetti of Uthagai taluk, Nandipuram, Arakodu, Kengarai, Denadu, Kallampalayam and Kodanadu of Kotagiri taluk fall under this class.

The shola forest are cut and the area has been converted into tea estates, wattle etc and in some areas the shola are cut for firewood. Similarly, the grasslands are also affected by indiscriminate large scale grazing by large number of cattles. Both shola and grasslands, i.e., the original landcover of Nilgiris are significant in terms of bio-diversity and prevention of soil erosion/land degradation. But due to the large-scale indiscriminate encroachment of the shola/grasslands, the fragile environment of the Nilgiris is being damaged.

Landslides are common in Nilgiris and are frequent and an annually recurring phenomenon during rainy season. In the Ooty – Coonoor corridor during 1978 – 1979 a number of landslides have taken place and again in 1990 a major landslide has occurred in Marapallam near Coonoor. These landslides have also caused degradation in these areas.

The population of the district has grown from 410,000 in 1961 to 762,000 in 2001. It is seen that in 2001 there is an increase of 85% over 1961 figures. Further, there has been an increase in the settlement size at Coonoor, Willington, Aravangadu and Uthagamandalam urban centers followed by Munanadu and Nellakotta of Gutalur taluk. The road density has also increased considerably. Thus, it may be concluded that growing urbanization in Willington, Coonoor, Aravangadu and Uthagamandalam has significantly contributed to the degradation in those areas.

A similar situation is reported in China also. A report was prepared by Jukuan Huang, Centre for Chinese Agricultural Policy, Chinese Academy of Agricultural Sciences, China. In his report “Land Degradation in China: Erosion and Salinity” (March 2000) submitted to the World Bank has analysed the causes for land degradation in China. He has reported that land suffering from soil erosion is 3.75 million sq.km. The areas affected by land degradation are about 39.4% of the total area of China. Similar to our findings in the Nilgiris for land degradation, the causes for land degradation reported in China are deforestation, destruction of grasslands, agricultural expansion and intensification, urbanization and industrialization, lack of education, institutional weakness and policies.

7.2.1 Satellite Image Data for Understanding the Status of Soil Erosion in the Nilgiris

Government agencies, that monitor and regulate the use of hilly terrains, are restricted in their ability to locate and assess problem areas by limitations on staff and finances. Good erosion surveys require expensive large-scale colour aerial photographs and ground inspection. There is also a considerable amount of skill involved in photo interpretation. Thus, field based methods would be difficult, time consuming and expensive. There is a rapid and simple method for identifying and distinguishing soil erosion, stability, and deposition using MSS or TM data from the Landsat series of satellites. Soil Stability Index, suggested by Pickup and Nelson (1984) is one such approach. SSI is a quick way of understanding the soil erosion status of an area. It gives the spatial location of soil stability and gives indirect information on erodability of an area. It is an important component for watershed management. Tests in the Alice Springs area indicate that this is so and both erosion and deposition may be mapped (Pickup and Nelson 1984). In the Nilgiris district, there is a distinct relationship between vegetation cover, status of land degradation and soil erosion. This was inferred by this author during many of the erosion surveys carried out over the past twenty five years. Hence, it was decided to carry out the SSI analysis

The SSI analysis was carried out for Nilgiris District using 1973 Landsat image data and 1992 Landsat TM data. From the analysis of the SSI image, it is seen that pixels in blue indicate areas in stable to transitional state, a category which dominates the landscape. Green pixels represent areas that are moderately exposed and hence, the erosion is moderate in this region. Red colored pixels represent areas that are exposed and can be considered erosional features. Comparing 1973 and 1992 SSI image, we can conclude that, an area under the erosion has increased in 1992.

7.2.2 Discussion

Following is a discussion about the SSI analysis. This discussion is mainly derived from the analysis presented by Pickup and Nelson (1984). The soil stability index works because of the way in which the 1/3-2/3 data space partitions out bare surfaces, dry vegetation, and green vegetation. Bare surfaces, which include soil, rock, and stones, all plot along the line that forms the upper limit of the data space. The position on the line seems to depend on color and brightness and a change in these variables results in a shift along the line rather than away from it. Dry vegetation plots away from the upper line usually in the middle of the 1/3-2/3 parallelogram, but as greenness increases there is a progressive shift towards the lower limit of the data space.

These tendencies translate into erosion and deposition in the following manner. The most severe erosion removes topsoil, destroys vegetation, and leaves a bare surface of soil, rock, or stone. Surfaces of this nature plot along the upper line. Less severe erosion is usually characterized by patches of bare soil interspersed with islands of remaining topsoil where vegetation survives. This produces a mixed soil-vegetation signal with a consequent shift away from the upper line. Areas in the early stages of erosion may not have large areas of bare soil but they do display relatively poor plant growth because of low nutrient status and deteriorating soil moisture storage capacity. Most of the vegetation present tends to be dry except after major rainfall events and even then these areas are much less green than those with a better soil status.

The effects of deposition are opposite to those of erosion and produce an environment that is much more favorable to plant growth. Deposition areas are sinks for soil, nutrients, and seed from surrounding areas.

They receive run-off and are consequently relatively well-watered. This produces vigorous vegetation growth, a good ground cover, and, where the deposition has been continuing for some time, an extensive cover of long-lived species such as trees. The result is that deposition areas display a much stronger green signal than other areas and little or no soil signal.

7.2.3 Conclusion

Soil stability index computed using satellite image data allows rapid survey of the erosion status of large areas commensurate with the size of management units. From the study, it is observed that there is increase in the area under erosion in 1992 compared to 1973. The results compare with the degradation status map prepared by the GIS overlay analysis method.

7.3 ACTION PLANS

7.3.1 General

Based on the degradation study, three watersheds namely Sillahalla, Kundahpalam and Neeralipallam in the highly degraded zone have been selected for further action plans preparation.

The action plans are suggested and prepared based on the slope and landuse parameters. It has been suggested that the annual crops are to be in the slope category 0 – 10%, agricultural plantations in 10 – 33% slope and forests, silvipasture etc in more than 33% slope.

7.3.2 Sillahalla

In the Sillahalla watershed, the area under Annual crops are about 3266 Ha. As per above mentioned rule, the annual crops are to be raised only in areas with 0 – 10% slope. However, as per ground reality the annual crops are grown in 3266 Ha but only 774 Ha are in tune with the slope. For the balance area of 2492 Ha, alternative landuse is suggested. Tea is grown in about 1607 Ha and out of this 539 Ha are in right slope and for the balance area multi layer approach is suggested. The forests, shola, built up grasslands in the watershed are to be conserved.

7.3.3 Kundahpalam

In Kundahpalam watershed, the annual crops are raised in 724 Ha and only 136 Ha are in confirmity with the slope and about 588 Ha needs modification. The horticulture, forest plantations are suggested in this area. The tea plantations are raised in 2198 Ha and out of this 1728 Ha are raised in unsuitable slopes. But it is not practicable to uproot the tea plantations and hence a multi-layer approach is suggested. The area under forests and grasslands are to be conserved. There is an extent of 216 Ha of barren uplands and for this silvipasture/forest plantation are suggested.

7.3.4 Neeralipallam

In Neeralipallam watershed, the predominant plantation crop is tea and it is raised in about 3846 Ha and out of this only 1366 Ha are in tune with the slope and rest are to be converted. But for about 2263 Ha multi layer approach is suggested and the rest of 217 Ha are to be converted to annual crops.

7.3.5 Summary

In general, in some of the watersheds in the Nilgiris annual crops such as potato, carrots and cabbages are grown in all slopes. These annual cropped areas remain fallow for about 6 months in a year and these areas on high slopes are most vulnerable to soil erosion, especially during rainy season. It is estimated that about 40 tons/ha/year is the soil loss from the above areas. In potato growing areas, tilling is done along the slopes to avoid brown rotting of potato, but due to this soil erosion is further accelerated. The author of this thesis observed this phenomenon in Nanjanad, Palada, Muttarai, Sholur and Kukkal, which results in severe soil losses. In Sillahalla watershed, the annual crops are main category, which needs to be changed. Suitable sustainable landuse practice such as agro-horticulture, agriculture plantations, silvipasture, forest plantation and afforestation is suggested.

Another important observation is that tea plantations are predominant in Neeralipallam and Kundahpalam watersheds. Though the study has been conducted for three watersheds, it is generally observed that tea plantations occur in all slopes and in about 55% of the watersheds which are not recommended for sustainable development. As they are not in conformity with the slopes, there is a need change either to annual crop/agro horticulture or tea with multi-layer approach. About 4 to 5 years are required for the tea plantations to achieve full growth. Till that time, the loss due to erosion is severe. Tea plantations in lower slopes along valleys encounter frost problems. Forest, shola and grasslands areas in all the three watersheds are to be conserved.

In the Nilgiris, under the Hill Area Development Programs (HADP), many action plans are being implemented. The Department of Horticulture is convincing the farmers/planters about the need for changing the existing landuse practices wherever they are not in conformity with the slope. The Agricultural Engineering Department (AED) is implementing soil conservation measures by constructing contour bunds and check dams to arrest the soil erosion. The farmers are given financial subsidy and tea saplings for implementation of action plan. The forest department is implementing many afforestation programmes. Thus, the action plans prepared by the author of this thesis have been adopted by the government departments for implementation.

7.4 MORPHOMETRIC ANALYSIS

7.4.1 Introduction

Sustainable development can be defined as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Conservation of natural resources is essential to sustain any development activity, and such measures especially for soil and water carried out on a watershed basis are very useful for watershed management. In this context prioritization of watersheds is required for watershed components source to take any further relevant conservation measures. In the prioritization of watersheds, the morphometric analysis is very useful and adopted in our study.

7.4.2 Drainage Pattern

The general drainage pattern of the basin is dentritic to sub-dentritic.

7.4.3 Bifurcation Ratio

The straight line plot satisfies Horton’s first law of stream numbers which states that the number of streams of different orders in a given drainage basin tends to approximate closely an inverse geometric series in which the first term is unity and the ratio is the bifurcation.

According to Strahler (1964) the bifurcation ratios characteristically range between 3.0 and 5.0 for watersheds in which the geologic structures do not distort the drainage pattern. The mean bifurcation ratios for Kundahpalam range from 3.3 to 4.87 for the micro watersheds. The Bifurcation ratios between second and third order streams are higher because the number of second order stream is more. The mean bifurcation ratio for Neeralipallam subwatersheds vary between 2.83 to 5.6 and average value is 4.12. In the Sillahalla watersheds the mean bifurcation ratio lies between 2.72 and 5.75 and average is 3.7. The lower values of Rb are characteristics of the subwatershed which have suffered less structural disturbances and the drainage pattern has not been distorted because of the structural disturbances (Nag, 1998). In the presence study, Rb lies between 3 and 5 and hence, in these watersheds geologic structures do not distort the drainage pattern. According to Babar (2001) where geology is reasonably homogeneous, the Rb varies between 3 and 5. In the three watersheds being studied, this hypothesis has been proved.

7.4.4 Drainage Density

The drainage density (Dd) for 6 microwatersheds Kundahpalam sub-watershed ranges between 4.36 and 5.76 km/sq.km, for 9 microwatersheds of Neeralipalam between 2.24 to 4.99 km/sq.km and for 13 microwatersheds of Sillahalla ranges between 3.17 and 6.5 km/sq.km. Drainage density measurements have been made over a wide range of geologic and climatic types in the United States. Values between 1.86 and 4.35 km/sq.km are considered to be low drainage density or coarse textured. Values in the range of 4.97 to 9.94 km/sq.km to be medium drainage density or medium texture and values between 12.43 and 18.64 km/sq.km as high drainage density or fine texture. For the Sillahalla sub-watersheds, average drainage density is 5 km/sq.km and hence, drainage texture of Sillahalla may be described as medium textured. The average drainage density for Kundahpalam is 5.01 km/sq.km and hence the drainage texture for Kundahpalam can be described as medium drainage textured. For Neeralipallam the average drainage density is 3.54 km/sq.km and the basin is considered to be having coarse drainage texture. The rock type of the basin is Charnockite under fairly dense vegetative cover and hence low drainage density is obtained for the basin.

7.4.5 Stream Frequency

The stream frequency for all the sub-watersheds is furnished in table 6.3. The stream frequency for the Kundah pallam watershed ranges from 9.94 to 17.11, Neeralipallam ranging from 6.61 to 15.5 and Shillahallah ranging from 6.19 to 19.8. It is noted that the stream frequency exhibits positive correlation with the drainage density values of the sub-watersheds indicating the increase in stream population with respect to increase in drainage density. Higher stream frequency in Kundahpalam indicates higher erosion in the sub-watersheds.

7.4.6 Drainage Texture

The Drainage texture for Kundahpalam sub-watersheds vary between 4.28 and 10, Neeralipallam sub-watersheds vary between 2.21 to 8.07 and Sillahalla sub-watersheds vary from 2.95 to 8.75. The drainage texture less than 2 indicates very coarse, between 2 and 4 is related to coarse, between 4 and 6 is moderate, between 6 and 8 is fine and greater than 8 is very fine drainage texture. In the present study, four sub-watersheds of Kundahpalam fall under the category of very fine texture. In the Neeralipallam, one sub-watershed and one sub-watershed in Sillahalla fall under the above category. In general, the drainage texture ranges from moderate to fine textures.

7.4.7 Form Factor

The form factor worked out for all the sub-watersheds are furnished in the table 6.3. The form factor value varies between 0.22 and 0.81 for Kundahpalam, 0.23 and 0.49 for Neeralipallam and 0.24 and 0.59 for Sillahalla. The form factor value varies from ‘0’ in highly elongated shape to the unity 1 in perfect circular shape. Hence ,higher the value of form factor more circular the shape of the basin and vice versa. It is observed that most of the values of Rf lie between 0.2 and 0.5 and this indicates that the sub-watersheds are elongated in shape.

7.4.8 Circularity Ratio

Circularity ratio for Kundahpalam varies between 0.39 and 0.68, for Neerali pallam 0.31 and 0.75, and for Shillahallah between 0.43 and 0.78. The sub-watersheds with higher Rc indicate that they are more or less circular and characterized by high to moderate relief and system is structurally controlled. The watersheds with low Rc indicates that they are elongated.

7.4.9 Elongation Ratio

The elongation ratios for Kundah pallam sub-watersheds ranges between 0.48 and 0.74, Neerali pallam ranges between 0.55 and 0.79 and for Sillahalla ranges from 0.56 to 0.86. The values Re generally ranges from 0.6 to 1 over a wide variety of climatic and geologic types. Values close to 1 are typical of regions of very low relief, where as values in the range 0.6 to 0.8 are usually associated with high relief and steep ground slope (Strahler 1964).

These values can be grouped into four categories namely (a) circular (>0.9), (b) oval (0.9 to 0.8) (c) less elongated (0.7 to 0.8) and (d) elongated (<0.7). From the values, it is seen that most of the sub-watersheds are elongated.

7.4.10 Erosion Model Adopted for the Study

Based on morphometric analysis Sillahalla, Neeralipalam and Kundahpalam watersheds are prioritized for taking up conservation measures. The method adopted by Biswas sujata et al (2002) has been adopted. The bifurcation ratio, drainage density, stream frequency, texture ratio and three safe parameters (form factor, circularity ratio and elongation ratio) are used considered for the prioritization micro-watersheds. The sub-watersheds are prioritized in to four categories which is very high, high, moderate, and low erosion. In the table 6.4 the maximum score is 23.43 and the minimum is 6.71. The very high priority watersheds are having the value between 6.71 and 11.86, high priority watersheds having the value between 11.87 and 15.29, moderate priority watersheds having the value of 15.30 and 19.00, and above 19.00 are grouped under low category. The present study highlights that microwatershed numbers 1,3,5,7,12,17,19 and 25 were subjected to maximum soil erosion; hence, these micro-watersheds need to be provided immediately with adequate soil and water conservation measures. Generating a soil map of 1:50,000 scale takes a lot of time and it may not be available in all areas; the present approach of morphometric analysis can be of immense use in prioritizing microwatersheds, and it is time saving.

7.5 CONCLUSION

Aim of the study is to prepare the degradation status map of the Nilgiris district on regional scale 1:250,000 for two years over a period of two decades. Hence for Nilgiris district the degradation status map has been prepared for 1973 and 1993. The analysis of the status map has clearly brought out that the degradation has increased considerably. This fact has been validated in the ground also. The soil stability index study conducted using satellite image data compares with the results obtained from degradation status map. To arrest further degradation, slope based landuse practice is suggested. Three sub-watersheds in the highly degraded zone were selected and action plans prepared and the line departments of Nilgiris district were advised to take up conservation measures immediately. The morphometric analysis was also carried out for further prioritization of the sub-watersheds for taking up the conservation measures.